D. Outage Information

1. Objectives

This section of the report provides a description and evaluation of Ameren-IL's outage management, restoration status monitoring and reporting, and damage assessment systems. While the focus was on the performance of these systems during the 2006 storms, Liberty also examined any modifications or enhancements to these systems since the storms. Liberty's objectives were to:

- Assess the effectiveness of the systems and procedures used by Ameren-IL to determine the extent of damage incurred, to determine the number of customer interruptions, and to develop service restoration estimates.
- Verify the accuracy of the data collection systems used for determining the extent of the outages, including the number of customers affected and the development of an accurate estimate of time for service restoration.
- Review the results of the interruption reporting systems and assess the data collection process and accuracy of such systems.
- Determine how Ameren-IL employs industry "best practices."
- Identify any areas that might be suitable for adoption of industry "best practices."

This section addresses item **2.3.2.5.26** from the Illinois Commerce Commission's Request for Proposals.

2. Background

Traditionally, electric utility customers have called the utility to report problems or interruptions in their electric service. In most cases, customers simply wish to make sure the utility is aware of their outage or problem and want to find out when the utility will restore service. Advances in computer technology and telephony have presented options for communicating service outage information to and from customers. Nearly commonplace now, utilities have embraced the use of Interactive Voice Response (IVR) technology to allow self-service outage reporting via telephone, largely as a self-defense measure to help cope with the spike in call volumes associated with large outages. Utilities also have leveraged Interactive Voice Response technology to enable 2-way communications, allowing customers to report outages as well as obtain customer-specific restoration status information from the utility.

The growth of the Internet, mobile computing, and internet-capable telephones have made it necessary for utilities to offer outage information on company websites. Most electric utilities in the United States are providing some level of outage information on the corporate website, at the most basic, listings of affected areas and number of customers out of service. Many utilities have also established self-service outage reporting through the web site, providing yet another way for customers to let the utility know they are without power. Not surprising, web access is becoming very popular during a large outage. While individual residences may be without power, businesses and public areas may have power and many cell phones have Internet access, giving the public access to the website, even during a large outage event.

Additionally, advanced metering technologies and distribution automation are beginning to present opportunities to identify customer locations that have lost power. Ultimately, automation will identify outages, reducing the need to rely on customers to report outages. In fact, utilities with this level of notification can proactively contact customers, especially critical care customers, to let them know that the company knows about the outage, provide the expected restoration time, and preempt a significant number of customer calls and website visits.

The management of outage information is critical to effective communications both within and outside the utility. By reporting individual outages, customers continue to play an important role in determining the extent and location of an outage, and will continue this role until the utility deploys distribution automation to the meter. Whether the customer speaks with a representative or self-reports the outage through telephone technology, the call creates a "trouble ticket" in the outage management system. Outage management systems automate trouble order management and expedite the analytical process, helping utilities more quickly identify outages and begin restoration.

Outage systems present the capability to predict affected devices by using algorithms to relate trouble tickets to the electric device schema. By automating the sorting and analyzing of outage tickets, management can better determine and dispatch the appropriate resources to restore service. Many outage systems disable or limit device prediction during a large event because the algorithms become less predictive.

While lights-out calls from customers are good indicators that damage exists and provide a feedback mechanism to tell whether trouble remains on the system, a complete and thorough damage assessment gives a utility the best chance of properly planning and executing the restoration. The planning function allows the utility to provide accurate and specific estimations of restoration time as the effort progresses. Qualified and trained individuals acting in their storm role perform damage assessment.

Just as critical, the restoration planning process plays a role by developing initial estimates of restoration time (ERTs). The utility must incorporate these estimates into the outage management system in a timely manner so that other employees, customers, corporate communications, community relations, and other interested stakeholders can share this knowledge. Equally as important, the utility must update the estimates of restoration time in the outage management system as more information becomes available. Accuracy is a key concern as the outage system usually serves as "the source" for the number of affected customers and storm restoration status for other areas of the company, including call centers, emergency operations centers, public relations, and regulatory relations.

Outage systems often have the ability to initiate automated customer call-backs, in conjunction with the utility's telephony. Adjunct to the damage assessment process, the automated call-back process attempts to contact all customers with open trouble tickets at the time the company believes that it has restored power. If pockets of customers remain without power, the utility may redeploy assessors to investigate and submit supplemental damage reports.

3. Findings and Analysis

This section contains the primary findings, analysis, and detailed descriptions of the systems and processes that support outage communications at Ameren-IL. Liberty organized this section to address the following:

a. Outage Management Systems
b. Estimated Restoration Time
c. Interruption Reporting
d. Outage Information Data Integrity
e. Communicating Outage Information
f. Best Practices

a. Outage Management Systems

Ameren installed its Outage Analysis System (OAS) in 1993. Originally purchased from Price Waterhouse, in-house Ameren resources have modified and supported the system since its implementation. Ameren-UE (Union Electric) was the first operating company to use OAS, followed by Ameren-CIPS in 1996, Ameren-CILCO in October 2003, and finally Ameren-IP in October 2005.[91] Although CILCO and Illinois Power each had their own different (vendor-supplied) outage systems, they were converted to Ameren's OAS system.

The Outage Analysis System (OAS) is the primary system used by the Ameren-IL companies to manage all gas and electric service requests and service orders, including: service connects, service disconnects, special reads, meter change-outs, meter installs, meter removals, tampering investigations, as well as service trouble orders—lights out, gas leaks, and wire downs.[92] Specific to storms and outages, the OAS analyzes, tracks, and records all information related to system outages and service problems.[93]

The following can initiate service trouble orders in the Outage Analysis System:

- Customers calling the company's call center representatives
- Customers self-reporting trouble through the Interactive Voice Response system
- Customers self-reporting trouble through the high-volume overflow Interactive Voice Response system
- Automatic meter reading device notification (minimal in Illinois in 2006)
- Supervisory Control and Data Acquisition (SCADA) can automatically trigger feeder outages in OAS. (Illinois has limited SCADA at the feeder level). Sub-transmission outages must be entered into the system manually.
- Dispatchers can manually create outage orders
- Work-management system maintenance requests can be initiated from OAS.

[91] Interview #9, October 4, 2007.
[92] Response to Data Request #257.
[93] Response to Data Request #92.

The Outage Analysis System analyzer module interprets each outage call and creates outage orders, which are associated or "tagged" to a likely electrical device, such as a transformer. Ameren's distribution electrical connectivity model groups devices using relational database tables that create the link for customers to transformers, transformers to fuses or other protective devices, devices to circuits, and so forth.

The system records all repeat calls to preserve the call history, however it just notes and groups with the existing order subsequent calls to the same order. Dispatchers have the capability to manually group or split orders, although these are difficult and time-consuming tasks due to system design.. As new trouble reports arrive, the system continues conditional grouping automatically until stopped.[94]

Because the Outage Analysis System manages outage and non-outage service work, service requests mix in with trouble/service orders. To help expedite restoration, Ameren prioritizes orders in OAS as outlined in the table below.[95] This allows users to filter out or limit the type of orders to those essential to the storm restoration process.

OAS Order Priorities	
1. Emergencies	29. Pole Leaning
2. Equipment Fire, Pole Down	30. No-Pay Reconnects
3. Gas Requests	30-45. Meter Job
4. One Call (Locates)	32. Successor Reconnects
5-8. Electric Outages (LO, WD)	41. Bracket Loose
9. Partial Outages	43. Tree on Service
10. Service Work	51. Dusk/dawn Reconnect
24. Pole Burning	52. Dusk/dawn Trouble
25. Service Down	53. Streetlight Trouble
26. Equipment Problem	55. Dusk/dawn Disconnect
28. Wire Problem	56. Remove Service

Outage Analysis System (OAS) information is readily available to Call Center Representatives, the Interactive Voice Response systems, Ameren's website, dispatchers, and any Ameren field or office employee that has access and has been trained to use the system. Troublemen and servicemen can access OAS by wireless mobile data terminals (MDTs). Generally, all single servicemen vehicles are equipped with MDT equipment for use with OAS.

To make outage information more accessible, Ameren created an intranet application, available to all employees, that summarizes Outage Analysis System (OAS) activity. The screen displays a snapshot of current outage orders, by state, division, and dispatch office. The screen provides a summary of the number of outage orders by outage type and status. It shows orders grouped into OAS "buckets" based on assignment—Dispatch, Field Checker, Forestry, and Construction. Users accessing this screen can "drill-down" into summaries by state, division, dispatch office, and specific areas of work.[96]

[94] Interview #9, October 4, 2007.
[95] Response to Data Request #259-A.
[96] Response to Data Response #334.

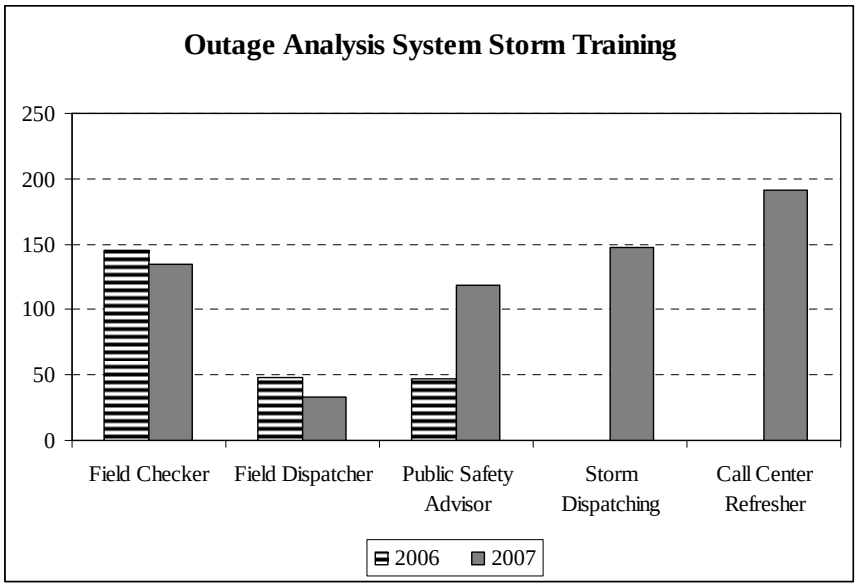
However, the Outage Analysis System is a "green-screen" system. That is, it is a command-based system (text and codes) not updated to take advantage of the point-and-click features of desktop computing. Users must know the correct code name of the screen to accomplish a transaction. As a result, personnel need a significant amount of training to become familiar with the system.[97]

During March and April 2006, Ameren's Employee Development and Systems Training group provided several OAS training classes for field and contact center employees. Approximately 240 Ameren-IL employees received training as field checkers, field dispatchers, or public safety advisors.

After the storms, Ameren modified the training curriculum to take advantage of "lessons learned." It rolled out new classes in Illinois in the spring and early summer of 2007, including classes for Public Safety Advisors, Field Checkers, Storm Dispatching, and Outage Analysis System refresher for Contact Centers. The level of Outage Analysis System training delivered to Ameren-IL employees after the 2006 storms nearly tripled—625 employees received training in 2007.

In addition, starting in 2007, Ameren instituted yearly storm training as a refresher for employees. At the end of 2007, Ameren-IL also began offering "OAS for Electric Dispatchers" training to gas dispatchers. This will enable gas dispatchers to provide support for electric dispatchers during storms and other emergencies.

The following chart details the number of Ameren-IL employees trained in the Outage Analysis System during 2006 and 2007. [98]



The increase in Outage Analysis System (OAS) training during 2007 was a direct result of recommendations from the both July and November 2006 storm critiques. A critique of the July

[97] Response to Data Request #611.
[98] Response to Data Request #94.

2006 storm suggested additional OAS training for field personnel, especially Ameren-IP personnel.[99] An action item resulting from the November 2006 storm critique directed Ameren to develop and execute additional OAS and restoration process training for all Illinois divisions who require it by May 1, 2007.[100]

Because Ameren deployed the Outage Analysis System (OAS) at Ameren-IP in October 2005,[101] many Ameren-IP employees had limited exposure to OAS prior to the storm and had never used OAS during a large storm.[102] The January 2007 Critique of Ameren Illinois Service Restoration Activities summarized the challenges faced:[103]

> *With some of the IP territories still mastering the functionalities of OAS, there were some issues with the timely updating of this information. Some of the areas will need retraining in the operation of OAS as well as in the restoration process (moving of work, updating of orders, breaking down the data into smaller more manageable subsets, etc.).*

The post-storm critiques and a subsequent technology evaluation identified 75 potential improvements to the Outage Analysis System, Ameren.com, Visual Dispatch, and the Interactive Voice Response. Ameren directed more than half (45 of 75 items) of the improvement opportunities at the Outage Analysis System.[104]

Outage Analysis System issues encountered during the 2006 storms included:[105]

- Improper grouping and rolling-up of orders. OAS groups orders automatically based on pre-defined rules and schema hierarchy. However, the auto-grouping function did not have the desired outcome on all orders, creating more work for people to examine groupings, separate orders, or partially restore orders. In addition, individual outage information was more difficult to locate when OAS grouped orders to a higher device, making it more difficult to restore orders that the system grouped improperly. In addition, the OAS created duplicate single outage orders when it had first grouped orders to a higher device and then call-takers logged another order linked to that same device (*e.g.*, transformer). As a result, people had to review more single outage orders and resolve the duplicates.
- All customer calls are logged into the OAS system. Customers often call multiple times and different customers often report the same problem resulting in duplicate wire-down and service-down orders logged by call-takers. This inflated the OAS order volume. Because the storms stretched out over days, many customers called multiple times trying to find out when Ameren would restore their service. There was no validation in the order entry system to prevent a call-taker from creating multiple OAS orders for the same issue. "There were a high number of duplicate orders during this storm. One account had a wire down, service down, lights out, and a wires burning for the same address. This

[99] Response to Data Requests #85-B.
[100] Response to Data Request #8-D.
[101] Responses to Data Requests #89-#91.
[102] Response to Data Request #85-B.
[103] Response to Data Request #8-D.
[104] Response to Data Request #8-C.
[105] Response to Data Request #261.

creates numerous pages of outages that need to reviewed and scrolled through by the Construction Supervisor."[106]

- Lights-out trouble orders logged to gas-only accounts. There was no validation in the order entry application to prevent call-takers from creating OAS electric trouble orders for customers with gas-only accounts calling. This happened in areas of Ameren-IL's service territory where it provided gas service but another company or municipal provided electric service. In these cases, customers were calling and creating orders through the IVR for "lights out" when they did not have electric service with Ameren, but happened to have their gas service with Ameren.
- Certain types of lights out, service down orders did not show up as an outage in history or as Power Out in My Electric Outage. (Service Order-Wire Down orders are not considered outages in the OAS system.) The programming for My Electric Outage failed to include lights-out, service down orders in a customer's outage history; it did not even indicate that the power was out. As a result, some customers visiting the website did not get verification of their reported outage or that the company knew their lights were out. This stimulated more calls to the call centers and frustrated customers.
- During a major storm, customers may be involved in multiple outage orders. The outage restoration call-back procedure did not eliminate duplicate orders, duplicate call-backs. Ameren's automatic call back procedure allowed duplicate call-backs. Because of this, customers could receive more than one call-back, depending upon how many different trouble orders were with their account.

The lack of training and exposure to OAS is an issue that Liberty discusses more in the next section of the report, Estimated Restoration Time.

In addition to the lack of preparedness of employees, Ameren also failed to identify "critical customers" in the Outage Analysis System prior to the July or November storms. As a result, each division had to identify and prioritize critical customers on their own as the storm progressed. Ameren has since created a list of critical customers in the Outage Analysis System by circuit based on SIC (Standard Industry Classification) codes.

Otherwise, the performance and reliability of the Outage Analysis System during the 2006 storms was generally good. OAS was operational during both storms, except during brief periods of preemptive maintenance. In addition, Ameren's Information Technology shut down mainframe testing and development resources during both storms to maximize the Central Processing Unit resources available to the Outage Analysis System during the storm. This was a proactive measure taken to maximize the Outage Analysis System throughput, not in response to any system problems.[107]

Ameren also halted processing of non-storm outage management system orders (queued them for later processing) to allow a better flow for storm-related orders during the July 2006 storm.[108]

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[106] Response to Data Request #8-F.
[107] Response to Data Request 264.
[108] Interview #9, October 4, 2007.

Ameren made the following enhancements to the Outage Analysis System since the 2006 storms:[109]

- E-mail alerts when the Outage Analysis System automatically turns off Estimated Restoration Times. These alerts notify division management, call center support, Emergency Operations Center management, and other individuals with storm responsibilities. These notifications alert management that sufficient trouble order volume has been received and turns off the reporting of Estimated Restoration Times (ERT) to customers. The OAS system continues to calculate automatic estimates.
- GIS Map viewing software integrated with the Outage Analysis System in 2007. Visual Dispatch displays outage events on geographic maps facilitating quicker location and analysis of the events. Visual Dispatch is also available via Mobile Data Terminals in the field.[110] These functions are generally not used by Dispatchers or Troublemen in real-time storm management due to a inadequate functionality.
- The Outage Analysis System (OAS) enhanced to offer e-mail and paging alerts of order volume when the number of outages exceeds a set threshold. This is another notification for division, Emergency Operations Center (EOC), and call center management indicating that OAS has received a significant number of outage orders. These alerts help communicate the need to ramp up the workforce and possibly open the EOC.
- The Outage Analysis System Call Entry screens modified to limit entry of outage orders to electric accounts only. This change eliminated the possibility of electric trouble orders created for gas-only accounts. This change helps call-takers easily identify these situations so they can discuss the matter properly with the customer.
- Generic weather cause relayed during major storms when an order does not have the cause. In the 2006 storms, Ameren was unable to deliver the cause of the outage to callers because cause code assignment was only at order completion. As a result, when customers called to check on the status of their trouble order, no cause was available. The Outage Analysis System change allows Ameren management to assign a generic "weather-related" cause to all open orders, thereby informing callers of the cause through Interactive Voice Response and on the website.
- E-mail alerts issued when orders dispatched for long periods. This enhancement alerts field management to any orders that have been in "dispatch" status for an extended period. This change will help prioritize orders by age, especially during a large event when Outage Analysis System has logged thousands of orders.
- The partial restoration process enhanced to increase the number of transformers that personnel can select. Outage Analysis System has established limits and rules for the manual grouping of orders. These changes make it easier to group restored orders and separate them from those not yet restored on a device with many associated trouble orders. In practice, the partial restore process is difficult and cumbersome. As a result it is, for the most part, abandoned during major storms.
- The Outage Analysis System restoration verification outbound call process now identifies if a customer has called in to report the outage while the call-back process was attempting to contact them to confirm power restoration.

[109] Response to Data Request #93 and 102.
[110] Response to Data Request #92.

Changes made after the 2006 storms to other systems and technologies that rely on the Outage Analysis System data include:[111]

- Improved use of Caller ID to make it easier to self-report outages in the Interactive Voice Response.
- Revised scripting in the Interactive Voice Response to recognize first outage calls and repeat outage calls. The system now offers different options to callers.
- Interactive Voice Response no longer relays an Estimated Restoration Time that has expired.
- Standardized and streamlined company-wide PBX (Private Branch Exchange [private telephone switchboard]) announcements. This creates a more consistent and coordinated message to customers.
- Allow My Electric Outage website access by phone number (registration not required).

b. Estimated Restoration Time

Another role of outage systems is to provide estimates for the time of restoration. Estimated Restoration Times (ERTs) are a critical information component of the restoration process. Customers, government officials, and the public want to understand how long the outage will last. This information is basic to determining if alternate housing will be necessary and helps residents and businesses make the appropriate plans for dealing with an extended outage. It is to the company's benefit to derive ERTs in order to determine better the level of resources required to restore the electrical system.

The absence of Estimated Restoration Times (ERTs) can generate a significant response from customers and the public, in the form of phone calls, website visits, and contact with government officials to try to find out something, anything about the outage. The longer the company proceeds without ERTs, the more frantic and disgruntled customers will become trying to contact the company.

However, offering Estimated Restoration Times (ERTs) that are grossly inaccurate can cause more damage that offering no ERTs at all. Inaccurate ERTs foster distrust and the perception of incompetence.

For day-to-day operations, Ameren programmed the Outage Analysis System to calculate automatically the Estimated Restoration Time based on area, order type, and active order volume.[112] The Outage Analysis System uses historical outage records and predefined rules to assign automatically Estimated Restoration Times to orders. Personnel can also manually update the Outage Analysis System's Estimated Restoration Times to override an automatic Estimated Restoration Time on any individual outage order.

Prior to the July 2006 storm, Ameren enhanced the Outage Analysis System to allow turning on or off the auto-calculate Estimated Restoration Time for all orders after encountering Estimated

[111] Response to Data Request #102.
[112] Responses to Data Requests #89-#91.

Restoration Time accuracy issues during a significant outage in August 2005.[113] Ameren has since established order volume thresholds by division to automatically turn off the auto-calculate during large outage events.

However, when the auto-calculate is off, personnel must manually update Estimated Restoration Times (ERT), or else the order will not have an ERT. This means that the Interactive Voice Response, My Electric Outage, and the Call Centers have no ERT information. As a result, customers and the public receive no information other than what Corporate Communications provides. During the July 2006 storm, only 35 percent of orders had an ERT assigned, and of those, the Outage Analysis System automatically assigned most. Only 6 percent of orders created during the July 2006 Storm had a manually updated ERT.[114] Similarly, only 35 percent of orders created during the November/December 2006 Storm had assigned ERTs. Only 4 percent of orders had a manually assigned ERT.[115]

Compounding the lack of estimated restoration information, during the July 2006 storm Ameren's Interactive Voice Response had incorrect programming. The Interactive Voice Response did not deliver the date component of the Estimated Restoration Time. For instance, if an Estimated Restoration Time indicated restoration the following day at 11:00 a.m., the caller would only hear 11:00 a.m. This led to the inaccurate interpretation that Ameren-IL would restore service the day the customer placed the call, creating additional frustration for customers.[116] Ameren corrected this flaw on July 22, 2006, however approximately 30 percent of the orders received prior to the correction (about 2,400 orders, affecting 316,000 Illinois customers) would have delivered incorrect Estimated Restoration Time information to customers.[117]

Additionally, during both storms, callers may have received expired Estimated Restoration Times, as the Interactive Voice Response was relaying all available estimated times, even if they had expired.

Ameren formed a team in January 2007 because of a Missouri Public Service Commission report and internal storm critiques to investigate the process for providing Estimated Restoration Times and to identify potential improvements.[118] The goal was to have a process to develop a geographical Estimated Restoration Time based on an initial assessment of storm damage and use those data to provide meaningful information to customers.

Because of the work by this team, Ameren formalized the process for developing area-wide estimated restoration times.[119] It is now the responsibility of the Operating Department as part of the activities of the Emergency Operation Center (EOC) to update manually Estimated Restoration Times. Damage assessment will generally take place within the first 24 hours of the

[113] Responses to Data Requests #89-#91.
[114] Response to Data Request #267.
[115] Response to Data Request #604.
[116] Response to Data Request #206.
[117] Response to Data Request #267.
[118] Response to Data Request #8-D and #574.
[119] Response to Data Request #89 – 91-B.

storm. Appropriate field personnel will complete the "ERT Template" available on the "Storm Info" SharePoint site to indicate estimated times for restoration based on their assessment. They will designate these estimates at the operating center level.

Designated members of the Emergency Operations Center will populate a particular screen on the Outage Analysis System with the restoration-time template data. Corporate Communications and Contact Center management can then expect that the Emergency Operations Center will complete the first update after the first 24 hours. Ameren-IL will repeat this process each succeeding 24-hour period in order to provide Estimated Restoration Time updates by order type and operating center.[120] However, any new trouble orders arriving after these updates will not have an ERT assignment.

In addition, the team specified a process to produce job-specific Estimated Restoration Time updates. It created handouts to stress the importance of the updates to Ameren field employees who dispatch mutual assistance and contractor crews, and to the outside crews themselves. In addition, Ameren created a "learning moment" presentation for its field operations employees.[121]

Ameren's revised area-wide Estimated Restoration Time process may still not be timely enough for customers. Analysis of an August 2007 storm revealed that the storm center updated area-wide estimated times manually at three points during the storm—a limited update at 7 a.m. (not the bulk of the customers affected), and two others at 2 p.m. and 4 p.m. However, it appears that the two afternoon updates were not timely enough to meet the peak customer-contact period for the storm, which was from 9 a.m. to noon. Since the storm occurred in the early hours on August 13, the majority of customers contacted the company when they awoke to no power. Since Ameren did not update the estimated times until later that afternoon, the bulk of customers did not receive any Estimated Restoration Times.[122]

Aside from surveying other utilities about their Estimated Restoration Time process, Ameren has not conducted any studies or analysis on the accuracy or appropriateness of the default estimates provided by OAS.[123]

c. Interruption Reporting

The Outage Analysis System is Ameren's primary interruption reporting system. The collection process for interruption primarily starts with a customer call and ends with the close out of outage records by Ameren field personnel through mobile data terminals during non-storm periods. During storms, Ameren office support personnel primarily close interruption records.

The overall outage management and interruption reporting schema is well structured. Relational tables organize the data for efficiency. Unique outage order numbering is the cornerstone of its referential integrity. The system has robust capacity to handle large data volumes during storm periods. Data input quality is dependent on data entry at the outage start and end, however

[120] Response to Data Request #574.
[121] Response to Data Request #574.
[122] Response to Data Request #447-B.
[123] Response to Data Request #573.

several "edit-check" features exist within the database to preclude the omission of key data fields at closeout.

The Outage Analysis System includes a pseudo-connectivity and analysis model that relates customers to transformers, transformers to protective devices, and devices to circuits. The model is hierarchical and based on the assumption of a single failure. During storms the system cannot distinguish multiple or nested failures that can occur in widespread severe weather. These limitations are common with a system of this vintage. Additional limitations include the lag time by personnel (~1 day in most Ameren service areas) to update OAS outage status. Given the design of the system, updating the system to reflect temporary field switching changes in the connectivity model is virtually precluded. This results in inaccuracies on OAS orders as they do not always reflect the correct outage device or correct customer affected count in these instances.

The Outage Analysis System supports several interruption reporting and extraction formats. In general, when reviewing Outage Analysis System summary data, one must understand the basis of the summary totals for transparent interpretation, *e.g.*, the Order Type inclusion and the duration of the summing interval. For example, summaries of the 2006 storms provided externally by Ameren and used in this report contain customer totals based on hourly intervals compared to the entire storm interval. Other summaries refer to "unique customer interruptions," *i.e.*, it counts a customer only once, despite several interruptions throughout the storm restoration.

d. Outage Information Data Integrity

During normal day-to-day operations, the Outage Analysis System automatically creates an Estimated Restoration Time (ERT) when it receives a trouble order. Dispatchers in each of Ameren-IL's Distribution Dispatch Operation Centers then assign orders to a troubleman. The troubleman or dispatcher may or may not update the ERT, depending on the circumstances found in the field. After completion of the trouble order in the field, the troubleman uses a Mobile Data Terminal (MDT) to record the completed order information in the Outage Analysis System, or calls in the order completion information that the dispatcher then records.[124] An automated call-back occurs through the Interactive Voice Response to confirm service restoration.

A third-party vendor, Stericycle, places Ameren's outbound restoration calls between the hours of 7 a.m. and 10 p.m. Central time.[125] Ameren programmed the system to call customers when the Outage Analysis System has recorded a closing of any outage with a device higher than a Single Outage or Transformer Outage.[126] Customers who indicate they are still without power generate a report back into the Outage Analysis System for dispatcher review and assignment.

This process changes significantly during large outage events, such as the July and November 2006 storms. During large storms, Field Superintendents assume the responsibility for dispatching trouble orders to field crews, who perform the bulk of the restoration. Field crews do not use the Outage Analysis System to accomplish their work. However, they rely on the Outage

[124] Interview #102, November 15, 2007.
[125] Response to Data Request #102.
[126] Response to Data Request #435.

Analysis System during large storms and outages. As a result, many are not as familiar with the Outage Analysis System as dispatchers and troublemen.

When Ameren disables auto-calculate estimated times during a large outage, the Outage Analysis System is dependent on the field forces to provide accurate and timely Estimated Restoration Times. However, because of the limited access to the Outage Analysis System by field crews, timely and properly closure of many of the orders does not occur. This was a problem during both 2006 storms. What actually happened was the order assignment and closure did not occur in real time, but rather at the end of the evening to close orders for that day. Often, orders closed past the 10 p.m. call-back cut-off time and did not receive a scheduled call-back. As a result, the automatic call-back process was less effective.

Issues related to the 2006 storms and Outage Analysis System updating and use in the field were:[127]

- Not all field crews had access to mobile data terminals or air-card equipped laptops. Some of the Outage Analysis System updating occurred at the end of the day when crews checked out to get rest. Outage Analysis System updates came from paperwork turned in by field crews.
- Not all field supervisors had laptops with air cards resulting in delays in updating Outage Analysis System data.
- Not all "crew guides" had access to mobile data terminals or air card equipped laptops resulting in delays in Outage Analysis System updates. Crew guides are responsible for updating Outage Analysis System with crew assignments and order completion information.
- The Field Supervisors' priority was restoring service, not completing, and updating Outage Analysis System orders.
- Field employees did not update OAS device outages with the identification of the actual device found in the field to be malfunctioning. For example, if the OAS system had predicted a feeder outage but ground-truth observation revealed that a downstream recloser caused the outage, that information was not reflected in the OAS system.
- There were delays in completing feeder outages until restoration of all the group outages to ensure that the feeder outage would not come back in the Outage Analysis System. This problem related to the rules that assign orders to devices and how grouped orders are rolled-up to devices. Closing out a feeder outage before closing all the associated grouped outages linked to this feeder could initiate a new feeder trouble order in OAS. As a workaround, dispatchers were leaving feeder orders open until they could close all linked orders. This resulted in longer restoration times in OAS for these individual feeders.
- During the November 2006 storm, weather conditions delayed damage assessment and the timely update of information in Outage Analysis System.

Ameren-IL's own critique of the November 2006 storm summarized these Outage Analysis System issues and challenges:[128]

[127] Response to Data Request #155.
[128] Response to Data Request #8-D.

> *…discussed the need to use OAS as our sole method of managing the work, and of doing so in a "real-time" fashion. We can't revert back to a paper system when the workload gets heavy, and we can't operate on OAS in a "batch mode". If we do so, it slows down the restoration process in a number of ways.*

The Division V Ice Storm Critique contained a similar finding:[129]

> *OAS not being utilized to managed storm restoration efforts:*
> *- OAS orders being closed at the end of the day versus real time as the crew makes repairs.*
> *- OAS being closed after 10:00PM when customer callbacks are not being made*
> *- Partial outages not being used to clean up OAS*
> *- Using the "C" and "D" Buckets for managing work*
> *- Leaving Feeder Outages (FO) on the "D" screen and only DDO can close them out.*

An action item resulting from this critique suggested additional OAS training for the division leadership team.

Other Outage Analysis System design considerations potentially compromise data integrity, especially during storms. For instance, the Outage Analysis System does not group emergency orders such as gas leaks or wire downs. During a large event, customers can call in repeatedly to report a wire down. In some cases, it is not possible to assign an order to a location or premise. Consequently, this can lead to multiple wire-down orders on the same device, and duplication of wire-down orders. These types of orders have to be resolved one-by-one. During both storms, Ameren-IL faced many of these orders.

The Outage Analysis System data integrity affects self-service inquiries through the Interactive Voice Response and Internet, press releases, regulatory updates, as well as call center communications with customers calling in. The delay can be substantial, enough so that the media has challenged the numbers.[130]

July 2006 Storm Specific Outage Analysis System Issues

During the July 2006 storm, Ameren's Information Technology automatically restored 590 Outage Analysis System orders on July 23, 2006. These "data repairs" closed out Outage Analysis System orders that the field assumed someone had repaired. The field was sweeping entire circuits with crews, repairing as they went. However, they did not close associated Outage Analysis System orders as they performed the work.[131] Ameren-IL made the decision to mass-close orders and then hope customers would call back if they still had no power.[132] While mass closing of orders might help Ameren-IL "catch up," it challenged the integrity of the Outage Analysis System data. Someone should close out orders individually as field forces work them.

[129] Response to Data Request #8-F.
[130] Response to Data Request #447, Attachment-B.
[131] Response to Data Request #579.
[132] Interview #102, November 15, 2007.

According to Ameren, this was the only time that Outage Analysis System orders were "automatically restored."[133]

According to Ameren-IL, since the July 2006 storms occurred shortly after Ameren-IP transitioned to the Outage Analysis System, it felt the opportunity existed for inaccurate data, both from employees using a new system and because of the tremendous volume of outages. It took several steps to review and clean up the Outage Analysis System data including[134]:

- Decatur Distribution Dispatch Office reviewed transmission and sub-transmission outages to make sure outage data reflected them correctly.
- Reliability Programs and Division personnel reviewed outages that affected entire circuits.
- Reliability Programs and Division personnel also reviewed several smaller outages to reduce the amount of potential overlap in the number of customer affected.

This clean-up process put the most focus on the largest outages that affected the most customers and worked down to lower impact outages. Ameren-IL conducted this effort in November 2006 and it was still underway when the November 30, 2006, storm hit. As a result, Ameren-IL never completed this clean-up effort. Due to the November 2006 storm occurring near the end of the year, Ameren-IL did not coordinate any high-level "clean up" effort for the storm. However, Distribution Dispatch Office and local area personnel performed additional review of outage data for both storms as part of ongoing efforts.[135]

November 2006 Storm Specific Outage Analysis System Issues

On December 1, 2006, the Outage Analysis System did not process 45,867 "lights out" trouble orders from Stericycle because the Outage Analysis System considered them "stale." Stericycle is Ameren's high-volume outage reporting service provider. Initiated by Ameren's mainframe job scheduler, the Stericycle process runs every six minutes to processing incoming outage tickets. However, for reasons unknown, the job scheduler put this job on hold on November 27, 2006. Consequently, the Stericycle process was not running during the first hours of the November/December Storm. Ameren's Outage Analysis System support discovered the job in the hold status at 3:16 a.m. on December 1, 2006, and restarted the transaction; however, the 45,867 lights-out calls received by Stericycle went unprocessed because they were older than one hour.[136]

Ameren recently found the root cause of the Stericycle transaction stoppage. The Stericycle process will not invoke if the job scheduler attempts to start the process exactly at midnight (system time 00:00:00). To rectify this problem going forward, Ameren instituted a daily manual process to check the status of the transaction. Additionally, Ameren-IL added these transactions to the Outage Analysis System Storm Checklist for monitoring during all future storms. Ameren scheduled a system code change for the second quarter 2008 to prohibit the job scheduling at midnight.[137]

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[133] Response to Data Request #580.
[134] Response to Data Request 581.
[135] Response to Data Request 581.
[136] Response to Data Request #225, Attachment-B.
[137] Response to Data Request #647.

This oversight resulted in 45,867 customer-reported lights-out discarded calls—these calls generated no Outage Analysis System trouble orders (includes both Missouri and Illinois customers). As this occurred early in the November/ December 2006 storm, Ameren lost a significant level of outage information at a point when gathering outage information is critical in establishing or confirming the storm's "footprint" or scope. Because the outage system does not require all affected customers to call in order to predict outage impact, there is a possibility that the system may have predicted some of these outages even though the calls were discarded. However, any of the 45,867 customers calling back to check on the outage that they previously reported would have been told that Ameren had no record of their outage. If the loss of outage intelligence was not significant enough, Ameren certainly experienced a loss in credibility from these customers.

Even more disturbing, Stericycle was experiencing extremely high call volumes at this point in the storm and the volume exceeded Stericycle's capacity to answer calls. Subsequently 61 percent of Ameren-IP callers received busy signals when attempting to log their outage on November 30, 2006.[138] Not only were many Illinois customers unable to reach Ameren to report the outage, Ameren discarded outage intelligence from 45,867 of 48,000 calls that were successfully logged by Stericycle at this point in the storm (40 percent of which were Ameren-IP outage tickets).[139]

In total, these discarded lights-out orders represent 25 percent of the total lights-out orders received by Stericycle during the entire storm (for all customers).[140]

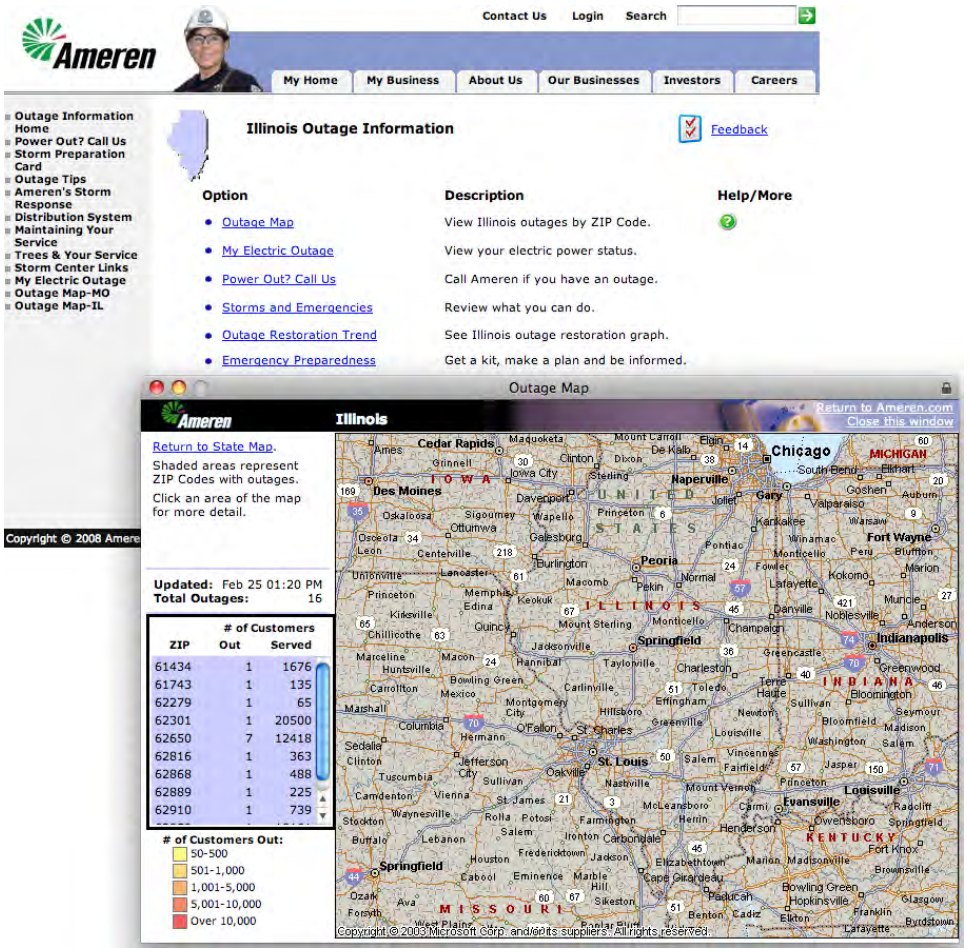
Another issue appeared during the November/December 2006 storm that created confusion for dispatchers and field employees working with Outage Analysis System. When this problem was occurring, certain dispatched outage orders were incorrectly showing assignment to one specific crew (XE16) as well as the actual crews assigned to work the orders. The problem occurred most prevalently on December 6, 2006, affecting about 100 Ameren-IL trouble orders. Ameren implemented a temporary repair on December 6 and continued to monitor for reoccurrence. Ameren made a permanent modification to Outage Analysis System in May 2007 to correct this problem.[141]

The Outage Analysis System data collection process does not have formal Quality Assurance or Quality Control. While there was some information checking following the July 2006 storm, this effort was not comprehensive nor did Ameren conduct this level of review following the November/December 2006 storm. In addition, there was no formal data lockdown process to safeguard the data from deletion or modification. Ameren needs formal processes to protect data integrity and ensure repeatable results retrospectively.

[138] Response to Data Request #327, Attachment-J2.
[139] Response to Data Request #327, Attachment-I.
[140] Response to Data Request #327, Attachment-I.
[141] Response to Data Request #263.

e. Communicating Outage Information

Ameren has leveraged its public website to provide outage-related information to customers and website visitors through its Storm Center. Customers can review general information on Ameren's storm response, emergency preparedness, and tree trimming procedures, access key weather and emergency assistance sites, and find out what number to call to report an outage. The figure below provides a sample from the website, including the outage mapping application.[142]



[142] Ameren.com

Ameren introduced outage maps to its website in May 2005.[143] In June 2005, Ameren formed the Customer Centered Business Initiative team to address customer satisfaction, with a goal of driving business initiatives to improve overall customer satisfaction. A spin-off of the team was an effort to improve customer outage communications led by an Outage Communications team. This team meets regularly to review customer feedback and website activity and discuss improvement efforts.[144]

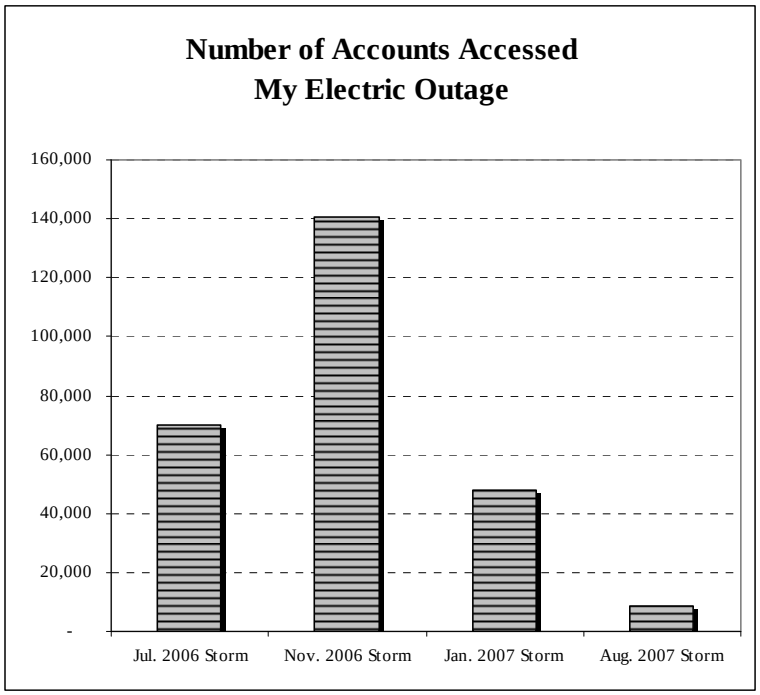
In the spring of 2007, Ameren enhanced Outage Mapping to provide more detail mapping by zip code and offering area-based pop-up alerts. It extracts Outage Analysis System information every 10 minutes to produce zip code-based outage maps available to any website visitor. Users can assign alerts or special messages to specific zip codes providing the capability for a more customized message.

In response to requests for restoration progress information, Ameren introduced Outage Trending to its website in early 2007.[145] With this feature, any visitor can view the last eight days of outage volume in each state, county or specific zip code location.

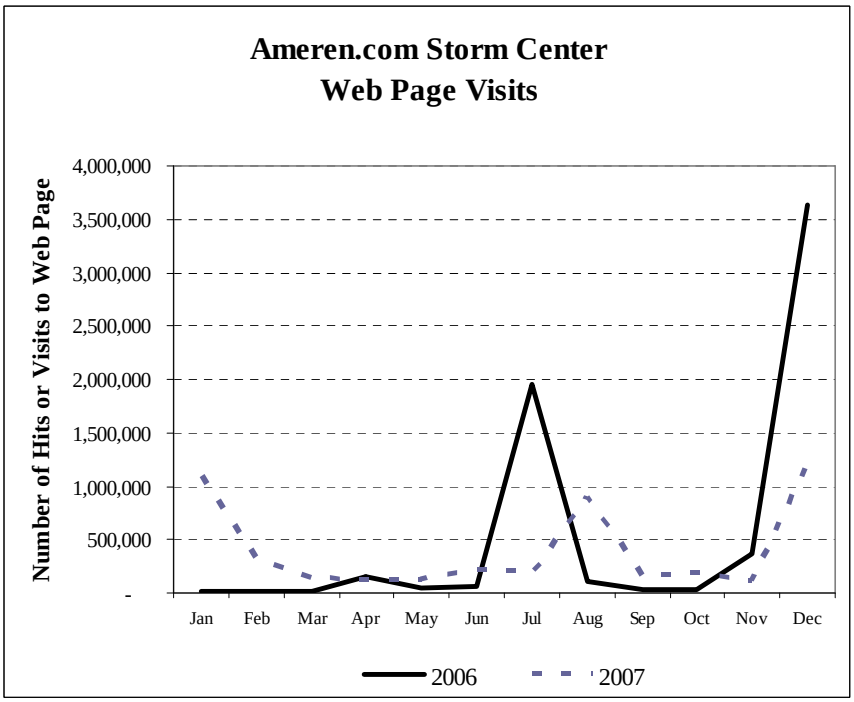
Ameren introduced My Electric Outage to its customers through the website on May 16, 2006.[146] Using My Electric Outage, customers can check on the status of their outage, review available restoration time information, and review outage cause. This information is available for up to 48 hours following the completion of the outage. Customers wishing to use My Electric Outage must establish a web account and password through Ameren. In 2007, Ameren modified this feature so that a customer can obtain outage information without an account, simply by entering a valid telephone number.

The chart below details the number of account accesses to My Electric Outage service during the 2006 and 2007 storms.[147] A significant number of customers in both Illinois and Missouri accessed the site during both 2006 storms, especially considering that a log-on and password was prerequisite to obtaining storm information.

[143] Response to Data Request #447.
[144] Response to Data Request #447.
[145] Response to Data Request #447-A.
[146] Responses to Data Requests #89-#91.
[147] Response to Data Request #578.



The chart below details the number of Storm Center website visits during 2006 and 2007. The peaks in the chart indicate significant website activity during the July and November 2006 storms. Ameren's Storm Center experienced nearly 2 million visits in the July 2006 storm and 3.6 million visits during the November 2006 storm. Visits to the Storm Center also peaked during January, August, and December 2007.[148]



[148] Response to Data Request #577.

However, Ameren.com did not hold up to the high volumes accessing the site during the July 2006 storm. At 8:30 a.m. on July 20, the web and Outage Map server locked up, rendering Ameren.com inaccessible (visitors received a server error message). Ameren found an interim solution later that afternoon at approximately 3 p.m. to make the site once again accessible. The true effect on web visitors is indeterminable; however, extrapolation of daily hit statistics suggests that the problem prevented as many as 100,000 hits.[149]

Ameren designed the Ameren.com website without redundancy or load balancing. When the increased web traffic exceeded the server's capacity, the server failed, bringing the corporate website down. In the spring of 2007, Ameren moved Ameren.com to a high-availability, fault-tolerant environment providing automatic failover and load balancing. Ameren has had no issues since it moved to this new configuration.[150]

f. Best Practices

This section addresses elements of the Ameren's Outage Communications that Liberty recognized as a utility "best practice" or practices that proved to be especially effective.

Based on its review, Liberty identified as an industry best practice:

- Ameren has integrated mobile computing with the Outage Analysis System to allow mobile update and interaction.
- Ameren has integrated mapping software with the Outage Analysis System to provide a more intuitive and visual analytical outage restoration tool although the tool has significant limitations in production mode.
- Ameren's ability to provide customer-specific estimated restoration times and storm status, through the call center, Interactive Voice Response, and web site during normal operations (not during a large storm).
- Ameren's deployment of the Ameren.com Storm Center, an interactive Internet website that provides general outage information, outage mapping, outage trending, and customer-specific outage restoration status.

Liberty also notes that Ameren has opportunities to adopt the following important best practices:

- Ability to offer early Estimated Restoration Times immediately to customers based on storm modeling and historical storm restoration performance. (Recommendations IV-21 and IV-22)
- Ability to provide area specific and customer-specific estimated restoration times and restoration status information through the call center, Interactive Voice Response, and web site during large storms or outages. (Recommendation IV-21 and IV-22)
- Proactively contacting critical care customers to warn of an upcoming storm or after a major storm to inform customers of the location of nearby shelters, telephone numbers where they can obtain help, the importance of making appropriate outage plans, the

[149] Response to Data Request #262.
[150] Response to Data Request #209.

progress of service restoration efforts, and other information relevant to the customer's situation. (Recommendation IV-20)

- Deployment of an interactive self-service outage reporting capability on the company web site. (Recommendation IV-19)
- A more intuitive user interface to streamline and simplify updating of Outage Analysis System data, especially in the field and during large outage events. (Recommendation IV-18)
- Deployment of additional mobile computing technology to restoration crews and other employees in storm roles during large outage events or enhancement of the data collection process through other means. (Recommendation IV-17)

The use of the above outage communications "best practices" combined with Ameren's implementation of Liberty's recommendations will further improve the company's outage communications and ultimately, improve customer satisfaction.

4. Conclusions

1. Ameren does not have a formal Quality Assurance or Quality Control process to ensure Outage Analysis System data integrity. (Recommendation IV-14)

The Outage Analysis System data collection process does not have formal Quality Assurance or Quality Control. While Ameren conducted some information checking following the July 2006 storm, this effort was not comprehensive nor did it conduct this level of review following the November 2006 storm. In addition, there is no formal data lockdown process to safeguard the data from deletion or modification. Ameren needs formal processes to protect data integrity and ensure repeatable results retrospectively. Additionally, Ameren must hold field employees accountable for Outage Analysis System data during large outage events.

2. Many Ameren-IL employees were not appropriately trained or equipped to use the Outage Analysis System as it was intended during the 2006 storms, possibly slowing restoration and compromising data integrity. (Recommendation IV-15)

While the Outage Analysis System was operational during both storms, Ameren-IL did not use it as intended. To a large degree, this was due to a lack of experience with the system, primarily in the Ameren-IP territories. This was understandable, considering that Ameren-IP employees had been operating on an entirely different outage management system up until October 2005. While employees had received initial training, none had experience with the Outage Analysis System in a storm situation. Many of the field employees were just not familiar with the system. The addition of foreign crews made it more challenging to update the Outage Analysis System with status and completion information.

The system provides the capabilities to support the storm restoration process if personnel collect and enter the data appropriately.

3. Ameren continues to enhance and improve the Outage Analysis System in response to storm critiques and user requests. (Recommendation IV-16)

Ameren has initiated a number of Outage Analysis System improvement projects since the 2006 storms to improve Outage Analysis System performance, order grouping, and analysis. Ameren should continue with these efforts to reduce the potential for duplicate orders, incorrect data, and inaccuracies in the number of affected customers. This should be a continual process until Ameren eventually replaces the Outage Analysis System.

Ameren should investigate the potential for adding a more user-friendly front-end to the Outage Analysis System to make it easier for field forces to interact and provide critical storm restoration data. This front-end should also simplify the partial restoration process and make it easier and more intuitive for infrequent users to correct the outaged device on an order.

4. Ameren's Storm Center website is rich in outage information and provides an interactive self-service tool for customer-specific outage information. (Recommendation IV-17)

Ameren's Storm Center website has evolved into an interactive, self-service tool rich in outage information for customers and other interested stakeholders. The site experienced significant usage during both 2006 storms. While the site failed for several hours during the July 2006 storm, Ameren has since corrected the design of the website, building in redundancy and load balancing. Since Ameren implemented these changes, the site has operated without any significant problems.

5. Ameren did not identify critical customers in Outage Analysis System prior to the July and December 2006 storms. (Recommendation IV-18)

Ameren failed to identify "critical customers" in the Outage Analysis System prior to the July or November storms. As a result, each division had to identify and prioritize critical customers on their own as the storm progressed.

Ameren has since created a new application that provides a list of critical customers in Outage Analysis System by circuit, based on SIC (Standard Industry Classification) codes. Ameren has identified Health Care / Life Quality facilities, First Responder Agencies, Critical Social Infrastructure, and Emergency Shelter Sites. A Critical Customer List is available by Division, SIC, and Priority that specifies the customer name, SIC, City, Address, Feeder, and Transformer. Another list details any out-of-service Critical Customers, specifying address, Outage Analysis System order #, ERT, and other trouble ticket information. Division personnel are responsible for keeping the Critical Care information up-to-date.[151]

[151] Response to Data Request #547.

6. Ameren's outage management and interruption reporting schema is well structured.

Relational tables organize the data for efficiency. Unique outage order numbering is the cornerstone of its referential integrity. The system has robust capacity to handle large data volumes during storm periods. Data input quality is dependent on data entry at the outage start and end, however several "edit-check" features exist within the database to preclude the omission of key data fields at closeout.

7. Ameren did not provide Estimated Restoration Times (ERTs) nor did it have a process in place to gather and update ERTs during the 2006 storms. (Recommendations IV-19 and IV-20)

The Outage Analysis System turned off the Estimated Restoration Time prediction component to delay providing Estimated Restoration Times until company resources could complete a full damage assessment of the outage. However, Ameren did not provide any area-specific Estimated Restoration Time updates during either 2006 storm.

The lack of Estimated Restoration Times and an ambiguous message was very frustrating for customers and call center agents trying to be responsive to customer inquiries. The lack of storm and restoration information aggravated the capacity constraints of the call center.

5. Recommendations

IV-14 Develop a quality assurance and review process to ensure Outage Analysis System data integrity.

Ameren needs to ensure the quality of Outage Analysis System data. Ameren performed some information checking following the July 2006 storm, but this effort was not comprehensive. It did not check data quality following the November 2006 storm. Ameren needs a means to safeguard the data from deletion or modification such as a secure historical data warehouse that maintains periodic (monthly) downloads of customers/circuit relationships to establish a history of these data. Retrospective results taken from Outage Analysis System data should be repeatable. Ameren must hold field personnel accountable for Outage Analysis System data during large outage events.

Ameren-IL is in the process of developing a formal process with defined roles and responsibilities for Outage Analysis System Quality Assurance and Quality Control (QA/QC).[152] This is a step in the right direction. Ameren-IL should continue pursuing a quality process to improve Outage Analysis System data integrity, including:

- Define the QA/QC goals and objectives
- Define the day-to-day QA/QC process
- Detail major storm QA/QC process
- Identify QA/QC process roles
- Assign responsibility to QA/QC roles, day-to-day and during storms

[152] Response to Data Request #581.

Ameren-IL should define this process within six months and implement these specific steps within twelve months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-15 Implement a multi-tiered process to ensure real-time updates of information into the outage system.

During large outage events, Ameren should equip its field forces with mobile data terminals or laptops that can communicate and interact with the Outage Analysis System or develop a real-time process wherein outage information is communicated from the field to a skilled OAS user in a dispatch office, operating center, or other location using cellular telephone, radio, or other communications device. This will improve the likelihood that Outage Analysis System trouble order data is updated in a timely manner. It will also eliminate a lot of paper.

Ameren instituted annual refresher storm training for employees. Ameren-IL should review its training for effectiveness after each major storm and incorporate any future lessons learned.

Ameren-IL should complete the implementation of this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-16 Enhance the Outage Analysis System with a user-friendly front-end to make it easier for field forces to interact and update storm critical data.

Ameren should investigate the potential for adding a more user-friendly front-end to the Outage Analysis System to make it easier for field forces to interact and provide critical storm restoration data. Ease of use will encourage better updating of data in the field, especially among infrequent users. These changes should also improve the partial restoration process and the ability to resolve nested outages for infrequent users. If system limitations prevent the addition of a more effective means for field forces to interact with the Outage Analysis System, Ameren-IL should implement more intense training for field forces.

In comments on the draft report, Ameren-IL indicated that it is considering the purchase of a **D**istribution **M**anagement **S**ystem (DMS) that would include a replacement outage analysis system. Ameren-IL should either implement a more friendly front-end on the current OAS system within twenty-four months or demonstrate plans for the implementation a DMS system within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-17 Continue to enhance and improve the Storm Center website and provide the option for self-reporting outages.

Customers clearly are coming to the Storm Center for information during large storm events. Ameren should continue to enhance the Storm Center website to make the site more functional for customers wishing to report their outage. With the growth in mobile devices, web-capable

phones, and Wi-Fi networks, customers have many more opportunities to access Ameren's website during a power outage. Ameren-IL should develop and deploy a self-service, web-based outage-reporting tool on its Storm Center website. Adding a self-reporting feature will provide another way to interact with the company, increasing customer satisfaction, and possibly reducing call volumes. Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-18 Expand efforts with Level One (Health Care / Life Quality) critical care customers to proactively contact these customers prior to planned outages and as soon as possible after unplanned outages when the emergency response plan is activated.

Ameren-IL should adopt a policy of contacting "critical care customers" prior to all planned outages. During a major storm, Ameren-IL should contact critical care customers at the earliest time it knows the effect and extent of the storm to encourage them to make alternative shelter arrangements. Ameren-IL should also seek customer feedback to determine the most effective means of contacting critical care customers.

Ameren-IL should implement this recommendation within twelve months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-19 Develop an "early" area-specific Estimated Restoration Time to set customer expectations and update Estimated Restoration Times as Ameren-IL learns more about the outage.

Due to the sensitivity relating to the lack of available outage information during the 2006 storms and the difficulties providing timely area-specific estimated times during the August 2007 storm, Ameren-IL should now make a concerted effort to develop an early Estimated Restoration Time, or "Smart ERT," which it can use initially during a large-scale outage. Ameren-IL would build the Smart ERT ahead of time, based on historical restoration performance, and adjusted by storm modeling predictions. The purpose is to present a "best guess" based on all known factors going into a storm so that customers can have an initial, realistic expectation of how the storm will affect their specific area. Ameren-IL can then modify this "best guess" as necessary as it learns more about the specifics of the outage.

Because it relies on predictive methods, Ameren-IL can continue to enhance and improve the Smart ERT process as Ameren-IL employs it. Ameren-IL should create a review and evaluation process to compare estimates to actual for the purpose of improving future estimates.

Ameren-IL should formalize the Smart ERT process in the Electric Emergency Restoration Plan (EERP), including the establishment of an overall Estimated Restoration Time Coordinator and Estimated Restoration Time Monitors within each division. The Coordinator should be responsible for monitoring storm conditions, outage and restoration progress, estimating outage duration, and ensuring that Ameren-IL posts up-to-date restoration times in a timely manner. The

Monitors should be responsible for continual posting, monitoring, and revision of customer restoration messaging for specific restoration nodes during a major storm.

The establishment of an Estimated Restoration Time Coordinator in the Emergency Electric Restoration Plan formalizes the process during a large outage event as well as assigns accountability. The process itself manages the development of the early Estimated Restoration Time and monitors in-progress Estimated Restoration Times to ensure better accuracy and ultimately, better information for customers.

Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-20 Develop specific, measurable goals and objectives for improving the accuracy and timeliness of outage related information provided to its constituents.

Ameren-IL will undoubtedly experience additional outages in the future and should develop goals and objectives to improve the accuracy of estimated restoration times. Ameren should begin measuring and tracking the accuracy of Estimated Restoration Times (ERTs) as compared to actual restoration time, both on a day-to-day basis and during major outage events.

Ameren-IL should revise outage communication procedures to provide more emphasis on the importance of providing accurate and timely estimates to customers, building upon the "learning moment" that was developed after the 2006 storms. Procedures should include documenting the Estimated Restoration Time originally provided to customers as well as a requirement to provide on-line an updated estimate prior to expiration of any existing estimate. It should offer an explanation to the customer if the estimate changes. During each outage, Ameren should record a complete history of Estimated Restoration Times given to each customer.

Finally, Ameren-IL should implement goals to communicate better with constituents in the aftermath of outages. It should analyze customer complaints to determine whether it is making improvements regarding estimated restoration times. Debriefing sessions should be held with all involved employees, including crews, customer service representatives, and communications personnel. The Company should also hold meetings with city and town officials, other government agencies, and the media.

Ameren-IL should implement this recommendation within two years of the date of this report.

E. Communications

1. Objectives

This section of the report provides a description and evaluation of Ameren-IL's event communications and performance of its call centers. Liberty's focus was on the performance of these systems and processes during the 2006 storms. However, Liberty also examined the modifications or enhancements made since the storms. Liberty's objectives were to:

- Examine whether Ameren demonstrated the ability to communicate effectively with customers and other stakeholders. This includes examining call center staffing and determining whether the performance of these centers was effective and efficient.
- Determine whether customers could reach the utility during the storms to report outages.
- Determine whether Ameren-IL kept key stakeholders informed during the storms.
- Determine whether Ameren-IL communicated effectively with the public with regard to matters that may have contributed to the length of restoration times or that dealt with public safety.
- Determine how Ameren-IL employed industry "best practices."
- Identify any areas that might be suitable for adoption of industry "best practices."

This section addresses items **2.3.2.5.27** and **2.3.2.5.28** from the Illinois Commerce Commission's Request for Proposals.

2. Background

When the power goes out, most customers pick up the phone and call their electric utility. It is a natural response. All customers want answers to the same questions: Does the utility know the power is out? What caused the outage? When will the utility restore power? Storms present unique challenges for utility customer service. Many customers can simultaneously lose power, causing a flood of calls to the utility. The bigger the storm in terms of customers affected, the higher the number of customers trying to contact the company.

This is a challenge common to the electric utility industry—how can utilities effectively respond to a sudden extreme and often extended peak in call volume associated with a storm or outage. Solutions have evolved over the years, with the development of various technologies and service providers. Most utilities have embraced the use of Interactive Voice Response (IVR) technology to offer self-service outage reporting and status updates via telephone. However, the number of calls can exceed in-house capacity quickly during a large outage. After-hours outages can be especially challenging to capacity as more customers are at home and fewer agents are on-hand to answer calls.

Generally, it is cost prohibitive to configure an in-house IVR system large enough to handle the largest spike in call volume. Attempting to staff a call center, or to outsource to a center large enough to handle these calls, also is cost prohibitive. A more economical approach is to outsource or offload overflow to a third party IVR when call volumes are threatening to exceed capacity—effectively renting capacity as needed. Many large investor-owned electric utilities in the United States have adopted this approach, contracting with a high volume outage handling IVR service to handle overflow.

Either by choice or by default, utilities have adopted three basic approaches to "peak" call handling:

1. Block calls (busy signal to customers) to a manageable level (within the capacity of call center staff and IVR system).

2. Provide an upfront "message" to many callers; immediately terminate the call or let queue limitations in the IVR or agent-queue force callers to "choose" to abandon if hold times become too long.
3. Let all customers who call or otherwise contact the company (website) notify the company of an emergency, report an outage, or inquire about restoration status, with the help of self-service technology (IVR / Web).

The industry best practice is option 3—let as many callers as necessary into your system to self-report outages and to offer customer-specific outage status messaging. Until distribution automation eliminates the need, this is the best option for customers and offers the highest satisfaction.

In addition to responding to customer inquiries and outage notification calls, utilities must be prepared to communicate storm restoration status to the general public as well as local and state officials and community leaders.

One of the most vital functions of a utility's Corporate Communications Department during a major storm is to make sure that all employees present the same information about storm restoration to their contacts outside the company. In addition, it must effectively disseminate storm restoration status information to stakeholders—state and local government officials, large industrial customers, the media, employees, and customers. The goal is to deliver the same message to the press, mayors, legislators, city officials, and the next customer calling into the call center.

To manage and disseminate information effectively, Corporate Communications must work closely with the Emergency Operations Center (EOC) to gather information on storm restoration progress, the number of customers out of power, and projected restoration times. Ultimately, the outage management system is the repository and source for this information. It effectively links the field with other areas of the company to manage the restoration effort and communicate progress.

An effective strategy is to time storm restoration progress-reports for release around the local news media cycles, early morning, noon, 5 p.m., and 10 p.m., so the media can feature the reports on local radio and television newscasts. Equally important is the need to coordinate with operations prior to each release so the numbers are fresh and accurate. Concurrently, call center representatives and other key employees working with community and public officials, key accounts, and state emergency agencies can receive this same message.

Community Relations is another key utility function during a major storm, especially keeping state and local officials informed. This role usually falls to community relations officials, quite often filled by district or division management. No one knows their communities better than the people who work in them day-in and day-out.

Before a storm even starts, community relations officials begin contacting elected officials, community leaders, and key customers to start the flow of communication. During the storm, the community relations officials can assist local emergency and other governmental agencies by

providing critical infrastructure information, offering restoration progress updates, and redirecting resources to address emergency issues and community priorities.

On an ongoing basis, it is important to play an educational role in communities regarding storm restoration. An excellent way to involve the community and open the lines of communication between local officials and the company is to host community workshops promoting storm response awareness. These forums also provide an opportunity for the utility to gather feedback and learn expectations. To be effective at community relations, utilities need to emphasize training for community relations representatives and other employees actively interfacing with the community and public. Training should familiarize employees with sources of outage information and with how best to interact with the public, governmental officials, and community leaders.

3. Findings and Analysis

This section contains the primary findings, analysis, and detailed descriptions of the systems and processes that supported outage communications at Ameren-IL during the 2006 storms. Liberty organized this section to address the following:

a. Customer Call Center Operations
b. Corporate Communications
c. Community Relations
d. Best Practices

a. Customer Call Center Operations

Ameren-IL's Customer Service organization reports to the vice president of Customer Service and Public Relations, who reports directly to the president and chief executive officer of Ameren-IL. During 2006, the manager of Customer Service led Ameren-IL's Customer Service organization. In September 2007, Ameren elevated this position to vice president and pulled the responsibility of Illinois Public Relations into the Ameren-IL Customer Service & Public Relations organization. Ameren intended this change to increase the focus of the organization on better serving the needs of Illinois customers and various other stakeholders.[153]

Call Center Technologies & Telecommunications

Ameren has five main call centers located in St Louis, Jefferson City, Decatur, Peoria, and Pawnee, with telecommunications hardware co-located at each center. Ameren configured the call centers to operate as a single virtual unit off a single Avaya Communication Manager PBX.[154] A primary server cluster is in the St. Louis General Office Building and a backup server cluster is located in Decatur. Gateway servers are in Peoria, Pawnee, and Jefferson City.[155]

[153] Response to Data Request #103.
[154] PBX means "Private Branch Exchange," a private telephone switchboard.
[155] Responses to Data Requests #204 and #189.

Three production Avaya IVRs (Interactive Voice Response) are in the St. Louis General Office Building location that supports all call centers. To support the call centers, there are 597 trunks[156] for all companies for inbound traffic.[157] An additional two production Avaya IVRs are in Decatur. There are 238 trunks for Union Electric and Illinois companies in Decatur. Additionally, the outsourcer First Contact connects to Ameren's call center telephony through trunks in both Decatur and St. Louis.[158] Peoria's call center configuration has 117 total trunks while Pawnee has 48 trunks.

To take advantage of interstate toll pricing, the Decatur PBX receives Ameren Missouri customer calls and Ameren Illinois overflow calls while the St. Louis PBX receives Ameren Illinois customer calls, AmerenUE overflow calls, and St. Louis AmerenUE local customer calls. Incoming calls first go to Ameren's internal IVRs. Calls not handled within the IVRs transfer to Ameren's private network and agent queues in each of the centers. The majority of inbound Ameren-IL customer calls originate through toll-free numbers.[159]

The flow for inbound calls is essentially the same during business and non-business hours. Calls go to the IVR for call classification and self-service. During business hours, callers can request to speak with an agent and the system transfers them to an agent queue. Emergency calls (reporting gas odor or downed wires) received at any time of the day are immediately queued to an agent group. Otherwise, all other call types will request authentication to provide self-service options or additional account information.[160] In 2007, Ameren modified the routing scheme such that if three or more agents are available to handle calls, the system immediately routes the caller to the agent queue bypassing the IVR.

Calls automatically overflow to Stericycle IVRs (Interactive Voice Response), Ameren's outage-overflow service provider during high volume periods, specifically when internal Ameren's primary call center trunks are full. Customers whose phone number the system can identify and match are able to report a power outage and receive an estimated restoration time for an existing outage. Customers should receive the same outage information, regardless of whether they interact with Ameren's or Stericycle's IVRs. However, the system immediately transfers all emergency calls, such as gas odors or downed wires, back to Ameren, through dedicated emergency trunks.[161] Both gas odor and wire-down calls share the same dedicated trunks.[162]

AT&T currently provides long distance (inbound 800 service), dedicated private line services (T-1, T-3, analog)[163] and Internet services to Ameren.[164] Ameren also assumed a contract with MCI (now Verizon Business) after the Illinois Power acquisition. Services provided by MCI included

[156] A "trunk" is a circuit between telephone switchboards or other switching equipment.
[157] Response to Data Request #204.
[158] Response to Data Request #204, Interview #43, October 25, 2007.
[159] Responses to Data Requests #189 and #204.
[160] Response to Data Request #189.
[161] Response to Data Request #183.
[162] Interview #43, October 25, 2007.
[163] T-1 and T-3 are communications schemes of certain capacity and speed.
[164] Response to Data Request #190.

long distance (inbound 800 services and outbound), dedicated private lines services, and Internet services.[165] In 2007, Ameren migrated Ameren-IP from MCI to AT&T.

Ameren's Information Technology (IT) group supports the call-center telecommunications technology. Ameren has implemented state-of-the-art telephony equipment with the appropriate redundancy. Ameren also uses AT&T's Disaster Recovery call allocation to redirect calls to any location "on-the-fly" and according to plan.

Ameren instituted a Disaster Recovery plan for its telephony equipment in early 2005.[166] Disaster Recovery is the ongoing process of creating, testing, and maintaining the policies and procedures an organization will follow should a disaster occur. The goal of a telecommunications disaster-recovery plan is to avoid service interruption by redirecting calls around failed facilities and equipment to backup facilities. In the event that equipment or an entire facility is lost, the plan attempts to bring up lost services as quickly as possible. Ameren's plan addresses telecommunications equipment and facility failure in any of Ameren's call centers and provides the appropriate contingencies to allow continuous operations with minimal disruption to the company and customers. The plan was in place prior to the 2006 storms; Ameren followed it at various points during the storms to address many of the issues experienced during the storms. However, prior to the 2006 storms, Ameren had not fully tested its Disaster Recovery plan through any drills or simulations.

Prior to the 2007 winter storm season, Ameren successfully tested its Disaster Recovery plan, including the simulation of a complete failure of the St. Louis telephony servers.[167] This was the first whole-scale test of the equipment. Ameren plans to conduct tabletop Disaster Recovery drills a minimum of two times per year on a random basis, working through the process that various employees should follow based on various scenarios. Going forward, Ameren is considering an annual drill, similar to the one conducted in October.[168] Testing a Disaster Recovery Plan on an ongoing basis helps ensure the effectiveness of the plan as policies, procedures, and personnel change.

Ameren's Network Operations Center (NOC) is responsible for monitoring operational performance of the telephony network. On a daily basis, the Network Operations Center (NOC) uses the "HP OpenView" applications to monitor system alerts from the PBX, networks, routers, radio systems, SCADA circuits, etc. They monitor trunk use and performance 24/7 for the Avaya system, as well.

Ameren had not fully established this group and only a few personnel had been trained on the call center technologies prior to the July 2006 storms; company personnel had to call in appropriately skilled IT employees as needed to resolve problems and issues with the network. Ameren put a new process in place prior to the November/December 2006 storm to enhance IT storm response; employees were required to report issues to the NOC and/or the IT Help Desk. Today, Ameren has established 24/7 coverage for call center telecommunications support. In

[165] Response to Data Request #191.
[166] Waiting on the response to Data Request #749 to confirm the initiation date.
[167] Response to Data Request #326.
[168] Interview #43, October 25, 2007.

addition, Ameren assigns a NOC liaison to the Emergency Operations Center during storms and large outages.[169]

Ameren cannot monitor its 800-network traffic, nor can it verify that calls are terminating successfully.[170] Ameren can only verify that trunks are operating and observe performance. As a result, Ameren did not know that customers were having trouble contacting the company during the 2006 storms. Call center supervisors brought the problems to the IT NOC's attention after Ameren call-takers relayed customer comments to the supervisors during the storms. Ameren did not understand the scope of the problem until after the storm, when AT&T was able to provide Ameren with network traffic statistics. Ameren is considering implementing AT&T's network monitoring software to monitor more closely network traffic.

Call Center Staffing & Operations

Residential customers wishing to contact Ameren-IL call one of three toll-free numbers, one for each Ameren-IL operating company. Similarly, business customers call one of three toll-free business telephone numbers. With the exception of specialized collections telephone numbers, Ameren's Integrated Voice Response (IVR) technology processes all calls. In 2008 all calls, including specialized collection calls, are routed to the IVR.

Three call centers handle calls for Illinois customers. Currently, each call center is able to operate independently in the event that network connectivity to the main and backup servers is lost, albeit at reduced capacities. The system routes calls to any location based on skill assignments at the agent level. Customer service representatives working in the Peoria or Pawnee call centers handle callers contacting Ameren-CIPS or Ameren-CILCO. Since January 2005, these two call centers have operated as one virtual call center—agents at either center can handle calls from Ameren-CIPS or Ameren-CILCO customers. Prior to 2008, representatives working in the Decatur call center exclusively handled customers calling Ameren-IP.[171]

The IBEW Local 1306 bargaining unit represents call center representatives working at Ameren-IP's call center, while a bargaining unit does not represent call center personnel at the two other Ameren-IL call centers. In 2008, all Illinois centers answer calls in a virtual manner as a result of a negotiated agreement with IBEW Local 1306.

Ameren's call centers operate from 7 a.m. through 7 p.m. Monday through Friday. During these business hours, call center representatives handle customer calls relating to service, billing and collections, and calls to report power interruptions. Ameren-IL supplements its call handling during business hours through a contract with First Contact. A skeleton crew handles emergency calls after hours and on weekends. The IVR informs callers that they can conduct after-hours business in a self-service mode and routes emergency calls to agents.

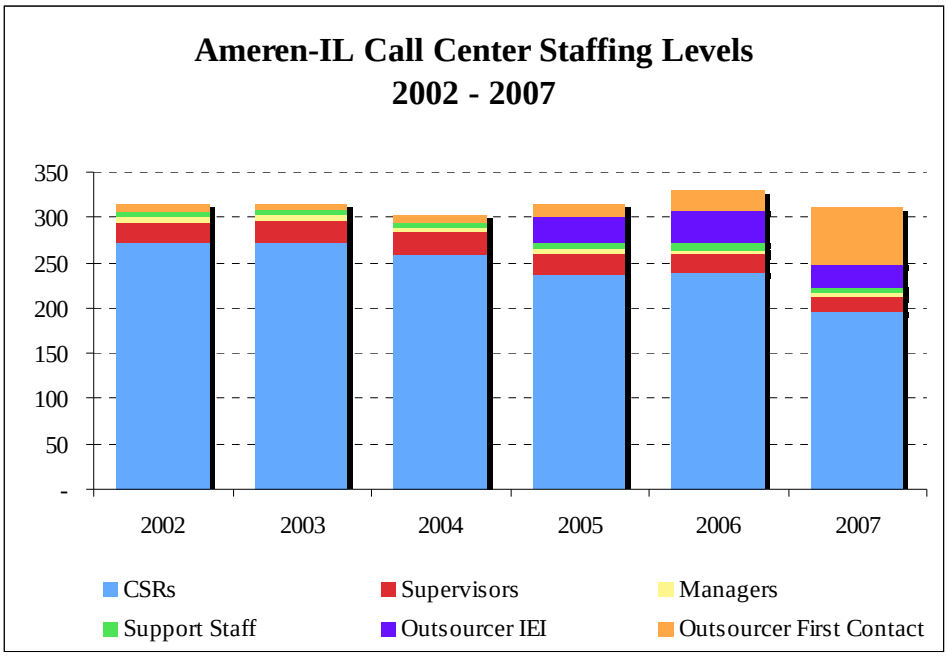
Management forecasts staffing levels to fit projected workload derived from historical call volumes, known events, and seasonal variations. To comply with Illinois Commerce

[169] Response to Data Request #330.
[170] Interview #43, October 25, 2007.
[171] Response to Data Requests #204.

Commission code "Part 410: Standards of Service for Electric Utilities and Alternative Retail Electric Suppliers," Ameren established service level goals as follows for all three Illinois call centers:[172]

- Average Speed of Answer of 60 seconds or less
- Abandon rate less than 10 percent

Ameren-IL's service level goals are consistent with other utilities. Based on these service levels, management determines the number of employees required to handle projected call volumes. This is a common call center staffing approach used by other utilities and other industries. As seen in the chart below, Ameren-IL's call center staffing has remained constant over the past five years, with a peak in staffing during 2006.[173]



CSR = customer service representative

On the basis of seat capacity, average call handle time, service level goals, and agent availability, Ameren-IL can handle 3,000 to 4,000 calls per hour at maximum staffing (during normal business hours) and another 2,000 to 3,000 self-service calls per hour through the IVR.[174] Ameren-IL adequately sized the total call center capacity to handle day-to-day call volumes. Call volumes exceeding these levels will increase the wait times in queue, reduce service level, and increase abandons.

July 2006 Storm Response

The July 2006 storms began on Wednesday, July 19, prior to close of business. Ameren-IL's call center management was able to shift gears quickly, reassigning on-duty employees to emergency

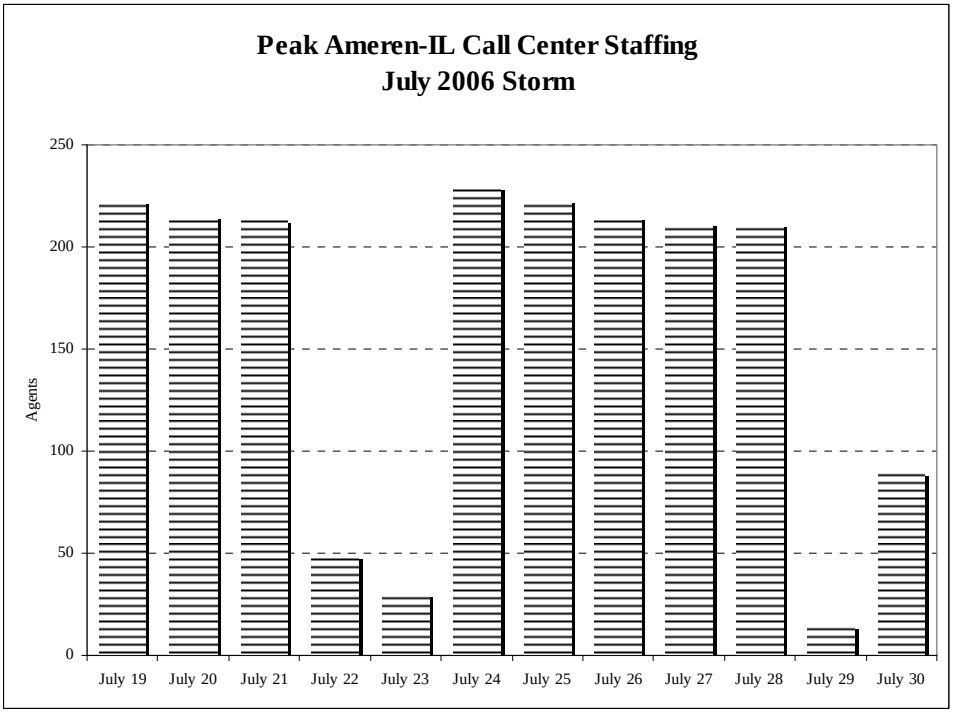
[172] Responses to Data Requests #105, #106, and #107.
[173] Response to Data Request #572.
[174] Response to Data Request #328.

and "lights out" queues, and asking for volunteers to work overtime. Ameren's call-center duty supervisor tracked storm progress and secured additional resources for overnight coverage. By 7:00 p.m., the outage system was reporting more than 220,000 Ameren customers without power.[175]

On Thursday afternoon, Pawnee and Peoria call center management asked employees to work one additional hour of overtime on Friday. Shortly following that request, management asked for volunteers to work overtime on Thursday.[176]

The Ameren-IL call centers did not have formal storm emergency plan~~s~~ documents in place, nor did they have one prior to the July and November/December 2006 storms. As part of a corporate-wide process, each of the call centers have developed Business Continuity Plans[177] addressing disaster scenarios such as tornados, fires, earthquakes, work stoppages, and pandemic events such as the Asian Flu. However, these plans do not address emergency storm response. The magnitude of the damage to individual services, poles, and lines caused the call centers to under-estimate the delay in restoring service. As a result, significant outages continued through the weekend resulting in under-staffing at the call centers on Saturday and Sunday. As a result, Ameren-IL was short staffed for the weekend and overstaffed during the following week as the chart below shows.[178] The sparsely staffed weekend shifts were unable to handle the volume of calls from customers reporting outages and emergencies over the weekend, creating long wait times and frustrating customers. By the time Ameren was able to ramp up staffing, the peak in call volume had subsided, resulting in the inefficient use of call center resources.

[175] Response to Data Request #324.
[176] Response to Data Request #324.
[177] Response to Data Request #207
[178] Response to Data Request #218.



The process followed by Ameren-IL management, specifically at the Decatur call center, to staff during a storm was quite onerous. Based on union protocol, up to 10 agents have pagers to give management a "head start" on staffing during storm situations. Employees with pagers should be at work within 30 minutes, and receive premium pay. However, several employees reported problems with the pagers during the storm, so Ameren's head start was somewhat limited. Ameren has since replaced the pagers with cell phones.[179]

Aside from the paged-in employees, management must call additional staff based on seniority and job position. Management must call all call center employees before it can ask employees in other areas, such as customer accounting or collections, to assist. Additionally, management must call all company employees before it can ask a contractor to assist. This was a time-consuming process during the July and December 2006 storms, delaying Ameren's ability to adequately staff its centers to handle incoming outage calls from customers and creating long waits and busy signals for many customers. Ameren recently automated this call-out process with an auto-dialer. The dialer automates the first-pass more efficiently; management can manually go back to make second requests.[180]

To add to the challenge, Ameren's telecommunications were not set up to easily shift call volume to the contractors. Moreover, the contractors were not ready or under contract to assist with the weekend load, further limiting Ameren's available call-takers, resulting in long waits in queue and busy signals for many customers. Ameren has since resolved this issue so that its contractors are trained and under contract to assist during large outage events.

[179] Interview #49, October 24, 2007.
[180] Interview #49, October 24, 2007.

Ameren encountered a number of telecommunications issues during the course of the storm. First, Ameren's Interactive Voice Response (IVR) ports locked up several times resulting in decreased capacity and requiring a restart to regain full capacity. Ameren's Information Technology (IT) group implemented a work-around, spacing calls by adding a few seconds at the end of each call. This gap was enough to keep the IVRs operational. This problem affected all five IVRs at some point. Customers using the IVRs at the time of the lock-up and who were connected to the impacted ports may have been dropped unexpectedly when the units were restarted, unable to complete their transaction, requiring another call to the company. After the July storm, Avaya released a patch to resolve the issue. Ameren has also configured the IVRs as an agent queue, making it easier to monitor and reset them when needed.[181]

Ameren-IL usually does not use an upfront-message (*i.e.*, the first message all callers hear) to alert callers to the storm, and to ask them to call back later if it is not an emergency. During the storm, management decided to place an upfront message when the queues began piling up. However, the call centers had problems placing the message because it would not record correctly; this resulted in a zero-length announcement. Ultimately, this caused the "Voice Announcement over LAN" (VAL) board to lock-up. IT resolved the problem initially by re-setting the VAL board. However, the problem was recurring. Each time the VAL board locked up, any callers that were waiting for that particular announcement were disconnected unexpectedly when the VAL board was re-set, requiring another call to the company. Ameren has since implemented a software and firmware patch and tested it vigorously. Ameren also made a hardware change at the end of 2007 to address this problem.

Ameren lost connectivity to its mainframe computer from one of its IVRs at approximately 9:30 a.m. July 21. The IVR was back on-line by 10:15 a.m. Callers directed to that IVR were not able to use the self-service "lights out" reporting functionality. The system directed affected callers to a customer service representative for assistance; however, wait times to an agent were lengthy, causing many callers to abandon in queue. Ameren has since implemented changes, discussed at the end of this section, to address this issue.

Ameren's Interactive Voice Response outage status application also did not deliver the date component of the Estimated Restoration Time to callers. For instance, if an Estimated Restoration Time indicated restoration the following day at 11:00 a.m., the caller would only hear 11:00 a.m. This led to the inaccurate interpretation that Ameren-IL would restore service the day the customer placed the call, creating frustration for customers.[182] Ameren corrected this flaw on July 22, 2006, however approximately 30 percent of the orders received prior to the correction (about 2,400 orders, affecting 316,000 Illinois customers) would have delivered incorrect Estimated Restoration Time information to customers.[183]

Ameren's call centers were unable to accommodate all callers. Ameren's telephony overflows to the high-volume IVR provider, Stericycle, when internal trunks are full. However, during the July 2006 storm, there were 6,860 blocked calls at the Stericycle facility. Callers blocked at the Stericycle facility received busy signals, requiring customers to call repeatedly to reach the

[181] Interview #43, October 25, 2007.
[182] Response to Data Request #206.
[183] Response to Data Request #267.

company. One of the primary goals of a high-volume overflow IVR provider is to guarantee that customers will not receive any busy signals when trying to report emergency or "lights out" situations.

Ameren-IP Customer Calls Blocked
July 2006 Storm:[184]

	Blocked at Stericycle	% Blocked
July 19	5,064	59.7%
July 20	16	47.1%
July 21	1,780	39.8%

Ameren-CILCO had problems as well with call overflow during the July 2006 storm. From about 6:00 p.m. through 6:30 p.m. on July 19, Ameren-CILCO outage calls did not overflow to Stericycle and customers received busy signals when they called the toll-free number.[185] While Ameren addressed the problem quickly, it occurred during a peak calling period at the beginning of the first storm.

Ameren also experienced issues while routing outage calls to one of its outsourcing providers, First Contact. On July 20 at 8:30 a.m., one span of First Contact trunks failed due to a bad circuit connection. Ameren alleviated the problem at 2:30 p.m. that afternoon by reducing the number of calls forwarded to First Contact.[186] However, Ameren was limited in the number of calls it could send to First Contact through the remainder of the July 2006 storm, further reducing Ameren's available call-takers and creating longer wait times for customers.

Considering that all Ameren companies shared telecommunications resources, it is relevant that Ameren-UE also experienced trunk loading and overflow problems during the July 2006 storm, from both the toll-free Ameren-UE number and its local numbers. Customers were receiving busy signals when calling one of two local numbers, indicating that calls were not overflowing correctly to Stericycle from 9:00 a.m. through 1:00 p.m. on July 20. As an interim fix, Ameren increased overflow trunking to Stericycle from 250 to 500 trunks.[187] The blocking was such a problem that Ameren asked customers to call the toll-free number instead of the local numbers in the morning and evening press releases on July 22.[188]

In addition to the difficulty in securing adequate call center staffing during the July 2006 storms, Ameren experienced significant failure of its telecommunications equipment, including:

- Ameren's internal Interactive Voice Response units locked up and had to be restarted at various times during the storm, interrupting customers attempting to use the self-service outage reporting application.
- Ameren's Voice Announcement over LAN (VAL) boards locked up numerous times during the storm, requiring a restart to resolve temporarily the problem, interrupting customers trying to reach the IVR or an agent.

[184] Response to Data Request #327-J2.
[185] Response to Data Request #206-D.
[186] Response to Data Request #206-D.
[187] Response to Data Request #206-D.
[188] Response to Data Request #366.

- Ameren's Interactive Voice Response units were not delivering the date component of the Estimated Restoration Time to callers, confusing many callers.
- Many customer calls were blocked when overflowing to the Stericycle high-volume IVR service, delivering busy signals to callers and making it extremely difficult to reach the company to report emergencies or lights out situations.
- Telephone trunks between Ameren and its contractor failed, further limiting the number of calls routed to the contractor.

November/December 2006 Storm Response

Ameren-IL summarized its call center response in the following paragraph from the Critique of Ameren Illinois Service Restoration Activities November 30, 2006, Ice Storm: [189]

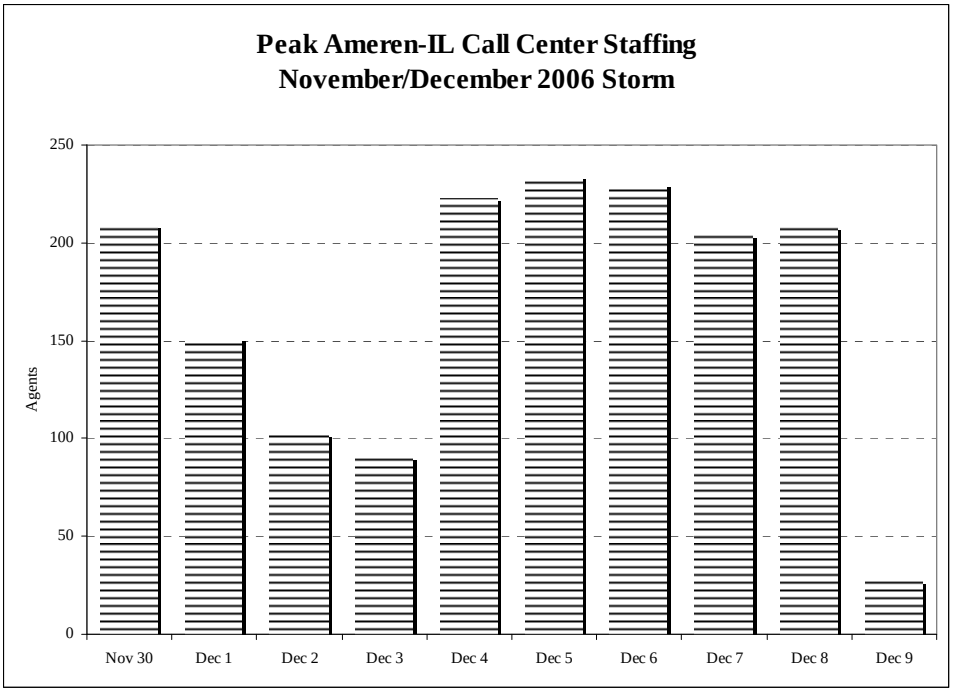
> *During the event we received 400,000 total in-bound calls with 150,000 going to agents, 220,000 to VRUs [voice response units] and about 20,000 abandoned (≈ 5%). Average speed of answer over the weekend was 3-5 minutes. The Ameren system did busy-out over the weekend. We utilized some 250 call takers with 150 being experienced and around 100 brought in from other areas. We utilized some home agents, and had challenges getting people into the call centers with the weather conditions. Cots were set up at the Pawnee center to keep agents overnight.*

After watching the storm develop on Thursday afternoon November 30, Pawnee and Peoria call center managers began asking for volunteers to stay late and to work the overnight shift.[190] The worst of the storm hit on Thursday night. By Friday morning, it was difficult for employees to drive into work. In addition, schools and daycare facilities closed, making childcare challenging for employees with children. There were more than 210,000 customers out of power in Illinois and many calls were coming in to the centers. By 7 a.m., Stericycle had handled close to 54,000 calls, the Illinois centers 22,000 calls, and there were many more blocked calls at the Stericycle facility.[191]

As management was coping with getting employees into work on Friday, they were also trying to staff for the weekend. Again, Ameren-IL did not have a call-center storm plan in place and instead followed a regimented call-out procedure to fill seats during evenings and weekends. During this storm, however, Ameren-IL was able to gain assistance from contractors over the weekend.

The following chart details the peak staffing for each day of the storm. While Ameren was more effective at securing contractor resources to assist with the weekend, there was still a significant problem ramping up required staffing. Ameren's staffing levels peaked on the sixth day of the storm.[192]

[189] Response to Data Request #8D.
[190] Response to Data Request 324-D.
[191] Response to Data Request 372-I.
[192] Response to Data Request 313.



The nature of this storm created many wire-down calls from customers. In addition, many customers attempting self-service through the IVR opted out or failed out, causing many "lights out" calls to queue for an agent. With the staff that was available, Ameren-IL concentrated on working the Wire Down/Gas Leak queue. This left many lights-out calls queued, creating long wait times and abandoned calls.

At the same time, Ameren-IL call-center's police/fire queues were filling up, especially in the Decatur area. Local police and fire stations have emergency telephone numbers for Ameren-IL that route to dedicated queues. Usually, these are calls to alert Ameren-IL to dangerous wire-down or other emergencies. The Pawnee and Peoria centers assisted the Decatur center in handling these calls. Agents also asked emergency officials to compile and fax lists of downed wires to keep the lines clear for more calls.[193] Ameren did not have enough call takers to handle all the emergency calls received from emergency officials. This caused long wait times to report these emergencies, ultimately delaying Ameren's ability to identify the emergencies so the field could respond. While Ameren asked emergency officials to fax in lists of emergencies to help clear the lines, these faxed requests had to be handled by call center resources that were already swamped with calls.

Call volumes reached their peak on Friday morning December 1, such that Ameren-IP instructed employees in the Decatur center to report to work after taking a 7 hour 45 minute rest, a practice common in the field. Additionally, Ameren placed an upfront message on the IVR to alert callers to the storm asking they call back later in the day for any reason other than an emergency.[194]

> *Approximately XXX,XXX customers are still without power. As a result, we are only able to handle emergency inquiries such as electric outages, gas odors, or*

[193] Response to Data Request 324.
[194] Response to Data Request #324-D.

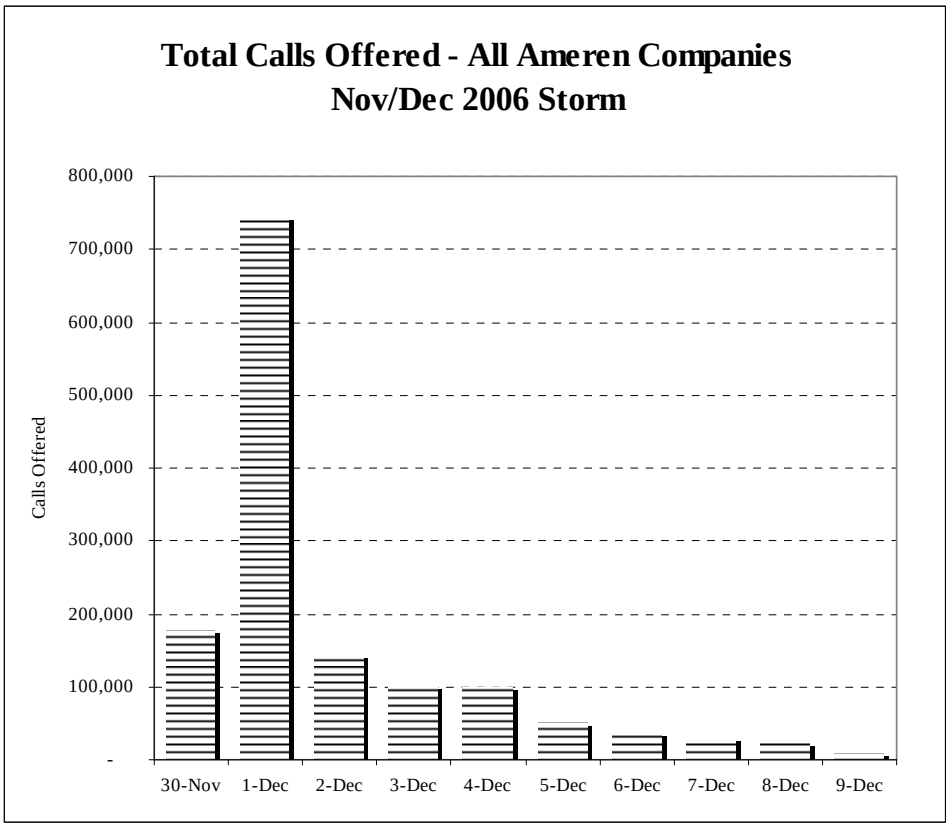
> *downed power lines. We are not able to answer your call regarding your bill, payment plans or requests to start or stop service. If you have any outage, please stay on the line to report your emergency using our automated system.*[195]

It was not until Monday that all Ameren-IL centers moved to an around the clock schedule. Management asked Peoria and Pawnee agents to work 12-hour shifts and agents working overtime in Decatur continued the 7 hour 45 minute rest periods. Additionally, management asked agents in Decatur to take half lunch periods, with lunch provided on-site by management. At noon, Decatur management implemented "mandatory" overtime, extending shifts by one hour before and three hours after. On Tuesday, Wednesday, and Thursday, Ameren-IP brought in employees from the field to assist with calls. The centers returned to regular shifts on Friday.[196] While these measures leveraged as many Ameren-IL employees as possible to handle customer phone calls, Ameren did not enact them until the fifth day of the storm, long after the peak in storm call volume. Had a storm-staffing plan been in place, Ameren could have ramped up staffing much more quickly and more efficiently.

Expecting a high volume of callers on Monday, Ameren reprogrammed its IVRs to the "after-hours" mode, informing callers that Ameren was handling emergency calls only (for all centers). This remained in effect until Wednesday morning for Ameren-IP and Ameren-UE centers and until Tuesday morning for the Ameren-CIPS and Ameren-CILCO centers.[197] However, due to technical limitations, Ameren was not able to change the IVR scripting that stated, "Our office is closed. Please call back Monday – Friday, 7:00 a.m. to 7:00 p.m." As a result, many callers reaching the IVR during business hours were confused by the script telling them to that the offices were closed and to call back during business hours.

An astounding number of callers attempted to reach Ameren during the first five days of the November/December 2006 storm—approximately 1.27 million calls came to Ameren (all operating companies) from November 30 through December 4.[198] On December 1 alone, nearly 750,000 callers attempted to contact the company—averaging about 31,000 calls per hour for that 24-hour period. The following chart shows total calls offered, by day, for all Ameren companies during the November/December 2006 storm.[199] During this same 5-day period, nearly 400,000 calls overflowed from Ameren-IP to Stericycle.[200]

[195] Response to Data Request #324.
[196] Response to Data Request #324.
[197] Responses to Data Requests #200, #201, #202, and #203.
[198] Response to Data Request #327.
[199] Response to Data Request #327.
[200] Response to Data Request #327.



Ameren identified an issue with Stericycle routing at 10:20 p.m. on November 30, 2006. Many of the calls that the system should have routed to Ameren-IP's wire-down emergency queues were misrouted. As an interim fix at 12:00 a.m., Ameren asked Stericycle to reroute calls intended for Ameren-IP's wire-down queues to Ameren-IP's gas odor queues. Limited testing conducted by Stericycle to investigate this issue determined that about half of the calls routed during this period went to a wrong number. MCI was at fault in this instance and corrected the routing problem at 1:10 a.m. on December 1. However, this problem caused anywhere from 800 and 2,000 wire-down emergency calls to be misdirected, requiring callers to hang up and call back to report their emergency.[201]

Ameren's call flow technology was not properly handling the extremely high call volumes received during the storm. Ameren's system "busied-out" over the weekend—customers received busy signals when trying to reach the company.[202] During the November/December 2006 storms, many callers were unable to reach Ameren's call centers because all trunks were full.[203]

Blocking at the Stericycle facility was much worse in the November/December 2006 storm. There were more than 270,000 Ameren-IP blocked calls on November 30 and December 1.

[201] Response to Data Request #311-A1.
[202] Response to Data Request #8-D.
[203] Response to Data Request #550.

Ameren-IP Customer Calls Blocked
Nov/Dec 2006 Storm: [204]

	Blocked at Stericycle	% Blocked
Nov. 30	49,832	61.6%
Dec. 1	228,030	75.0%

While Ameren-IP calls were overflowing correctly to Stericycle during the storm, Ameren-CIPS calls were not. Another 100,000 calls were supposed to overflow from CIPS/CILCO, however, due to a technical problem, calls did not overflow from CIPS to Stericycle. Instead, 100,000 or so of the customers attempting to reach Ameren-CIPS received busy signals.[205] Ameren did not discover this during the storm. In fact, it was discovered recently in a response to Liberty's investigation of blocked calls.[206] At Liberty's request, Ameren asked AT&T to provide further documentation to quantify the volume of calls blocked during the storm, specifically the calls that were sent to Stericycle from Ameren. The additional documentation provided by AT&T pointed out the blockage at CIPS/CILCO. Ameren did not have network-level call traffic monitoring software installed during the storms. As a result, Ameren could not see the disposition of calls outside its centers. It could not see that so many calls were being blocked. Ameren is considering implementing this software going forward. The following table details calls blocked during the storm:

Ameren-CIPS 800# Customer Calls Blocked
Nov/Dec 2006 Storm[207]

	Calls Offered	% Blocked
Nov. 30	11,773	69.5%
Dec. 1	86,477	90.8%
Dec. 2	511	9.1%

Callers wishing to report an emergency, such as a gas leak, downed wire, or fire, also had difficulty reaching an Ameren agent. During the November/December 2006 storm, 27 percent of the calls presented to Stericycle were identified as emergency calls—gas odor or downed wires.[208] Stericycle's system immediately routes these emergency calls back to Ameren for an agent to handle. However, during the storm there were several occasions when Ameren-IP's emergency trunks were full and could not accept any calls from Stericycle. The following table details the number of calls that were blocked, both gas odor and wire-down emergencies, as Stericycle attempted to route the calls back to an Ameren agent handling emergency calls.

[204] Response to Data Request #327-J2.
[205] Response to Data Request #327.
[206] Response to Data Request #327.
[207] Response to Data Request #327-B.
[208] Response to Data Request #327.

Ameren-IP Emergency Calls Blocked
Nov/Dec 2006 Storm[209]

	Ameren-IP Gas Odor Customer Calls Blocked[210]		Ameren-IP Wire-Down Customer Calls Blocked[211]	
	Blocked	% Blocked	Blocked	% Blocked
Nov. 30	157	80.1%	3,212	83.8%
Dec. 1	719	82.5%	13,336	81.8%
Dec. 2	30	63.8%	476	62.0%

In total, there were 17,930 blocked emergency calls during the first three days of the November/December 2006 storm, indicating that Ameren-IP did not have enough trunk capacity to handle this volume of emergency calls. During the 2006 storms, Ameren-IP had only 24 trunks to handle inbound gas and wire-down emergency calls (separate published 800 toll free number) and any emergency calls transferred back from Stericycle.[212] Not enough to handle the volume of emergency calls generated by the November 2006 storm, as evidenced in the chart above. Blocking emergency calls means that customers who are reporting gas leaks or wire-down emergencies are receiving busy signals—they cannot get through to the company to report the emergency. This delays getting the needed information to the field so it can resolve the emergency and lengthens public safety concerns.

Since the storms, Ameren has added trunking such that AmerenIP now shares 48 trunks with the other two Ameren-IL companies for all calls transferred back from Stericycle. However, the shared 48 trunks would have not been sufficient to handle the volume of calls received in the November/December 2006 storm. Ameren has designed its secondary overflow routing to point back to its normal inbound trunk groups, when the primary overflow is full.[213] However, calls are routed to Stericycle when Ameren trunks are full, so the likelihood of finding an available inbound trunk if all other trunk groups are full is very slim. If Ameren is going to rely on inbound trunks to supplement the 48 shared emergency trunks, then Ameren must route calls to Stericycle much earlier, rather than waiting until it has reached maximum capacity. This would provide the ability to reserve more trunks when needed for emergency calls.

In summary, Ameren again encountered difficulty in securing adequate call center staffing during the November/December 2006 storm, and experienced significant failure of its telecommunications equipment, including:

- Many customers attempting self-service through the IVR opted out of the system or failed out of it, resulting many "lights out" calls to queue for an agent.
- Ameren's Voice Announcement over LAN(VAL) board locked up numerous times during the storm, requiring a restart to resolve temporarily the problem. This resulted in reduced capacity of self-service customers trying to reach the IVR or an agent.

[209] Response to Data Request #327.
[210] Response to Data Request #327-G.
[211] Response to Data Request #327-G.
[212] Response to Data Request #676.
[213] Response to Data Request #676.

- Close to 300,000 Ameren-IP customer calls were blocked when overflowing to the Stericycle high-volume IVR service, delivering busy signals to callers and making it extremely difficult to reach the company to report emergencies or lights out situations.
- 100,000 Ameren-CIPS calls were blocked because the calls were not overflowing to Stericycle, delivering busy signals to callers, and making it very difficult to reach the company.
- Ameren-IP's dedicated fire and police emergency telephone lines were full, making it difficult for emergency personnel to report dangerous wire-down and wire-burning situations.
- Several thousand Ameren-IP emergency calls were improperly routed from Stericycle to a wrong number, making it difficult for customers to report wire-down or wire-burning emergencies.
- 17,000 Ameren-IL customers calling to report wire-down and wire-burning emergency situations received busy signals as more than 80% of these calls were blocked on November 30th and December 1st due to insufficient telephone capacity.

The biggest issue Ameren encountered during both storms, in terms of impacted customers, was the blocking of calls to or from Ameren's high-volume overflow provider, Stericycle, through improper call routing or due to insufficient telecommunications capacity at Ameren or Stericycle. The primary goal of a high-volume overflow provider is to handle the extremely high peak calling periods that occur with any large outage or storm. While Stericycle was able to handle a high volume of the calls presented during these storms, it failed to handle several hundred thousand calls, creating frustration for callers and delaying the identification of customers without power. Stericycle's capacity was insufficient to handle the volume of calls presented. Ameren's internal telephony was operating at full capacity as well, too full to accommodate the emergency calls that Stericycle was instructed to route back to Ameren agents. This reduced Stericycle's capacity, as it was required to hold these calls until they could be successfully transferred, resulting in more call blocking.

High-Volume, Outage-Overflow IVR Services

Call blocking at the Stericycle facility occurred because Stericycle was not configured appropriately to handle the call volume that Ameren received during the July 2006 and November/December 2006 storms.

In late 1997, Union Electric contracted with Twenty First Century Communications, Inc. to provide high volume outage IVR services, with the capacity to handle a minimum of 20,000 calls per hour (average call duration of one to one and one-half minutes).[214] The contract provisioned service to handle UE overflow calls with an option to implement similar services at CIPS, with no increase in capacity. In 2000, Ameren switched its outage overflow services contract to Stericycle (NNC Hanover at the time), at a reduced cost, and with commitment from Stericycle to develop an outage notification service (for planned outages).[215]

[214] Response to Data Request #443.
[215] Response to Data Request #184.

Initially, Stericycle configured its Overflow Outage IVR to handle 20,000 calls per hour. Ameren initiated a stress test of the service in November 2001:[216]

> *The purpose of this stress test is to confirm that more than 100 concurrent calls can be processed and rerouted to Hanover Communications via a Hanover provided AT&T toll free number when an "all trunks busy" condition occurs on Ameren's local trouble reporting number. This will demonstrate that Hanover (and SBC/AT&T) can handle the call load and that there is no network bottleneck or limitation of 100 lines. Also, this will help address any concerns for the next phase of overflowing Ameren's regional toll free outage number to Hanover. Both local and regional outage calls could potentially hit 20,000 calls per hour.*

In June 2004, Ameren renewed its contract with Stericycle.[217] At that time, however, Stericycle had closed its Indianapolis center and the maximum calls that Stericycle could handle per hour was 15,000. Ameren accepted this contract change, even though it had originally projected call volumes as high as 20,000 calls per hour for UE and CIPS. However, the reduced capacity of 15,000 one-minute-calls per hour applied to all Ameren operating companies, UE, CIPS, and CILCO, at that time. Moreover, Ameren did not add capacity when it acquired Illinois Power in 2004.

In an amended contract between Ameren and Stericycle, effective March 1, 2007, Stericycle agreed to provide inbound call capacity of 15,000 one-minute calls per hour, with an option to expand capacity to 30,000 one-minute calls per hour after Stericycle expanded its system.[218] This contract change became operational in August 2007.[219] The 30,000 call per hour capacity should be able to handle a similar sized storm as the November/December 2006 storm, if Ameren has allocated enough trunk capacity to handle emergency calls transferred back from Stericycle. However, if Ameren continues to overflow to Stericycle after it has reached maximum capacity, there will not be enough emergency trunks available and blocking of emergency calls will occur as well as blocking at the Stericycle facility.

Technology Enhancements Following 2006 Storms

The following is a summary of the enhancements Ameren made to its telephony equipment since the 2006 storms:[220]

- In 2007, Ameren modified the routing scheme such that if three or more agents are available to handle calls, the system routes the caller immediately to the agent queue (and bypasses the IVR).
- In July/August 2007, Ameren developed and rolled out a hardware/software status display that delivers hardware statistics for the IVR servers, such as CPU usage, memory utilization, and disk space consumption. In addition, various critical software applications are monitored to collect usage statistics, such as call processed, calls active in IVR, and

[216] Response to Data Request #213, Addendum-A2.
[217] Response to Data Request #442.
[218] Response to Data Request #442.
[219] Response to Data Request #550.
[220] Responses to Data Requests #550 and #213.

status of the communications channels between the IVRs and Ameren's systems (such as OAS for logging outage reports).

- Ameren implemented a web-based tool to make it easier for Ameren's call center supervisors to shift calls to its outsourcer, First Contact. Call center management can now control the level of calls routed to First Contact without requiring IT assistance.
- Ameren installed and tested a software and firmware patch to address the PBX's Voice Announcement over LAN (VAL) board lockup issues. The VAL boards enable the PBX to broadcast upfront general announcements—all callers will hear the announcement when first reaching the company. Ameren also developed scripting to notify the Network Operations Center and Voice Engineering when a zero length announcement occurs, to help avoid possible VAL board lockups. Ameren created a procedure for replacing the zero length announcements with a valid announcement.
- Ameren implemented audio groups for static announcements, spreading the load of announcements across multiple VAL boards and reducing the probability that a single board lockup will affect all callers.
- IVR Zip Code Outage Announcement – Ameren implemented loading across multiple ports to reduce the probability of a port lockup affecting multiple callers.
- Load Distribution – Ameren addressed IVR Loading by distributing incoming calls across all five IVRs in a circular fashion.
- Call Center Announcements – Ameren implemented standardization of announcements played to customers across the Illinois call centers.[221]
- Ameren automated the process for placing an up-front message. Call center supervisors can now enter a 5-digit code and pick from a standard set of messages. This is much easier to do, easier to turn on and off, and presents a more consistent message in all centers. Using the scripted message provides an alternative to avoid the VAL board update process, which, at times, can be problematic.
- Ameren expanded the capability of reader-board functionality in the call centers by allowing supervisors to view more detailed call handling information and call handling agent status information on their desktop PCs. Ameren-IL and Ameren-UE supervisors were given view access to each others' displays, making it easier for call centers to shift calls to available resources.
- Ameren is now sharing contractor resources among all three Ameren-IL centers, balancing resources so that each center can meet service level goals.
- Ameren-IL has a number of at-home agents that can more easily assist in handling after-hours calls.
- In June 2007, Ameren moved to a "trunk pool" concept, designating 428 trunks for the Illinois call centers to draw capacity, as needed. At this point, Ameren-IP is drawing from the pool. Ameren-CIPS and Ameren-CILCO will switch over in second quarter of 2008. As of July 2008, all Ameren-IL companies are in the trunk pool.

These changes have addressed many of the problems that Ameren encountered during the 2006 storms, described earlier in this section, and should serve to improve Ameren's call handling

[221] Response to Data Request #311.

performance in future storms. However, Ameren has more opportunities to improve its telecommunications to handle better customer calls in future large outage events. Liberty discusses these opportunities in the Recommendations section at the end of this section.

Storm Restoration Internal Communications

While Ameren-IL experienced trouble with its telephony, it was also having difficulties delivering a consistent storm-restoration status message to its employees or customers. Call center employees generally receive updates from supervisors and this occurred during both storms. However, call center leadership did not regularly receive consistent information from Operations or Corporate Communications about the storm. This is evident from the e-mail logs of the call center's Duty Supervisor during the storms.

The following table lists the storm status (number of customers out of service) information that was available to call center agents during the July 2006 storms:

Date	Time	Center	Source[222]	Illinois Out	Total Out
July 19	3:52 pm	Pawnee/Peoria	DDO Query[223]	8,500	10,491
	7:38 pm	Pawnee/Peoria	DDO Query	36,804	224,032
	10:30 pm	Pawnee/Peoria	DDO Query	11,000 CIPS/CILCO	416,000
July 20	1:07 am	Pawnee/Peoria	DDO Query	7,000 CIPS/CILCO	419,000
	6:51 am	Decatur	DDO Query	43,261 IP	305,762
	7:35 am	Pawnee/Peoria	CILCO/CIPS IRV[224]		400,000
	8:00 am	Pawnee/Peoria	News Release		500,000
	8:52 am	Decatur	EOC Conf. Call	46,183	297,334
	9:20 am	Pawnee/Peoria	Media Conf. Announced		500,000
	1:08 pm	Decatur	Media Advisory		500,000
	1:49 pm	Pawnee/Peoria	Call Center Mgt		450,000
	5:00 pm	Decatur	EOC Conf. Call	89,178	
	5:08 pm	Pawnee/Peoria	News Release		400,000
	9:09 pm	Pawnee/Peoria	Call Center Mgt		400,000
July 21	8:08 am	Pawnee/Peoria	News Release		320,000
	10:00 am	Pawnee/Peoria	CILCO/CIPS IRV[225]		320,000
	10:07 am	Pawnee/Peoria	EOC Conf. Call		400,000
	2:31 pm	Pawnee/Peoria	News Release	100,000	570,000
	7:10 pm	Decatur	EOC Conf. Call	167,000	577,000
July 22	9:41 am	Decatur	EOC Conf. Call	67,000	457,000
	2:38 pm	Decatur	DDO Query	65,800	424,338
	9:06 pm	Decatur	EOC Conf. Call	64,727	
July 23	8:52 am	Pawnee/Peoria	EOC Conf. Call	76,000	327,000
	1:52 pm	Decatur	DDO Query	56,000 IP	321,000
	5:58 pm	Pawnee/Peoria	EOC Conf. Call	66,000	298,000
	10:09 pm	Decatur	EOC Conf. Call	45,000+	
July 24	9:11 am	Decatur	EOC Conf. Call	39,548	193,579
	1:28 pm	Pawnee/Peoria	EOC Conf. Call	52,000	240,000
July 25	5:36 pm	Decatur	EOC Conf. Call	35,000	142,000
July 26	1:21 pm	Pawnee/Peoria	EOC Conf. Call	23,700	105,700
	5:22 pm	Decatur	EOC Conf. Call	15,000	82,000

The information e-mailed to call takers during the storms did not correlate with the information documented during the EOC conference calls. The following table provides the outage statistics discussed and documented during the twice-daily EOC Restoration Update Conference Calls:[226]

	Time	IL Out	MO Out
July 20	8:00 am	100,000	406,000
	4:00 pm	89,178	406,000
July 21	8:00 am	60,000	350,000
	4:00 pm	167,000	410,000
July 22	8:00 am	88,000	352,000
	4:00 pm	95,000	319,000
July 23	8:00 am	76,000	251,000
	4:00 pm	66,000	232,000

[222] Response to Data Request #324 for all sources in table, except where otherwise noted.
[223] DDO Query refers to an intranet-based user query that pulls storm-restoration outage statistics from the Outage Analysis System creating an outage snapshot at the time of the query.
[224] Responses to Data Requests #192, #193, #194, and #195-B.
[225] Responses to Data Requests #192, #193, #194, and #195-B.
[226] Response to Data Request #424.

The following table lists the storm status (number of customers out of service) information that was available to call center agents during the November/December 2006 storm:

Date	Time	Center	Source[227]	Illinois Out	Total Out
Nov 30	10:29 am	Pawnee/Peoria Decatur	News Release		
Dec 1	8:43 am	Pawnee/Peoria Decatur	EOC Conf. Call	210,000	482,000
	10:06 am	Decatur	News Release		500,000
	12:03 pm	Pawnee/Peoria	CIPS/CILCO IVR[228]		500,000
	12:41 pm	Pawnee/Peoria	EOC Conf. Call	220,000	500,000
	5:04 pm	Decatur	News Release		500,000
	5:05 pm	Decatur	News Release	230,000	500,000
Dec 2	5:45 am	Pawnee/Peoria	DDO Query[229]	214,168	461,908
	7:15 am	Pawnee/Peoria	Dec 1st News Release	230,000	500,000
	8:00 am		Ameren.com[230]		2.4 million
Dec 3	9:06 am	Pawnee/Peoria	EOC Conf. Call	187,000	383,000
	11:17 pm	Pawnee/Peoria	EOC Conf. Call	170,000	353,000
Dec 4	11:23 am	Pawnee/Peoria Decatur	EOC Conf. Call	146,000	300,000
Dec 6	12:30 pm	Decatur	EOC Conf. Call	55,000 IP	
	12:47 pm	Pawnee/Peoria	DDO Query	66,650	
	4:49 pm	Pawnee/Peoria	DDO Query	61,975	78,204
	7:17 pm	Pawnee/Peoria	EOC Conf. Call	63,000	80,500

Emergency Operations Center conference call notes existed only from the July 2006 storms. Ameren discontinued the practice of developing conference call notes on July 23.[231]

Call center employees received their information largely from the Emergency Operations Center conference calls, through the notes taken by participating call center management. However, even that was inconsistent, considering that Ameren held the EOC conference calls twice a day during the storm. Call takers also received some of the news releases issued by Corporate Communications—three releases were shared with agents on December 1.

The lack of a consistent, coordinated message was especially difficult for call center employees trying to answer difficult questions from thousands of callers. Ameren-IL call center leadership summarized Ameren's call center challenges in the following paragraph from the Critique of Ameren Illinois Service Restoration Activities November 30, 2006 Ice Storm:[232]

> *We need to communicate correct data to manage customer expectations and also need to build consistency in our message (i.e., information from the agents, the VRU, Corporate Communications, etc.). Automated restoration functionality is turned off during a major storm. While we input an estimated restoration time*

[227] Response to Data Request #324 for all sources in table, except where noted otherwise.
[228] Responses to Data Requests #192, #193, #194, and #195-C.
[229] DDO Query refers to an intranet-based user query that pulls storm-restoration outage statistics from the Outage Analysis System creating an outage snapshot at the time of the query.
[230] Response to Data Request #311-F.
[231] Response to Data Request #424.
[232] Response to Data Request #8D.

> *into jobs that are assigned to construction, we need a better way to communicate to those customers whose outage orders have not yet been assigned. In addition, we need to build consistency into the information we provide to customers from different corporate entities (i.e. Corporate Communications, Call Centers, VRUs [voice response units], and Divisions).*

Even the media became confused with outage information during the November/December 2006 storm, as the Chicago Sun-Times reported that "About 2.4 million Ameren Corp. customers across central and Southern Illinois and parts of Missouri were without power early Friday after ice snapped power lines and tree limbs."[233] According to Ameren, outage maps displayed on its Storm Center website showed that Ameren served 2.4 million customers. A media source misinterpreted this number to mean that Ameren reported 2.4 million customers out.[234] However, the published caused customers to comment on this as they called Ameren's call centers. Ameren removed this statement from the outage maps on its website, hoping to avoid further misinterpretation by customers and the media.[235]

Call takers did not have the information they needed to discuss storm restoration status with customers. In addition, limited information was available publicly, through press releases and media advisories. As a result, customers were worried and frustrated because they had no idea how long they would be without power, making it difficult to make the appropriate decisions about making other living arrangements. This created more calls to the company as the outage duration lengthened. As customers had no information, they would call back repeatedly hoping to get some information from the company.

Ameren established an Integrated Communications Strategy Group in 2005 to discuss a variety of company and industry issues. Its goal was to determine the appropriate means and media for continuing to educate customers, shareholders, legislators, and others about company and industry issues. A team comprised of senior executives from each of Ameren's business lines met and dealt with communications issues. Following the 2006 storms, members of the team provided perspective on what worked and did not work during the storms. "Storm Communications—After Action Review Summary" documented comments from team members.[236] It listed 19 items under "What Worked":

- Frequency of communications
- Ameren personal stories – the human side
- Formal (managed) press conferences
- Releases kept primary spokespeople "on message"
- Information flow to community/state leaders and regulators
- Collection process for Ameren personal stories
- Volume of positive stories reduced volume of negative stories
- Media access to Ameren leadership

[233] "Storm blasts region", *Chicago Sun-Times*, December 1, 2006.
[234] Response to Data Request #674.
[235] Response to Data Request #674.
[236] Response to Data Request #445.

- Managing Al Sharpton's claims before his press conference
- Scheduled call-in briefings in the Storm Center
- Coordination between customer contact centers
- Keeping ICC abreast on regular basis
- Follow-up thank you to coworkers and customers – letter in papers
- Internally generated commercials
- Worker hardship angle in messages
- Messages were more strategically managed as event progressed
- Improved language-from repairs to system rebuilds
- Positioning of storm magnitude-no electrical system in US could withstand
- Executives on TV, radio, print gave company a human face and expressed empathy

It listed 31 items under "What could have been done more effectively?" The top ten items on the list were:

- Better information on where crews are working
- Varying restoration estimates caused confusion/lack of credibility
- Approval process for press releases too slow
- IL under-represented regarding restoration progress
- Outage numbers reported from various sources were inconsistent
- "End of Storm/Emergency" declared too early
- Web site numbers did not agree with Distribution Dispatch Operations & storm center
- Confusion between "storm related outages" and "non-storm related outages"
- Difficulty weaning media off storm stories after the event was over
- Post's reporting of $30M cost figure without Ameren approval

Liberty discusses most of the items on the "What could have been done more effectively" list in this chapter. A major problem was the inconsistency or lack of restoration status information. The lack of a consistent storm restoration message, and inconsistencies in outage statistics, made it difficult for customers and Ameren employees communicating with customers and the public. Ameren recognizes that these were problems during the storm and has addressed many of these items since the storm, or initiated improvement initiatives.[237]

b. Corporation Communications

Ameren's Corporate Communications department issued nine news releases during the July Storm. It issued the first release at 8:00 a.m. on July 20, 2006. "Half Million Ameren Companies Customers Affected by Massive Storm; Restoration Efforts Underway." A second release followed at 5 p.m. on July 20: "160,000 Restored of More Than 500,000 Customers Affected by Massive Storm."

[237] Response to Data Request #446.

It issued two releases each day on July 21 through July 23, and one release on July 24, 25, and 26. The following table summarizes the information released by Corporate Communications regarding the number of customers without power:[238]

Date	Time	Illinois Out	Missouri Out	Total Out
July 20	8:00 am			500,000 & 450,000
	5:00 pm			400,000
July 21	8:00 am		320,000*	
	2:00 pm	100,000		570,000
July 22	8:00 am	100,000	360,000*	
	6:00 pm		305,000*	395,000
July 23	12:00 pm		255,000*	320,000
	4:30 pm		241,000*	298,000
July 24	?		171,000*	216,000
July 25	9:00 pm		88,000*	113,000
July 26	?		50,000*	58,000

*Metro St. Louis Area only

The press releases reported outage restoration status and outage counts generally oriented towards the St. Louis Metro area. Only two releases stated the number of Ameren-IL customers out of power during the entire July 2006 storm—on July 21 and July 22. Otherwise, Metro was the area of focus for these releases. Additionally, Ameren generally issued the morning releases at the same time the Emergency Operations Center (EOC) morning conference call was taking place, making it difficult to ensure the numbers were consistent with EOC discussions.

While Ameren indicated a three-day restoration effort on July 20, this was before the second storm hit the service territory on July 21. Ameren stretched the initial estimate after the second storm, from 72 hours to 4 to 7 days. The following details when Communications released information regarding estimated restoration times:[239]

	Message in News Release	Anticipated Restoration Date
July 20	Cannot offer anticipated restoration times	
July 20	At least 72 hours, make customer-specific restoration times available as soon as possible	July 23
July 21	A total of 72 hours, make customer-specific restoration times available as soon as possible	July 23
July 22	Initial 3 to 5 day restoration estimate could stretch a day or two longer	July 24 to July 26
July 23	Tuesday or Wednesday	July 25 or July 26
July 24	Majority Tuesday night, remainder Wednesday and the very last customers on Thursday	July 25 to July 27
July 28	Complete all restoration by noon today	July 28

[238] Response to Data Request #366.
[239] Response to Data Request #366.

Ameren did not deliver a consistent message to customers affected by these storms. Ameren's initial 72-hour restoration time ended up stretching to 8 days. While Ameren was providing a general estimate to all customers, it was not providing customer-specific estimates. Because the majority of Ameren press releases were oriented towards restoration efforts in the Metro St. Louis Area, Ameren-IL customers received limited information about the damage and restoration efforts in their area. The lack of publicly available information forced customers to call the company, already overwhelmed with incoming calls, to learn more about the restoration efforts. This further frustrated customers because call-takers were unable to offer any more detail.

Ameren alerted customers to the predicted winter weather on November 30 at 10:00 a.m. It issued six releases (three for Illinois, three for Missouri) on December 1 detailing the number of customers out of power, the hardest hit areas, and the level of resources assigned to the restoration effort. It also warned customers that "lengthy outages are expected" and that the company could not offer anticipated restoration times.

During the November/December 2006 storm, Ameren generally issued separate releases for Illinois and Missouri, as can be seen in the table below:[240]

	Time	Illinois Out	Missouri Out	Total Out
Nov 30	Ameren Prepares for Predicted Winter Weather			
Dec 1	10:00 am	220,000		
	10:00 am		280,000	
	1:00 pm	235,000		
	1:00 pm		285,000	
	5:00 pm	230,000		
	5:00 pm		280,000	
Dec 3	Ameren's Safety Warning on Portable Generators			
Dec 4	?	50,000*		
	?	150,000		
Dec 5	10:00 am	100,000	80,000	180,000

*Decatur only

Corporate Communications did not release the next news release until Monday, December 4. While it broadcast an anticipated restoration date of Wednesday, December 6 in this release, this was very late in the storm—the fifth day of the storm. The table below details the estimated restoration information released by Corporation Communications during the November/December 2006 storm.[241]

[240] Response to Data Request #366.
[241] Response to Data Request #366.

	Message in News Release	Anticipated Restoration Date
Dec 1	Cannot offer anticipated restoration times, lengthy outages are expected	
Dec 4	Most restored by Wednesday, difficult conditions by Friday	Dec 6 to Dec 8
Dec 5	Bulk restored by end of day Wednesday	Dec 8

While Corporate Communications did a better job providing statistics and town information specific to Illinois during the December 2006 storm news releases, anticipated restoration dates were absent. As a result, customers had no idea when Ameren would restore their power. One of the primary purposes of a storm-restoration status news release is to release storm information to a wide audience, thereby eliminating the need for customers to call the company to hear this same information. However, Ameren did not provide anticipated restoration dates, as a result, more customers called the company, breaching the call center capacity, causing other telephony equipment to fail, and creating busy signals.

Corporate Communications did not effectively coordinate with all relevant groups to gather and disseminate storm restoration information. While Corporate Communications participated in EOC conference calls, it did not take control of the "storm message" for the company and it did not press Operations for anticipated restoration times. At a point when the public, state, and local government officials were unhappy with restoration progress and the lack of information, Corporate Communications neglected its responsibilities.

Although Corporate Communications had a "Communications Plan for Severe Storms," it did not appear that it followed the plan. Rather, the group fell into a reactionary mode, returning "media hotline" calls as it received them, and putting out fires as they popped up.

In fact, during the July storm, Corporate Communications group had already left for the day when Ameren activated the Emergency Operations Center at 7:15 p.m. on July 19. No one from Corporation Communications reported into the EOC that evening to begin preparing the message. It was the next morning before Corporate Communications began addressing the situation and responding to media hotline inquiries.[242]

Additionally, Corporate Communications provided minimal information to Ameren-IL customers during the July 2006 Storm, as the majority of news releases were oriented to the Metro St. Louis area. While damage was significantly worse in that area, there were still 100,000 customers without power in Illinois.

Corporate Communications was not an effective "gatekeeper." There was no coordination or control of the information released to the media, the recordings placed on the telephone systems, and the information relayed by other personnel in the field, such as the community relations' representatives. As a result, Ameren released conflicting statistics, anticipated restoration dates

[242] Interview #97, November 13, 2007.

were late, and company employees were ill informed. Customers were confused with the provided information and frustrated because they were unable to get anticipated restoration times from the company until late in the storm. Ameren's credibility suffered as a result.

Ameren worked with the media a little differently during the November/December 2006 storm to show how Ameren conducted restoration work, and to provide media access to crews, the Decatur "war room," and other key operations personnel. Ameren shortened the approval process for news releases from 60 minutes during the July storm to 30 minutes. Drafts of releases were prepared well in advance of Emergency Operations Center conference calls so the releases could be prepared in time to meet evening news broadcast schedules.

c. Community Relations

At Ameren-IL, the community relations responsibility generally falls to the field Customer Service Supervisor or Business Administrator, reporting to Division management. This is not a dedicated job at Ameren, as the individuals filling this role can also be responsible for meter readers, meter changers, and other clerical support staff. Normally, community relations representatives attend city events and planning meetings, community leader meetings, and any franchise and rates meetings. Other participation includes local community leader clubs, school boards, and charities, with a goal of establishing a company presence in the local community.

During storms and other emergencies, Ameren-IL's community relations representatives also coordinate closely with state and local emergency organizations. The community relations representative also participates in local and state emergency management meetings, providing restoration status, damage assessments, and the number of customers out of power.

During the July 2006 storm, Ameren assigned two community relations officers to work 24/7 with the Illinois Emergency Management Agency (IEMA) at its Unified Command Center (UCC). This was the first time in Illinois history that IEMA had set up a remote location within the area most damaged by the storm. Ameren's presence and participation in the UCC was very effective, giving IEMA direct access to storm restoration progress and helping to coordinate efforts among the Health Department, Fire, Police, Illinois Department of Transportation, Red Cross, and other state and local organizations. Additionally, city officials and legislators visited the IEMA trailer often during the storm, improving Ameren's visibility.

Each field supervisor filling the community relations role for Ameren-IL was responsible for developing and maintaining relationships in the community and with local officials and leaders. The individual controlled community relations; there was no overall coordination or consistency among divisions.

As a result, community relations' involvement in the storms varied among the divisions. There was no community relations plan that each division could follow. As a result, there were inconsistencies in response and a few public relations incidents, particularly in towns that were without power for several days.

During a large storm, the public looks to the utility first for restoration estimates. When these are unavailable, the next step is to contact local officials, demanding they get an answer. As a result,

if the utility does not keep these town and city officials informed, they become angry and frustrated because they cannot answer their constituents. This happened in several locations, particularly during the November/December storm. For instance, the mayor of Decatur took issue with Ameren because no one from the utility had contacted him during the storm. Ameren also received many calls from mayors and school officials looking for information.[243]

Ameren had no consistent or coordinated approach to keeping city officials and municipal leaders informed. In addition, critical infrastructures, such as water treatment plants, lift stations, gasoline stations, hospitals, and nursing homes, were not easily identifiable in the Outage Analysis System. As a result, Operations was unable to prioritize restoration efforts for critical customers. This left many small towns in difficult situations—without drinking water or water treatment facilities, gas stations unable to pump gasoline, schools without power, etc. This made it difficult to prioritize restoration efforts, and in some cases, creating public relations issues. Lessons learned discussed in the July storm debriefing presentation to the Illinois Department of Transportation identified a need to improve communications with local community leaders.[244]

d. Best Practices

This section addresses elements of Ameren's outage communications that Liberty recognized as a utility "best practice" or practices that proved to be especially effective. Based on its review, Liberty identified as an industry best practice:

- Ameren has the ability to manage and operate its five call centers as one or two virtual centers using "first available agent" routing so that calls can be balanced among available resources in all centers (currently deployed at Peoria and Pawnee centers)
- Ameren has developed a comprehensive disaster recovery plan for its call center telecommunications, and revised it following the 2006 storms.
- Ameren's Outage Information intranet application provides a quick snapshot of storm progress for any Ameren employee.
- Ameren's practice of embedding a company liaison into Illinois Emergency Management Association's (IEMA) Unified Command Center during catastrophic events helped expedite emergency response and improve communications.

Liberty also notes that Ameren has opportunities to adopt the following important best practices:

- Call center staffing plan for storms so that all call center employees know their role and job expectations during a large storm. In cases when the company can predict or model potential storm damage, making accommodations for call takers at local hotels, so they do not have to travel to work in bad conditions and to ramp up staffing quickly at the onset of a storm. (Recommendation IV-23.)
- Consistent and timely storm restoration information communicated internally and externally. (Recommendation IV-25 and IV-26.)
- High-volume stress testing to ensure telephony and integrated systems respond as designed during actual high-volume outage events. (Recommendation IV-27.)

[243] Response to Data Request #8-G.
[244] Response to Data Request DR #455.

The use of the above outage communications "best practices" combined with Ameren's implementation of Liberty's recommendations will further improve the company's outage communications and ultimately, improve customer satisfaction.

4. Conclusions

1. The Ameren-IL call centers had no formal emergency storm plan documented and were unable to ramp up staffing as quickly as needed during the 2006 storms to respond to customer calls. (Recommendation IV-21)

Ameren's call centers do not have a call center formal Storm Plan documented today, nor did they have one prior to the July and November/December 2006 storms. The lack of a plan forced management to ask for volunteers to cover after-hours and weekend needs. Ameren enforced mandatory overtime in the November/December 2006 storm after the weekend staffing proved insufficient. As a result, Ameren-IL was short staffed for the weekend and overstaffed during the following week. In addition, weather conditions made it difficult for employees to report to work during the November/December 2006 storm, further reducing Ameren-IL's available staff. Ameren could not take advantage of its contractor workforce because the contractor had not been trained to handle outage calls, nor had the contract had been established for weekend and after-hour support. In addition, Ameren did not configure the telephony to easily shift call volume to the contractor's facilities.

2. Ameren experienced significant failures in its call center telephony during the extremely high volume of calls received during 2006 storms. (Recommendation IV-22 and IV-26)

The systems blocked many Ameren-IL customer calls during both 2006 storms, largely due to insufficient capacity of its telecommunications facilities, especially its high-volume outage-reporting provider, Stericycle.

Additionally, various technology failures inhibited call flow and made it difficult for customers to report outages. Ameren instituted patches and "workarounds" to deal with some of the problems; however, the failures damaged the caller "experience" and customer satisfaction, and further inflated call volume.

3. Ameren was unable to recognize the extreme level of call blocking occurring during the storms. (Recommendation IV-22 and IV-26)

Ameren cannot monitor its 800-network traffic, nor can it verify that calls are terminating successfully.[245] Ameren can only verify that trunks are operating and observe performance. As a result, Ameren did not know that customers were having trouble contacting the company during the 2006 storms. Supervisors brought problems to Information Technology's attention after Ameren call-takers relayed customer comments to the call center supervisors during the storms. Ameren did not understand the scope of the problem until after the storm, when AT&T was able to provide Ameren with network traffic statistics.

[245] Interview #43, October 25, 2007.

4. Callers wishing to report an emergency situation, such as a gas leak, downed line, or fire had difficulty reaching an Ameren agent. (Recommendation IV-22 and IV-26)

In total, there were 17,930 blocked emergency calls during the first three days of the November/December 2006 storm; Ameren-IL's emergency trunks were not large enough to handle this volume of emergency calls. As a result, callers wanting to alert Ameren to a dangerous situation received busy signals while trying to reach dedicated emergency lines. Callers had to redial repeatedly until they reached the company, and then wait in queue for an available agent. This delayed getting critical information to the field to locate and mitigate these emergencies. Furthermore, the blocking of emergency phone calls is a public safety concern, delaying the dispatch of first responders to assess and secure, lengthening public exposure to unsafe conditions.

5. Ameren has instituted appropriate disaster recovery contingencies for its call center telecommunications equipment.

Ameren has instituted an appropriate Disaster Recovery Plan for its telephony equipment. Ameren successfully tested its Disaster Recovery Plan in October 2007, including the simulation of a complete failure of the St. Louis telephony servers.[246] This was the first whole-scale test of the equipment. Ameren plans to conduct tabletop Disaster Recovery drills a minimum of two times per year on a random basis, working through the process that various employees would follow based on various scenarios. Ameren is considering an annual drill, similar to the one conducted in October, going forward.[247]

6. Ameren's Corporate Communications group did not deliver a consistent message nor did it make a real effort to obtain Estimated Times of Restoration from Operations. (Recommendation IV-23)

One of the most vital functions of a utility's Corporate Communications department during a major storm is to make sure that all employees present the same information about storm restoration to their contacts outside the company. In addition, it must effectively disseminate storm restoration status information to stakeholders—state and local government officials, large industrial customers, the media, employees, and customers. The goal is to deliver the same message to the press, mayors, legislators, city officials, and the next customer calling into the call center. A critical component of this message is the anticipated time and date of restoration.

Corporate Communications did not effectively coordinate with all relevant groups to gather and disseminate storm restoration information. While Corporate Communications participated in EOC conference calls, it did not take control of the "storm message" for the company and it did not press Operations for anticipated restoration times. Although Corporate Communications had a "Communications Plan for Severe Storms," it did not appear that it followed the plan. Rather, the group fell into a reactionary mode, returning "media hotline" calls as it received them, and putting out fires as they popped up.

[246] Response to Data Request #326.
[247] Interview #43, October 25, 2007.

At a point when the public, state, and local government officials were unhappy with restoration progress and the lack of information, Corporate Communications neglected its responsibilities. As a result, Ameren delivered conflicting messages to the press, city and emergency officials, and customers calling into the call centers. Ameren did not effectively provide estimated times of restoration to customers, the public, city and state officials, call center representatives, or other key employees during the 2006 storms. In addition, the timing and limitations in the level of detail provided about the storm and restoration progress frustrated customers, the media, emergency and public safety coordinators, and government officials, ultimately creating more phone calls and customer dissatisfaction.

7. Ameren's Corporate Communications Storm Plan for Severe Storms does not reference or coordinate with Ameren's Electric Emergency Restoration Plan. (Recommendation IV-24)

There is no reference in the Corporate Communications Storm Plan for Severe Storms to the corporate Electric Emergency Restoration Plan or the Ameren emergency response organization. To be effective, emergency plans need to be coordinated and consistent with each other. In addition, the plan does not contain any information concerning the communications emergency response organization or job duties within that organization.

To be a complete and effective corporate communications emergency response plan, it should furnish this information and should be coordinated with and refer to the corporate EERP. Ameren-IL should complete this improvement within six months of the date of this report.

8. Ameren-IL did not have a consistent and coordinated approach to keep city officials and municipal leaders informed. (Recommendation IV-25)

Ameren did not have a consistent or coordinated approach to keep city officials and municipal leaders informed. In addition, critical infrastructures, such as water treatment plants, lift stations, gasoline stations, hospitals, and nursing homes, were not easily identifiable in the Outage Analysis System. This made it difficult to prioritize restoration efforts, and in some cases, creating public relations issues. Since the 2006 storms, Ameren has identified critical infrastructure accounts in the Outage Analysis System. However, Ameren has an opportunity to improve its relationships in all communities and further educate constituents in its storm restoration process.

5. Recommendations

IV-21 Create a call center staffing model to facilitate quick ramp-up and consider staging agents in nearby hotels in preparation for a large storm, especially one that makes travel to the center difficult or unsafe.

To be adequately prepared for the high volume of calls into its call center during a large outage, Ameren-IL should have adequate and experienced agents on hand to respond. This could be a combination of Ameren employees and third-party agents, if the agents have appropriate access to Ameren information systems and restoration information. In either case, Ameren should be prepared to fully staff centers to be able to respond to customer outage calls.

To assist with the need to ramp up staffing beyond normal staffing levels, Ameren should develop a call-center resource plan that it activates during major storms or large outage events. Integrated with this plan should be a staffing model that will provide guidelines for adding resources, based on the predicted severity of the event, projected call volumes, the timing, and expected duration.

Ameren should consider a pre-storm staging strategy for its call center agents, especially when weather makes travel difficult. Ameren's planning process should ask agents to come to the centers prepared to spend several days away from home, if necessary, and arrange for rooms in a nearby hotel, along with meals and other logistics. Ameren-IL should complete this improvement within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-22 Redesign call center technology to improve communications with customers during a large outage or storm.

While Ameren has committed to adding more physical telephone trunks to improve the overall capacity of its call centers,

- Ameren-IL should reconsider its routing strategies. It should route calls to the high volume IVR provider well before Ameren reaches maximum capacity. This will ensure that enough of Ameren's inbound trunks are available to supplement dedicated emergency trunks to eliminate all blocking on emergency wire-down and gas odor calls.
- Ameren-IL should alleviate the telephony capacity restraints to minimize instances when callers receive busy signals.
- Ameren should implement network-level monitoring services to be able to track the disposition of calls routed outside its centers, to vendors and high-volume overflow service providers.
- Ameren should continually review its call volumes, handle times, and service level performance to ensure the call center is adequately sized (trunks, seats) to deliver responsive service.

Ameren-IL should complete this improvement within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation and indicated that it is reviewing various options to meet it.

IV-23 Revise and update Ameren communications policies and develop comprehensive communications procedures related to outage communications.

Communications policies must be comprehensive and should address all aspects of outage-related communications and the organizations and personnel involved. They should include communications intended to prepare customers and their communities for outages, such as media advertisements, mailings, and bill inserts, in addition to emergency communications and information provided while an outage is in effect. They should also include post-outage communications, such as debriefings with city officials, reports to the ICC, and media articles explaining outage causes and remedial activities. Policy documents should cover both internal

and external communications, and should establish the roles and responsibilities of all participants in the various processes. This includes not only communications personnel and others in the traditional public affairs functions, but also Operations and Customer Services employees.

Once Ameren establishes and documents revised and updated policies, it should write procedures that clearly identify the actions that responsible individuals should take. Procedures should focus on the communications processes and, as such, should cross department lines. This will mitigate the effect of future organization changes on communications procedures.

The procedures should emphasize other important aspects of communications, such as the need to press Operations for accurate estimates of restoration times, specific time requirements for advanced communications, thoroughness, and consistency. Ameren-IL Communications should server as the "gatekeeper" to coordinate and control of the information released to the media, the recordings placed on the telephone systems, and the information relayed by other personnel in the field, such as the community relations' representatives.

Procedures should also address coordination with community relations officers to ensure that Ameren keeps key customers, government officials, and others informed.

Finally, the procedures should include a requirement and process for a periodic review and update. This should include the processes as well as personnel names, locations, telephone numbers, etc. The review and update process should call for regular interface with personnel outside Ameren, such as customers, government officials, the ICC and the media, in order to ensure that communications policies and procedures are still meeting their needs. Ameren-IL should complete this improvement within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-24 Modify the Corporate Communications Storm Plan for Severe Storms to emphasize effective communications and better coordination with the Emergency Operations Center.

Ameren should revise the Communication Plans for Severe Storms to reference the corporate EERP and other emergency plans and to establish consistent definitions of storm levels between the different plans. Ameren-IL should complete the recommendation within six months of the date of the final report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-25 Ameren should pursue a more coordinated and consistent approach to keeping community leaders and municipal officials better informed of storm restoration status.

Ameren should standardize and coordinate community relations efforts among the Illinois divisions. The role of a community relations officer should clearly specify duties during major storms as well as day-to-day activities to develop relationships, maintain contact lists, update

critical infrastructure records, and educate communities on Ameren's storm response approach. This includes interfacing with all communities, big and small, within the Illinois service territory.

Ameren should be more proactive during storms, contacting community leaders regularly before, during, and after the storm to provide an update on restoration progress, so that they can keep constituents informed and make proper decisions. Ameren-IL should complete this improvement within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-26 Rigorously test call-handling technology to ensure it operates to expectations and specifications.

Ameren owns a HAMMER server from Empirix that allows testing of its call center scripting and applications. However, the HAMMER tool is limited to 48 simultaneous calls and cannot simulate the high volumes needed to sufficiently test Ameren's telephony, such as the volumes received during the peak calling periods of a large storm.

Ameren has made changes and improvements to its telecommunications facilities since the 2006 storms, including increasing the capacity of its third-party outage overflow provider. It is critical that Ameren stress test these changes to ensure proper performance during future storms, especially in light of its performance during the 2006 storms. The test should place great demands on Ameren's existing call answering technology, simulating at least 30,000 calls per hour, to demonstrate system performance under extremely high call volumes. This will help Ameren confirm the upper limitations of its customer-facing technology in terms of simultaneous callers, queue build-up, and systems response. The test will also provide important feedback in terms of how the system works as a whole, from the PBX through the IVRs and to an agent as well as the overflow to Stericycle. Many of the problems encountered during the 2006 storms could have been avoided if Ameren had comprehensively stress tested its telephony after each major equipment upgrades or change.

Additionally, Ameren's emergency drills should include scenarios that test the supporting technologies and telephony. This will help Ameren be prepared and more responsive during emergencies. Ameren-IL should complete this improvement within one year of the date of this report and after major modifications to its telecommunications equipment or supporting systems.

In its comments on the draft report, Ameren-IL accepted this recommendation.

F. Support Organizations

1. Objectives

This section provides a description and Liberty's evaluation of the support functions that were part of the Ameren emergency organization responding to the 2006 storms. Specifically, this report provides an analysis of each specific support function and its effect on the restoration of service to Ameren-IL's customers. The report addresses the following item in the ICC's Request for Proposals for this investigation:

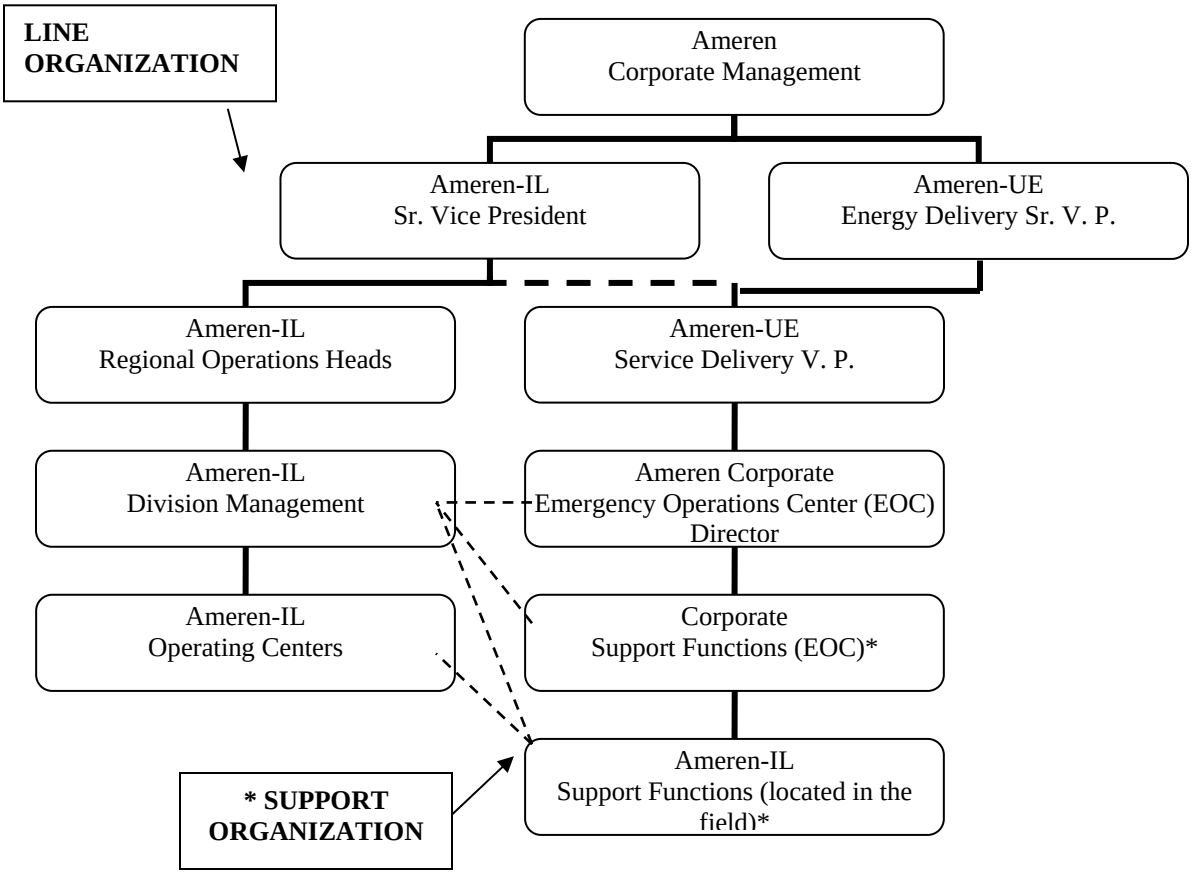
- **4.3.2.5.29** An evaluation of the performance of the utilities' support organizations such as safety, security, logistics, materials, and transportation.

2. Background

An evaluation of a utility's response to a major outage event rightly focuses much attention on the "line organization." Section IV.C (Organizational Performance) and Section IV.G (Field Restoration) contain the findings and analyses of Liberty's review of Ameren-IL's line organization during the two 2006 storms. Liberty defines the Ameren-IL line organization as the corporate management structure responsible for oversight and direction of the storm effort, the corporate storm management organization (*i.e.*, the Emergency Operations Center (EOC)), and the Ameren-IL emergency organization, including regional operations, the divisions, and the operating centers. The functions of storm management, damage assessment (field checking)/ engineering, dispatch, first responders/switchmen, line repair crews, and vegetation management (tree) crews are included in the line management organization.

This section of the report deals with the support functions, which are Safety, Stores (Materials), Transportation/Fuel, Security, and Logistics (Lodging, Meals, Laundry). A military saying is that "an army fights on its stomach," meaning that the military line organization needs ammunition, food, fuel, and supplies to do its job. Similarly, the utility's line emergency-response organization needs support to be timely, efficient, and reliable.

The chart below shows the relationship between the emergency response line organization and these support functions.



Ameren personnel with the responsibility to lead a support function or to perform a role at the corporate level in that function are in the box entitled, "Corporate Support Functions (EOC)." They were either located at or near the Emergency Operations Center (EOC) at the Ameren General Office Building in St. Louis or maintained close and ongoing contact with the EOC from their workstations during the emergency response. These individuals communicated and coordinated directly with Division Managers and/or Division Superintendents or their designees. They provided direction and support to the members of their support organization who were located in the field in the Ameren-IL service area. The members of the support organization shown in the box entitled, "Ameren-IL Support Functions (located in the field)" communicated and coordinated directly with Division Managers and/or Division Superintendents or their designees as well as the Ameren-IL supervisory personnel in charge of the restoration in the operating centers.[248]

3. Findings and Analysis

This section presents Liberty's findings and analysis of:

1. The organizational structure of the following support functions assisting the Ameren-IL emergency response organization in the two 2006 storms:

- Safety

[248] Response to Data Requests #5 and #70 and Interview #77 (November 2, 2007).

- Security
- Logistics
- Stores/Material
- Transportation/Fuel

2. The effectiveness and timeliness of the performance of the above organizations in supporting the Ameren-IL response effort in the two 2006 storms, including the organization's performance in:

- Promoting and ensuring employee and public safety
- Providing responders with necessary information, equipment, services, supplies, etc.
- Supporting and enabling responders in restoring service as quickly and efficiently as possible.

a. Safety Support Function

No matter how timely and efficiently a utility restores service in a major outage event, if the safety performance—protecting the safety of the public and the response workers—was not good, the effort was not successful. This segment analyzes how Ameren-IL organized and performed its safety support function.

(1) Safety Support Organizational Structure

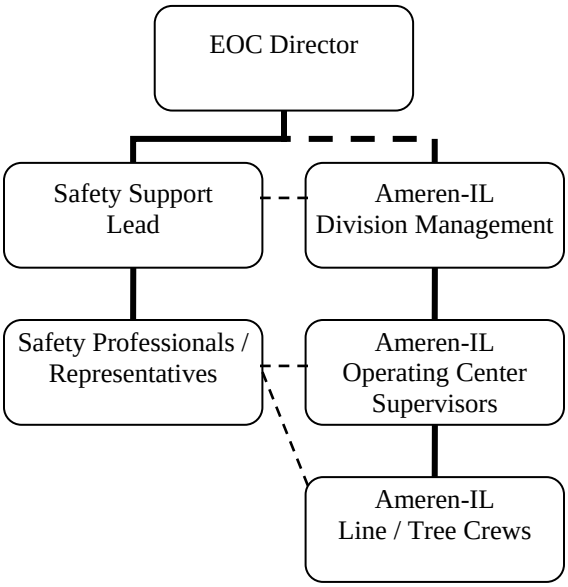
The Safety Lead, located in the Ameren General Office Building in St. Louis, headed the safety support organization for Ameren-IL in the July 2006 storm. In the July storm, this individual was the Managing Supervisor, Safety, Energy Delivery, with responsibility for safety in Missouri and Illinois. He, like the other lead personnel who had responsibility for support functions in the two 2006 storms, had good experience in his assigned functional area. In his emergency response role as Safety Lead, he reported directly to the Emergency Operations Center (EOC) Director. The safety professionals/representatives assigned in the field reported to him as Safety Lead. The normal complement of Ameren-IL safety professionals in July 2006 was six. Ameren brought in additional qualified safety professionals from other areas of the company (*e.g.*, the nuclear organization). In addition, some of the line and tree contractors had safety representatives designated for their contingent. The Safety Lead requested that all outside crews/teams coming in from outside to assist Ameren either bring their own safety professional or designate a member of the crew/team as the safety representative. The total of the safety professionals/representatives for the Ameren-IL area for the July 2006 storm was thirteen (13).

Ameren changed the safety support organization for Ameren-IL for the response to the November/December 2006 storm. Rather than report to the corporate EOC Safety Lead, the Ameren-IL safety professionals/representatives reported to the various division managers where they were assigned. The total number of safety professionals/representatives for the Ameren-IL area for the November/December 2006 storm was twelve (12).[249]

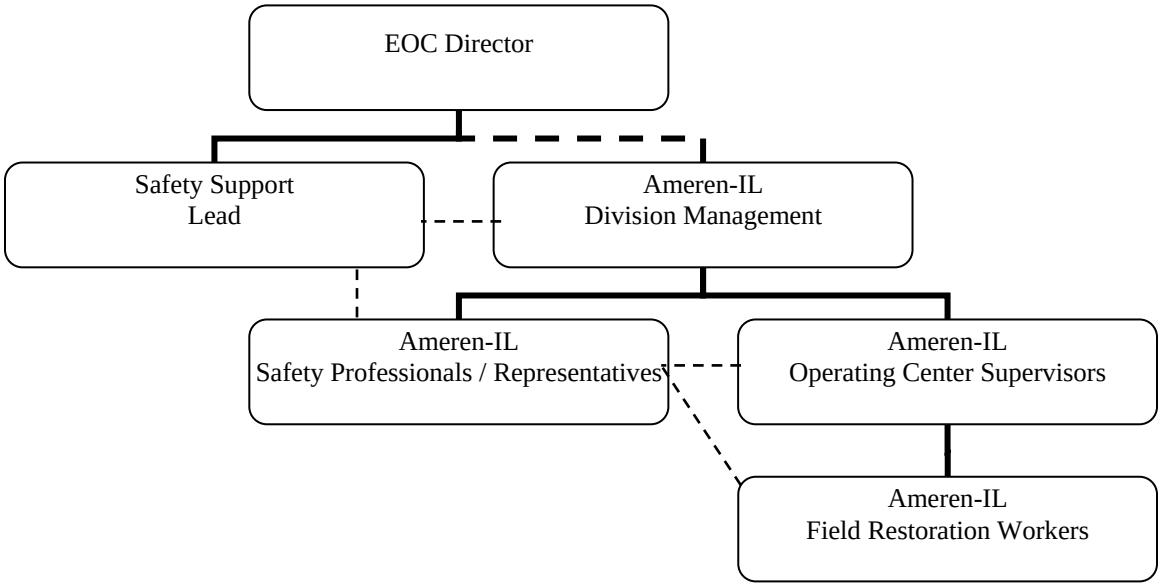
The two charts below depict the Safety Support organization for the two storms.

[249] Interview #92 (November 15, 2007), Response to Data Requests #76 and #160.

July 2006



November/December 2006



Ameren-IL did not give a specific reason for this organizational change. However, in an interview with the Ameren-IL CEO (who was the Senior Vice President, Ameren-IL, during the two 2006 storms), Liberty learned that Ameren's top management had made the decision in the spring of 2006 to begin moving toward a state-run organizational model.[250] In light of the move to bring in a Co-Director of the Emergency Operations Center (EOC) with specific responsibility for Illinois during the November/December 2006 storm response, and the subsequent move to establish a separate Illinois EOC in 2007, it seems reasonable to assume that this change in the safety support organization was made as part of the move to more individual state control.

[250] Interview #15 (November 14, 2007).

Regardless of the reasons, Liberty found that the Ameren-IL Safety Support organization for the November/December 2006 storm response was not the best option. When the safety professionals/representatives report directly to the assigned Division Manager, there is a negative effect on communications among these individuals as well as the coordination of a consistent approach to the safety support function. Flexibility is affected, as it becomes more cumbersome to quickly move the safety representatives than if they were all reporting to one Safety Support Lead. Now that Ameren-IL has established its own Emergency Operations Center (EOC), it would be better if it establishes a Safety Support Lead position at the Illinois EOC and have all safety professionals/representatives report to that lead.

(2) Safety Support Organizational Performance

Safety performance is the responsibility of each individual employee, of each crew or work unit, of each functional group or department, and ultimately the entire emergency response organization. Unless each of these maintain a high level of care and focus on safety rules and precautions, safety performance will suffer. The emergency response line organization has the highest exposure to safety incidents, accidents, and injuries, and typically, the majority of safety issues arise from this group. Section IV.G (Field Restoration) covers specifics of the actual safety performance of the Ameren-IL emergency response organization.

The focus of this segment of this report is on the activities of the Safety Support group in assisting the Ameren-IL emergency response organization. Because this group assisted Ameren-IL only during the July 2006 storm response, Liberty confines its comments here to activities and results for that storm only. Section IV.G (Field Restoration) includes a review of the November/ December 2006 safety-related activities, assigned to the Ameren-IL operating divisions.

The Ameren corporate Electric Emergency Restoration Plan (EERP) in use at the time of the 2006 storms did not include a section on safety. Recommendation III-1 of Chapter III (Emergency Plans) recommended that Ameren add safety, as well as other functions not covered in the plan. In the absence of any plan to direct the Safety Support Lead, the individual in that role performed the activities that were deemed the most appropriate and useful to accomplish the task. Upon review, Liberty found that the activities were appropriate and accomplished the desired goal.

At the onset of the July 2006 storm, which occurred after the end of the normal workday on July 19, the Safety Support Lead began following the outages through use of his “Blackberry.” After receiving a call from his supervisor, he contacted all of the safety professionals. He instructed them to pack and report early the next day. For the safety professionals in the affected area, he assigned a specific operating center and told them to report there. He instructed the others to begin traveling in to the metropolitan St. Louis area and that they would receive their assignment while en route. This gave the safety professionals the amount of specific instruction they needed while allowing time to determine where their services could be put to the best use. The Safety Support Lead reported that there were no conflicts with any of the Ameren-IL operating divisions on his assignment of safety professionals in the July 2006 storm.

The Safety Support Lead did not have a workstation at the Emergency Operations Center (EOC), but was located in the same building at the Ameren General Office Building in St. Louis. He

made "ten to twelve visits per day" to the EOC during the July 2006 restoration effort. He described his goal as trying to maintain a "decent knowledge of where work was going on." He worked closely with the logistics group to learn where Ameren housed people so that he could get safety professionals to go there at the start of the day. He attended all morning Resource Update Calls at the EOC, providing a report on the call. His report covered safety incidents and the areas of focus of the safety group.

Safety professionals made a concerted effort to meet with outside crews at staging areas when they first arrived on Ameren property. They tried to go where the crews were going. The Safety Support Lead thought they did a good job in meeting incoming outside crews for orientation in the July 2006 response effort. As an example of the effort toward that end, in one instance Safety called a Division Superintendent to meet a crew at 10:00 p.m. when no safety professional was available.[251]

The area of communications is extremely important for effective safety support, as it is for every other emergency response function. Two-way communications between the Safety Support Lead and the safety professionals/representatives, as well as between the Safety Support organization and the rest of the emergency response organization, are essential. As noted above, the Safety Support Lead participated in the EOC Resource Update Calls. He did not hold special conference calls in the July 2006 storm with the safety professionals/representatives. In the November/ December 2006 response effort, when the safety professionals/representatives in the Ameren-IL area were reporting to the operating divisions, Ameren corporate Safety Support instituted two conference calls per day, one call with safety representatives from each outside crew/team (contractor and Mutual Assistance utility[252]), and one with Ameren safety professionals. The Ameren-IL safety professionals usually participated in these calls, even though they were no longer reporting to the corporate Safety Support Lead.[253] Conference calls such as this among support function groups are a utility "best practice" and should be part of the standard procedure by these groups during a major outage event.

Two areas can be problematic in the Safety Support function. To the credit of the Safety Support Lead and the safety professionals/representatives, there were no reported issues in either of these areas. The first is the perceived or actual authority of Safety Support personnel in their dealings with the rest of the emergency response organization. Put another way, how much weight is given to what they say in the area of safety rules and practices? There were no reported issues in this regard. The Safety Support Lead put it this way, "I think what I said was respected." The other potential problem area is feedback from field workers received by the safety professionals/representatives. Because of the emphasis put on safety, reports from the safety professionals/representatives concerning situations in the field that could pose a safety risk are routed quickly up the emergency response organization and receive prompt and close attention by those in leadership roles. There is sometimes a tendency among field workers to seek resolution to non-safety issues by reporting them to the safety professionals/representatives. Examples of this would be the quality of the meals, the lodging arrangements, the length of the

[251] Interview #92 (November 15, 2007).
[252] A "Mutual Assistance utility" is one which has entered into a reciprocal agreement with other utilities to come to each others' aid during major outage events on a "not for profit" basis.
[253] Interview #92 (November 15, 2007).

daily commute, etc. Liberty found that the safety professionals/representatives were seasoned veterans and did a good job of screening the feedback received from the field.

The Safety Support Lead addressed safety issues that arose during the restoration effort, such as the need for more specific direction on the amount of rest time between shifts for the field workers, the process for crew convoys traveling through intersections, identifying orientation sites, and specific incidents when personnel did not follow safety procedures correctly.[254] The post-storm critiques discussed these matters. Section IV.G (Field Restoration) addresses the orientation sites for incoming outside crews and the rest time issue.

b. Security Support Function

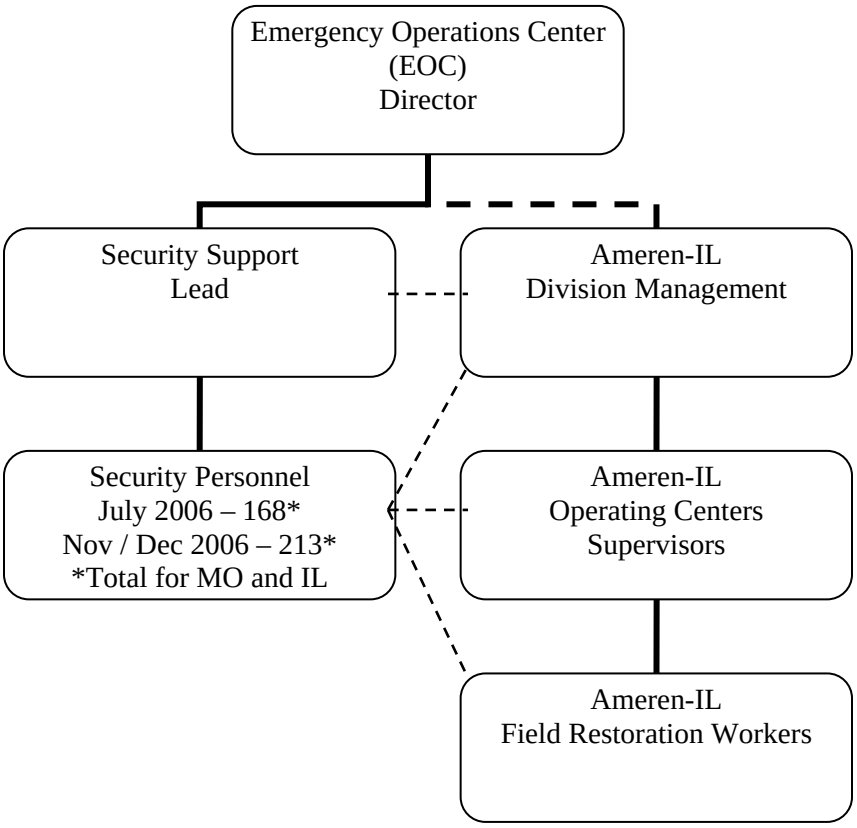
The security of workers, customers, and the public must be a primary concern of a utility emergency response organization during a major outage event. The large amount of outside workers and equipment brought into the area from other locations increases the risk. Irate customers, vandals, thieves, and saboteurs all pose a certain level of risk to utility workers, customers, and the public, as well as a risk of property theft and damage.

(1) Security Support Organizational Structure

Ameren's organization chart of the corporate Emergency Operations Center (EOC) showed two leads for the Security Support function. However, in interviews, the Security representatives explained that in reality, there was only one lead person for the Security Support function. The individual filling this role was Ameren's Manager, Corporate Security. He assigned the other full time Ameren security personnel various duties in the field. Contract security personnel and off-duty police officers made up the largest portion of the security workforce. Ameren did not furnish a breakdown of the number of security personnel assigned specifically to the Ameren-IL area for either of the two 2006 storms. Ameren corporate level managed overall security, with security resources moved between states as the need required. They used 168 security personnel to respond to the July 2006 storm, and 213 for the November/December 2006 storm. The diagram below shows the organization chart for the Security Support function.

[254] Interview #92 (November 15, 2007).

Security Support Organization



(2) Security Support Organizational Performance

The Ameren security organization has someone on call, twenty-four hours a day, every day. All of the Ameren fulltime security personnel are equipped with a laptop computer, a "Blackberry," and two different phones. With the aid of this technology, and the additional outside resources brought in, the Ameren fulltime security personnel were able to remain in their normally assigned area where they had familiarity with the facilities, geography, and available outside security resources.

The Security Support lead reported directly to the Ameren Emergency Operations Center (EOC) Director, but did not remain at the EOC in St. Louis. He functioned as a "floater," moving to those areas that needed attention, and checking on the status of security in different areas. The Security Support lead conducted two conference calls daily with Ameren security personnel. He or his designee sat in on all of the EOC Resource Update Calls. Two Security Support personnel sat in on all Ameren Logistics conference calls, which occurred three or four time per day.

The Security Support lead and other members of his staff arranged for coverage and support from local police departments in the affected area. When there was an equipment breakdown on one of the repair crews, Security would notify law enforcement and they would supply assistance.

Ameren focused attention on the issue of relations between union and non-union crews. The Ameren workforce in the affected area was comprised of bargaining unit employees, and

typically, Ameren would not bring in non-union forces to assist them in this area. Due to the significant damage and number of customers affected, Ameren had no viable alternative but to bring in non-union workers. Ameren contacted the union leadership and reached an agreement. There were some disgruntled individuals, and Ameren needed security assistance to ensure that "no games were being played." Ameren established clear boundaries between the work areas of union and non-union crews. Ameren separated the crews and placed marked security vehicles in clear sight. The effectiveness of these measures was borne out in the fact that with all of the exposure and risk, only one incident of a cut tire was reported.

During extended outages, customers' patience is put to the test and tempers grow short. This is a common challenge for all utilities responding to major outage events. The Ameren Security Support group experienced some problems with irate customers. Some geographic areas in particular were a concern. With regard to such areas, the established rule among repair crews was, "Don't work unsafe – back out – go to a safe haven." Ameren put out public safety announcements advising that repair crews would be withdrawn in threatening situations and only return when it was deemed safe. Again, these steps proved effective in that only one customer had to be arrested because of threatening actions.

Another important role of the security forces was the protection of equipment and tools belonging to outside repair crews who left trucks parked overnight at staging sites and hotel parking lots. The security forces successfully protected all of this equipment and property during the two storms, with only one incident in which someone stole tools when a crew came in earlier than expected, before the security detail was in place.

Given the large number of workers, equipment, and tools involved, and the difficult situations attendant with prolonged power outages, Liberty found that the Ameren Security Support function performed their role well in the two 2006 storms.

c. Logistics Support Function

Three people who headed the Logistics Support functions defined logistics as including:[255]

- Security
- Fueling
- Lodging
- Meals
- Transportation
- Laundry
- Staging Sites (excluding materials)

Liberty addresses security, fueling, and transportation separately. Therefore, the functions addressed in this segment as being included in the Logistics Support function are Meals, Lodging, Laundry, and Staging Sites (excluding materials).

[255] Interview #85 (November 27, 2007).

(1) Logistics Support Organizational Structure

Three individuals who served as "directors" or leads headed the Logistics Support function. They were located at the Emergency Operations Center (EOC) in the Ameren General Office Building in St. Louis. The three worked as a team; there was no one designated Logistics Support lead. They divided the different logistics areas such as lodging and meals among the three, rather than assignment responsibility by state. Ameren brought in three or four additional people to assist the three leads at the EOC. The rest of the employees working in the Logistics Support area were located in the operating divisions where field personnel needed the logistical support. The table below shows the number of employees who worked in these support areas in the two 2006 storms.

Logistic Support Staffing – 2006 Storms[256]

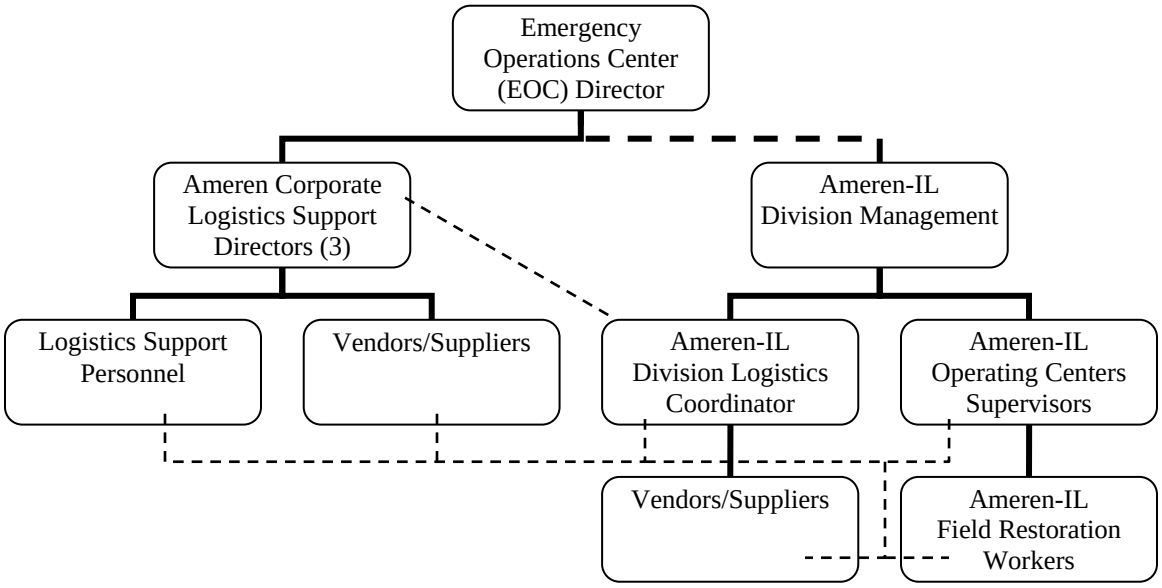
	July 2006 Storm		November/December 2006 Storm	
Logistics Area	EOC	Ameren-IL	EOC	Ameren-IL
Lodging	86		93	
Meals	3		45	
Laundry	11		3	
Staging Sites*	4	4	28	5
Total	104	4	169	5

*Set up, maintenance, & management, traffic control

The disparity in the staffing numbers shown in the "EOC" column compared to the Ameren-IL column for these two storms was due to the approach taken by Logistics Support to make assignments by logistics area rather than by state or operating division. This was an acceptable approach. The reduction in the numbers assigned to "Laundry" was due to Ameren's decision to discontinue its July 2006 practice of providing centralized laundry service in the metropolitan St. Louis area for the November/December 2006 storm. The general increase in staffing for the November/December storm was understandable given the larger number of workers for that storm (3,553 compared to 1,518 in July 2006). The staffing level of three employees to handle meals for the field workers in July 2006 was woefully inadequate.

[256] Response to Data Request #160

The diagram below shows the organization of the Logistics Support function.



The dashed lines on the above organization chart can be confusing. The concept of the Logistics Support organization was that the three Logistics Support heads at the EOC, with logistics personnel working for them, engage vendors and suppliers to provide certain supplies and services; they also coordinate closely with the Division Logistics Coordinators, who are located in the operating divisions and report directly to the Division Manager. The Division Logistics Coordinators are part of the division emergency response organization, and are not included in the staffing numbers for corporate Logistics Support. These Division Logistics Coordinators, working in concert with the corporate Logistics Support staff also engaged vendors and suppliers as needed to provide certain supplies and services. There was close coordination between the corporate Logistics Support staff, the Division Logistics Coordinators, vendors and suppliers engaged by corporate and the divisions, and the "end users" the operating centers and the field restoration workers.[257]

(2) Logistics Support Organizational Performance

The three individuals serving in the role of Logistic Support Co-Director had very little logistics experience between them. Liberty understands that no utility maintains a staff of people who do nothing but logistics work. Any utility employee moved into a logistics role during a major outage event comes from another work area. Hopefully, some of the leaders of the logistics support function will have had several years' experience with logistics during a major outage event. In the case of the two 2006 storms that are the subject of this report, Ameren had three employees heading up Logistics Support, none of whom had been working logistics in major storms for as long as a year. The most experienced of the three began in the fourth quarter of 2005, the second most experienced began with a storm in March 2006, and the third got his first logistics experience in the July 2006 storm. Notwithstanding this fact, the three Co-Directors acquitted themselves well. Liberty did not find any evidence of serious logistics deficiencies in

[257] Response to Data Request #70, Interview #85 (November 27, 2007).

either of the storm response efforts, certainly nothing that affected the restoration time or safety and welfare of the workers.

The Ameren corporate Electric Emergency Restoration Plan (EERP) provided very little guidance for the Logistic Support organization. Liberty addresses this fact in Chapter III (Emergency Plans) of this report.[258] The Logistic Support function leads referred to the EERP, but had to develop the tasks "as they went along."[259] Ameren brought additional people into the EOC to help them. They identified necessary tasks, began developing estimates of numbers of outside personnel coming in, and adjusted as things changed. They used information software, Resources on Demand (ROD), and a spreadsheet developed by Asset Management to help track pertinent information. Logistics Support made extensive use of the Ameren internal web site (SharePoint) for gathering and posting storm management information.[260] The Logistics Support organization held several conference calls each day to share information and update everyone on status and issues.[261]

The following comments address some of the particular activities and issues in four logistics areas.

Meals

During the November/December 2006 restoration effort in the Ameren-IL area, there were 16,000 box lunches and 38,000 meals prepared.[262] No separate figures were available for Illinois in the July 2006 storm. Mid-day meals for restoration workers were box lunches. This avoided the non-productive time of shutting down workers and traveling for a lunch meal. The Ameren-IL operating divisions and operating centers arranged for their box lunches with coordination and support of the Division Logistics Coordinators. The largest number of those lunches came from independent vendors (*i.e.*, delicatessens and caterers). Some commercial restaurants in some areas provided box lunches. At the time of the July 2006 storm, Ameren only had a few providers of box lunches and had to quickly find and engage others. The outlying areas had been working in advance on specifications for box lunches and did not have much difficulty in finding providers because the amount of box lunches needed were less than in the metro area.

Ameren provided the morning and evening meals at or near the location housing workers. They did not provide meals at staging sites in the two 2006 storms, but are now considering this.[263] Feeding workers at the staging sites is a utility "best practice." Experience has shown that with proper planning and qualified caterers, the utility can feed large numbers of workers healthy, economical meals in a short period, eliminating a great amount of lost time eating at commercial establishments. Additionally, the utility can realize significant savings in lost time and expense by parking the trucks overnight at the staging sites and shuttling the workers to and from their lodging. This arrangement is very beneficial in the efforts to fuel all vehicles at night, provide security for the trucks, equipment, and tools, and to meet with workers in large groups for the

[258] Conclusion #5 and Recommendation V-3 in Chapter V, Emergency Plans.
[259] Interview #85 (November 27, 2007).
[260] Response to Data Request #8, Attachment 8-D.
[261] Interview #90 (November 27, 2007).
[262] Response to Data Request #8, Attachment 8-D.
[263] Interview #85 (November 27, 2007).

purpose of orientation and updates on safety, restoration progress, and other items of interest. Liberty recommends that Ameren adopt this practice.

Lodging

In the Ameren-IL area during the November/December 2006 restoration effort, there were a total of 10,000 "room-nights" engaged at 35 different hotels. Due to the tremendous influx of outside workers, the Logistics Support group was hard-pressed to accommodate all of the lodging needs. At one point, Logistics reported that they had "run out of hotels." In some locations, Ameren housed workers in school dorms secured by the Logistics Support group from school officials.

Logistics Support workers went to the lodging sites, assigned lodging, and personally checked workers into their lodging when they knew where the workers would be located. They sent volunteers out to assist at the school dorms with any needs that might arise. They made an effort to keep crews together and to locate them near their assigned work area.

In spite of the challenges, Ameren met all lodging needs and Liberty found no significant deficiencies in this area.

Laundry

In the July 2006 restoration effort, the Ameren-IL operating centers at E. St. Louis and Alton, known as Metro East, were included in a centralized laundry process set up in the parking lot of the Ameren General Office Building in St. Louis. Ameren brought in equipment and set up to handle all of the laundry needs in the metro St. Louis area. When the vendor had trouble initially getting the equipment up and running, 30 Logistics Support volunteers took all of the laundry to commercial Laundromats and worked through the night to get the laundry cleaned. Once the equipment was running, the centralized process worked well. The rest of the Ameren-IL area handled the laundry needs locally.

Ameren did not use the centralized laundry process in the November/December 2006 storm effort, and Ameren handled all laundry needs locally. Ameren washed over one thousand loads of laundry.[264] Liberty found no deficiencies in this area.

Staging Sites

The Logistics Support group was responsible for providing staging sites with ice, water, portable restrooms, trash receptacles, and other incidentals. The Stores/Material group was responsible for the material at each staging site.

Ameren set up staging sites at divisions and local operating centers located near the affected area. In the July 2006 storm response, Ameren set up two additional staging sites, one in East St. Louis, and one at Trenton, IL. In the November/December 2006 effort, Ameren set up two additional sites, one in Swansea, and one in Collinsville, IL. Logistics Support coordinated with

[264] Response to Data Request #8, Attachment 8-D; Ameren-IL Power Point presentation, "Ameren-Illinois Storm Response, November-December, 2006."

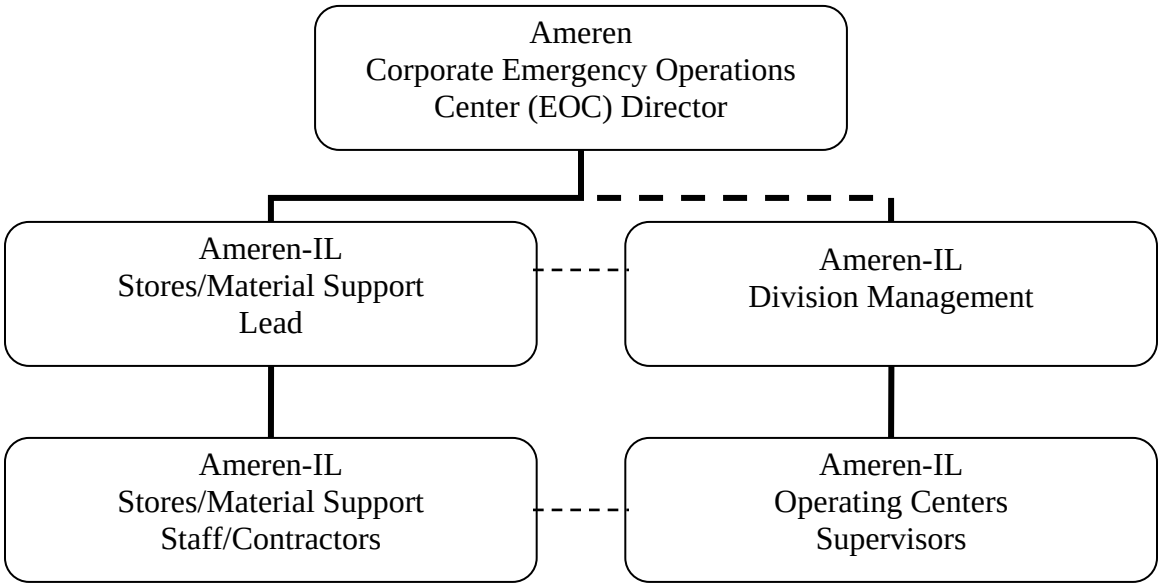
the divisions and with Stores/Material personnel to provide the needed supplies and services (as described above) for each staging site. Again, Liberty found no deficiencies in the Logistics Support response to staging sites.

d. Stores/Material Support Function

(1) Stores/Material Support Organizational Structure

The Stores/Material Support lead for Ameren-IL in the two 2006 storms was a superintendent in the Ameren Energy Delivery, Supply Chain organization with responsibility for all Illinois storerooms. During the 2006 storms, he was the Stores Storm Manager for Illinois, working out of the Materials Distribution Facility (MDF) in Decatur, IL. The total staffing for materials procurement and management for Ameren-IL for both storms was approximately 75.[265]

The diagram below depicts the Stores/Material Support organization and its relationship to the corporate Emergency Operations Center (EOC) and the Ameren-IL emergency response organization as used in the response to the two 2006 storms.



(2) Stores/Material Support Organizational Performance

The table below, which shows the material issued for each storm, provides a sense of the workload on the Stores/Material Support organization during the 2006 storms.

[265] Interview #89 (January 9, 2008); Response to Data Request #160.

Material Issued – 2006 Storms - Illinois[266]

Item	July 2006	Nov / Dec 2006	Total
Poles	848	1,359	2,207
Cross Arms	1,519	2,973	4,492
Wire/Cable (Ft.)	1,040,004	1,431,609	2,471,613
Transformers	806	601	1,407

The increase in three of the four items of material between the July 2006 and the November/December 2006 storms is reflective of the greater severity and scope of the winter storm event in the Ameren-IL area. The decrease in numbers of transformers is understandable in light of the fact that wind and lightning storms generally do more damage to transformers than do winter storms. The "bottom line" of the above numbers is that these were two significant weather events, and the Stores/Material Support organization had quite a challenge in supplying the Ameren-IL emergency response organization with the needed material in a timely and efficient manner.

The Ameren corporate Electric Emergency Restoration Plan (EERP) had no information on the duties/responsibilities of the Stores/Material Support organization. The Ameren-IL Stores/ Material Support Lead based the actions he took on his years of experience in this field and his specific experience in major outage events.

In the interview with the Stores/Material Support Lead, Liberty learned that he was not notified of the fact that a major outage event had occurred until July 20, the day after the initial impact. He was notified by a call to dispatch a material storm trailer to E. St. Louis. Liberty addresses the issue of Ameren's ineffective alert system in Section IV.B (Pre-Storm Preparations), and Recommendation IV-3 provides for the use of a paging system to avoid such problems in the future.

Material storm trailers were first used in Illinois in 1995. They are for storm use only. Each trailer contained enough material to outfit 50 poles in a 12,000-volt line plus services. There were 200 different types of material in each of these trailers. Within 24 hours of a trailer's return to the warehouse, personnel can fully load it and ready it for use again. Ameren-IL indicated that it could reduce this turn-around to a matter of a few hours in an emergency. Ameren-IL assigned stores supervisors at each location where it sent a trailer during a major outage event.

In the July 2006 storm response, Ameren-IL sent three material storm trailers to the field, one to E. St. Louis, one to Maryville, and one to Trenton, IL. In the November/December 2006 storm response, Ameren-IL also deployed three material storm trailers, one to Belleville in advance of the storm, and one each to Maryville and Decatur after the storm hit.[267]

The Stores/Material Support organization monitored the Outage Analysis System (OAS) to get information on the amount of damage. The function lead or his designee sat in on the Emergency

[266] Response to Data Request #71, Attachment 71-F.
[267] Interview #89 (January 9, 2008); Ameren-IL PowerPoint presentation, "Ameren-Illinois Storm Response, November – December, 2006."

Operations Center (EOC) Restoration Update Calls to provide and obtain information. Members of the Stores/Material Support group worked closely with Stock Control – Procurement. This group worked 18-hour days and provided good support. They worked with their normal supplier contacts and were able to get the material they needed. The Stores/Material Support function lead put it this way, "Coming out of the chute we gave them big numbers – got good support."[268] By this he meant that they operated under the philosophy that it would be much better to order more material than needed than to run out of material and delay restoration.

The trucking arrangement set up by the Stores/Material Support group to move the storm trailers worked very well; they moved the trailers quickly and efficiently.

Overall, this support organization fulfilled their role during both of the storms. Liberty found no instances in which a material shortage or delivery slowed restoration.

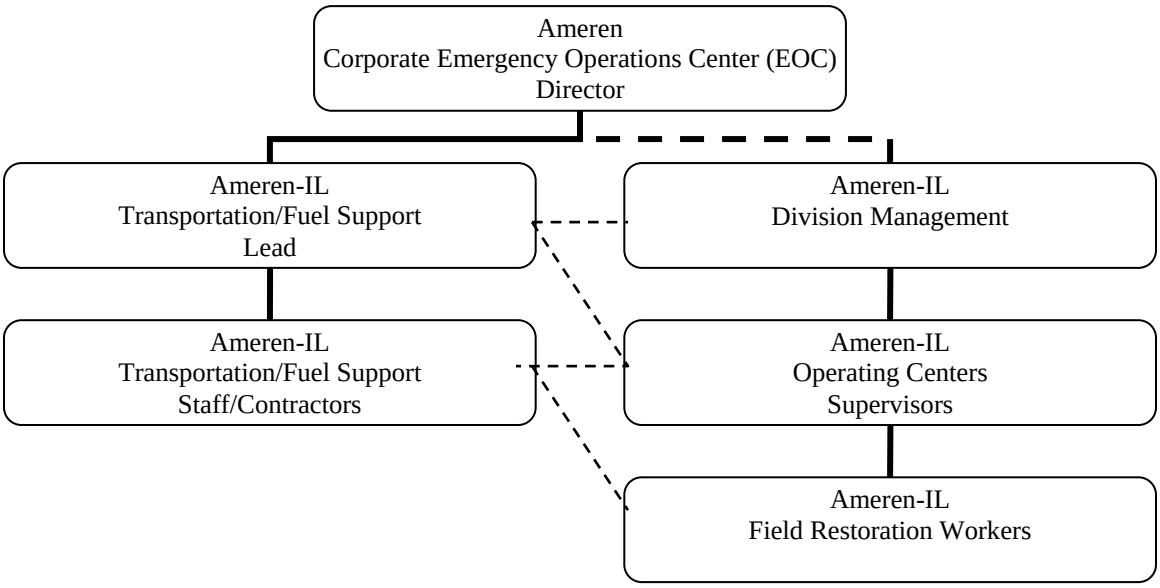
e. Transportation/Fuel Support Function

(1) Transportation/Fuel Support Organizational Structure

The Transportation/Fuel Support Organization consisted of one lead who reported directly to the Ameren corporate Emergency Operations Center (EOC) Director. The balance of the staffing for Ameren-IL in this functional support group was in the field. The staffing level for the Transportation/Fuel Support organization during the July 2006 response effort was 45, including the function lead. For the November/December 2006 storm effort, that number was 39. The Transportation/Fuel Support lead for the two storms was an experienced Ameren employee who serves as the Ameren corporate Fleet Administrator, with responsibility for Missouri and Illinois.[269]

The diagram below depicts the Transportation/Fuel Support organization and its relationship to the corporate Emergency Operations Center (EOC) and the Ameren-IL emergency response organization in place during the response to the two 2006 storms.

[268] Interview #89 (January 9, 2008).
[269] Interview #90 (November 27, 2007); Response to Data Request #160.



The function lead, while reporting directly to the Emergency Operations Center (EOC) Director, coordinated closely with management at the operating division level, and to somewhat of a lesser degree, with the supervisors in local operating centers. By far the most detailed coordination was between the Transportation/Fuel Support staff, the operating center supervisors, the team leaders, and other members of the field restoration workforce.[270]

This organizational approach provided the oversight and direction necessary, while at the same time allowing for the flexibility that is so important in coordinating processes such as re-fueling large numbers of trucks spread over a large geographic area.

(2) Transportation/Fuel Support Organizational Performance

The July 2006 storm response for the Transportation/Fuel Support organization did not get off to a very good start. In fact, it got off to a late start. Nobody notified the function lead of the major outage event or for the need of support until the second day of the storm, after crews had been working 1½ days. The trucks needed gas and gas stations were without power, a familiar situation in any major outage event.

The Transportation/Fuel Support group moved quickly into action. It had secured a contract with a supplier in 2005, and the group arranged with that supplier to provide tanker trucks[271] to handle the re-fueling needs. The maximum number of tankers brought in to help in either of the two storms was 23. As Ameren released outside work crews, it reduced this number. Ameren brought in tankers from Mississippi and Arkansas.

[270] Interview #90 (November 27, 2007).
[271] A "tanker truck" is a truck or a tractor and trailer rig equipped with a large storage tank, pump, and hose to facilitate the emptying of the contents of the tank. Varying sizes are used depending on whether the tank will be set up at one location to fuel many trucks, or if the re-fueling will occur at different sites, where there are fewer vehicles.

Ameren had re-fueling performed at night. The Transportation/Fuel Support group would find out through the divisions and operating centers (as well as Logistics) where crews were at night. It then arranged to get tankers to those locations.

As was the case with some other support functions, the Ameren corporate Electric Emergency Restoration Plan (EERP) did not contain any information to provide guidance to the Transportation/Fuel Support Lead or the members of that support group.

With his years' of experience, the function lead knew what actions to take, and provided effective leadership to this group. His office is one and one-half blocks away from the Emergency Operations Center (EOC) in the Ameren St. Louis General Office building. He spent a great deal of time at the EOC. He got regular updates on the number of workers and vehicles, and used this information to calculate the anticipated fuel needs.

One obstacle faced by this support group was the Illinois Fire Code regulation that does not permit "wet hose fueling" within 100 feet of a permanent structure. The only exception is during an "emergency." The regulation does not define an emergency. The function lead got an opinion from the Ameren legal department, and based on that used the Operations Managers as the authority to declare an "emergency." The state authorities did not challenge this during either restoration effort. The performance of the re-fueling process was excellent; there were no spills and no problems encountered.

The function lead worked 12 hours a day and turned it over at night to his back-up who monitored the re-fueling data – numbers of vehicles, amount of gas, vehicle owners, etc.

Although the re-fueling process was the largest single ongoing effort by this support group, another important duty was the maintenance and repair of vehicles to minimize down time. This group handled that challenge as well, using Ameren mechanics and independent shops as conditions dictated. When necessary, the Transportation/Fuel Support group also handled the repairs to contractor and Mutual Assistance utility vehicles, but the preferred arrangement was for those companies sending crews to send their own mechanics because of workload and familiarity with equipment.

Liberty found that the Transportation/Fuel Support organization fulfilled its role in supporting the Ameren-IL emergency response organization. There was no evidence of undue delays in restoration caused by lack of fuel, tardiness in the re-fueling process, or vehicle downtime waiting on repairs.

4. Conclusions

1. The Ameren employees who performed in lead support function roles all had good experience in their assigned storm role with one exception. (Recommendation IV-27)

Liberty interviewed all of the Ameren employees who served in a lead role of a support function in either one or both of the 2006 storms. In all but one case, the assigned employee had a number of years experience in that particular field. The one support function that had relatively

inexperienced people in the lead role was Logistics Support. Of the three Co-Directors assigned to lead this support function, one had begun working in that area in the fourth quarter of 2005, one had their first major storm experience in logistics in March 2006, and the third got his first experience in the July 2006 storm.

It is crucial to have lead personnel who are experienced in the assigned function. The past work experience provides necessary information to allow the lead to initiate the proper steps in a timely and efficient manner. This results in the response "line organization" receiving the right amount of support in a timely and efficient manner. In addition, contacts with other utilities, suppliers, contractors, and consultants developed through this experience provide a good network of assistance in procuring needed material, supplies, services, and equipment.

The three Co-Directors who headed the Logistics Support function acquitted themselves very well. Liberty did not find any evidence of serious logistics deficiency in either of the storm response efforts, certainly nothing that affected the restoration time or safety and welfare of the workers. However, having so little experience in the lead role of an important support function such as logistics is not the desired state. It is not fair to the employees who get the assignment or to those depending on their performance. In order to ensure timely and efficient performance in all areas of emergency response, a utility should seek to keep a certain level of experience in lead roles in the response effort.

2. The organizational change made in the Ameren-IL Safety Support function for the November/December 2006 storm response was not the best option for the response organization. (Recommendation IV-28)

In the response to the July 2006 storm, the safety professionals/representatives working in the Ameren-IL area reported to the Safety Support Lead, who was part of the corporate Emergency Operations Center (EOC) team. This lead person coordinated all of the activities of the safety professionals/representatives, who were assigned to different Ameren-IL operating divisions. In the response to the November/December 2006 storms, these safety professionals/representatives reported directly to the division manager in the division in which they were assigned.

This change in organization had a negative effect on communications among these individuals as well as the coordination of a consistent approach to the safety support function. It affects flexibility, as it becomes more cumbersome to quickly move the safety professionals/ representatives than if they were all reporting to one Safety Support Lead. Now that Ameren-IL has established its own Emergency Operations Center (EOC), it will be better served if it establishes a Safety Support Lead position at the Illinois EOC and have all safety professionals / representatives report to that lead.

3. The Safety Support, Stores/Material Support, and the Transportation/Fuel organizations did not have any emergency plan to direct their activities. The lead personnel of these support organizations did a good job in developing and implementing appropriate and useful action steps to accomplish the desired goal. (Recommendation IV-29)

As discussed in Chapter III (Emergency Plans), the Ameren corporate Electric Emergency Restoration Plan (EERP) in use at the time of the two 2006 storms was lacking information on

several important emergency response functions. Without any plan, the lead personnel and each of these support organizations had no specific direction as to the appropriate and useful steps to take in order to provide timely and efficient support to the Ameren-IL emergency response organization in their assigned area. Notwithstanding this fact, they did a good job in determining the necessary action steps to be taken. Ameren-IL should develop sections on each of these support functions to be included in the corporate Electric Emergency Restoration Plan (EERP).

4. Conference calls by the support function groups were not regularly scheduled and held during the two 2006 storms. (Recommendation IV-30)

Having daily conference calls among the team members involved in a particular support function is a utility "best practice." Given the large amount of restoration workers brought in to assist in the effort, with the attendant support needs, it is crucial that leads keep all team members updated with progress, developments, resource deployment changes, organization, and procedures. This is an excellent forum for team members to raise issues and seek guidance.

The Safety Support organization implemented conference calls for the November/December 2006 storm effort. It held two calls each day, one with safety representatives from outside contractors and Mutual Assistance utilities, and one with Ameren Safety professionals.[272] In addition, the Logistics Support organization held several conference calls each day.[273]

5. The Safety Support group employees, including the lead, were seasoned safety veterans. Their advice, suggestions, and guidance in safety issues were received well by the field workers in the emergency response organization, and they did a good job of screening the feedback from the field to give proper attention to genuine safety-related issues.

Two areas can be problematic in the Safety Support function. To the credit of the Safety Support Lead and the safety professionals/representatives, there were no reported issues in either of these areas. The first is the perceived or actual authority of Safety Support personnel in their dealings with the rest of the emergency response organization. Put another way, how much weight is given to what they say in the area of safety rules and practices? There were no reported issues in this regard. The Safety Support Lead put it this way, "I think what I said was respected."[274] The other potential problem area is feedback from field workers received by the safety professionals/representatives. Because of the emphasis put on safety, reports from the safety professionals/representatives concerning situations in the field that could pose a safety risk are routed quickly up the emergency response organization and receive prompt and close attention by those in leadership roles. There is sometimes a tendency among field workers to seek resolution to non-safety issues by reporting them to the safety professionals/representatives. Examples of this would be the quality of the meals, the lodging arrangements, and the length of the daily commute. Liberty found that the safety professionals/representatives were seasoned veterans and did a good job of screening the feedback received from the field.

[272] Interview #92 (November 15, 2007).
[273] Interview #90 (November 27, 2007).
[274] Interview #92 (November 15, 2007).

6. The Security Support function performed its storm role well, with few security incidents reported despite the exposure and risk involved in the two major outage events.

The Security Support group recruited assistance from security contractors and off-duty police officers to augment their workforce. They made arrangements with police departments in the impacted area, and law enforcement assistance was provided during times of equipment breakdown and threatening situations with irate members of the public. Considerable effort was expended to prevent any incidents involving Union and non-Union work crews. These efforts were successful in that only a few incidents were reported during the two 2006 storms.

7. The Logistics Support Co-Directors did a good job of developing the necessary tasks that needed to be performed in the absence of any information of this sort in the corporate Electric Emergency Restoration Plan (EERP). (Recommendation IV-31)

The Ameren corporate Electric Emergency Restoration Plan provided very little information on specific tasks needed in the logistics support function. As pointed out in Chapter III (Emergency Plans) of this report, Ameren-IL needs to revise the EERP to include more specific and helpful information. The Logistic Support Co-Directors brought in additional people, identified necessary tasks, began developing estimates of numbers of outside personnel coming in, and adjusted as things changed. They used software – Resources on Demand (ROD) – and a spreadsheet developed by Asset Management to help track pertinent information.[275] Logistics Support made extensive use of the Ameren internal website, SharePoint, for gathering and posting storm management information.[276]

8. The Logistics Support organization did a good job assisting the emergency response organization, but there are improvement opportunities in providing meals for the workers. (Recommendation IV-32)

Liberty's investigation revealed no significant deficiencies in the services rendered by Logistics Support in the areas of meals, lodging, laundry, and staging sites. (Logistics support is responsible for providing ice, water, portable toilets, trash receptacles, and other incidentals for staging sites, but not material.)

The staffing level for Logistics Support employees assigned to providing meals for workers was 3 for the July 2006 storm and 45 for the November/December 2006 storm. The July staffing was woefully inadequate for the meal function, and was reflective of the relative inexperience of the Logistics Support function leaders and the lack of specific guidance from the emergency plan. At the time of the July 2006 storm, Ameren only had a few providers of box lunches and had to quickly find and engage some others. The outlying areas had been working in advance on specifications for box lunches and did not have much difficulty in finding providers because the amount of box lunches needed were less than in the metro area.

[275] Interview #85 (November 27, 2007).
[276] Response to Data Request #8, Attachment 8-D.

Ameren provided the morning and evening meals at or near the location where it housed the workers. They did not provide meals at staging sites in the two 2006 storms, but are now considering this.[277] Feeding workers at the staging sites is a utility "best practice." Experience has shown that with proper planning and qualified caterers, large numbers of workers can be fed healthy, economical meals in a short period, eliminating a great amount of lost time eating at commercial establishments. Additionally, significant savings in lost time and expense can be realized by parking the trucks overnight at the staging sites and shuttling the workers to and from their lodging. This arrangement is very beneficial in the efforts to fuel all vehicles at night, provide security for the trucks, equipment, and tools, and to meet with workers in large groups for the purpose of orientation and updates on safety, restoration progress, and other items of interest.

9. The Stores/Material Support organization did a good job assisting the emergency response organization. There were no delays in service restoration due to material shortages or late delivery. This was despite the fact that the Stores/Material Support lead was not alerted to the July 2006 storm until the next morning. (Recommendation IV-33)

The Stores/Material Support organization monitored the Outage Analysis System (OAS) to get information on the amount of damage. The function lead or his designee sat in on the Emergency Operations Center (EOC) Restoration Update Calls to provide and obtain information. Members of the Stores/Material Support group worked closely with Stock Control – Procurement. This group worked 18 hour days and provided good support. They worked with their normal supplier contacts and were able to get the material they needed.

Nobody notified the Stores/Material Support lead of the fact that a major outage event had occurred until July 20, the day after the initial impact. He was notified by a call to dispatch a material storm trailer to E. St. Louis. Liberty addressed the issue of Ameren's ineffective alert system in Section IV.B (Pre-Storm Preparations), and Recommendation IV-3 provides for the use of a paging system to avoid such problems in the future.

10. The Transportation/Fuel Support organization did a good job assisting the emergency response organization. There were no undue delays in service restoration due to fuel shortages, tardiness in re-fueling vehicles, or vehicle downtime waiting for repair. This was despite the fact that the Transportation/Fuel Support Lead was not alerted to the July 2006 storm until the second day of the storm, after crews had been working for 1½ days and were having problems getting re-fueled. (Recommendation IV-34)

Re-fueling occurred at night. The Transportation/Fuel Support group would find out through the divisions and operating centers (as well as Logistics) where crews were being tied up at night. They then arranged to get tankers to those locations. One obstacle faced by this support group was the Illinois Fire Code regulation that does not allow "wet hose fueling" within 100 feet of a permanent structure. The only exception is during an "emergency." The Operations Managers declared an emergency, and state authorities did not challenge Ameren's decision. The

[277] Interview #85 (November 27, 2007).

performance of the re-fueling process was excellent, there were no spills, and no problems encountered.

This group also handled well the task of vehicle maintenance.

The July 2006 storm response for the Transportation/Fuel Support organization did not get off to a very good start because the function lead did not learn of the major outage event or for the need of support until the second day of the storm. The trucks needed gas and gas stations were without power, a familiar situation in any major outage event. The Transportation/Fuel Support group moved quickly into action and brought in as many as 23 tankers.

5. Recommendations

IV-27 Develop and implement a process to identify and train future response function leaders to provide appropriate levels of experience to all who will be in leadership roles in the emergency response organization.

Ameren-IL should review the roster of employees who are presently serving in lead roles in the emergency response organization to confirm experience level and anticipate the effect of attrition and retirements. Ameren-IL should identify future response-function leaders and employ them in emergency response roles in order to provide the necessary experience and prepare them to assume the leadership role. The goal should be to avoid having to place inexperienced personnel into response lead roles. Ameren-IL should complete this review and identify employees within six months of the date of this report, and determine storm assignments for future leaders and make those assignments in the next major outage event after it has completed the review.

In its comments on the draft report, Ameren-IL accepted this recommendation but proposed an implementation schedule that Liberty believes is too long.

IV-28 Establish a Safety Support function at the Ameren-IL Emergency Operations Center (EOC) with direct line authority over the safety professionals/representatives working in the Ameren-IL operating divisions during a major outage event.

The Safety Support Lead person should report directly to the EOC Director and have line authority over all safety professionals/representatives. Ameren-IL should include this organizational concept in the corporate Electric Emergency Restoration Plan (EERP) and should implement the concept within one month and update the EERP within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-29 Add a section on safety support, stores/material support, and transportation/fuel support to the Ameren-IL corporate Electric Emergency Restoration Plan (EERP). (Also, see Chapter III, Recommendation III-1.)

Ameren should add sections to the corporate EERP detailing these three support organizations, and the action steps the function lead personnel and other members of these support

organizations should take. Ameren-IL should complete this action within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-30 Implement daily conference calls for each support function assisting in a major outage restoration effort.

Ameren should revise the corporate Electric Emergency Restoration Plan (EERP) to include the daily conference call procedure as a standard practice among all support functions. Ameren should make this change to the EERP and implement the procedure within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-31 Provide necessary details in corporate and division Electric Emergency Restoration Plans (EERPs) to give appropriate guidance to logistic support employees. (Also, see Chapter III, Recommendation III-3.)

Ameren-IL should revise the corporate Electric Emergency Restoration Plan (EERP) and its division plans to include specific details on logistics duties and activities at the EOC, Division, and Operating Center level. Ameren-IL should complete this recommendation within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-32 Improve meal and feeding practices.

a. Ameren-IL should establish desired staffing levels of Logistics Support employees to assist in the meal function of Logistics Support, based on the number of restoration workers to be fed and the meal arrangements necessitated by the profile of the storm response. Ameren-IL should include this provision in the Ameren-IL Emergency Response Plan and complete implementation within six months of the date of this report.

b. Ameren-IL should identify caterers and other establishments throughout their service territory that are qualified, willing, and able to provide quality meals in the quantities and conditions that it might require. Ameren-IL should reach and maintain formal agreements with these providers to ensure on-going and short-notice access to their services in the event of future emergency response events. Ameren-IL should include this provision in the Ameren-IL Emergency Response Plan and complete implementation within nine months of the date of this report.

c. Ameren should implement as the normal meal practice during major outage events the feeding of workers at the staging sites for the morning and evening meals where practical. Ameren-IL should revise the Electric Emergency Response Plan [EERP] to incorporate this change and complete implementation within six months of the date of this report.

d. Ameren-IL should implement as normal practice during major outage events the parking of crew trucks at the staging sites where practical. It should provide shuttles to transport workers to and from the staging sites and their lodging. Ameren-IL should revise the Electric Emergency Response Plan [EERP] to incorporate this change and complete implementation within six months of the date of this report.

IV-33 Implement a process to confirm that all line and support function lead personnel have been alerted when the initial event alert has been sent. (Also, see Recommendation IV-3, Section IV.B, Pre-Storm Preparations.)

A process should be developed and implemented to have all lead personnel – both line and support functions – in the Ameren-IL emergency response organization to respond confirming receipt after Ameren transmits a major outage event alert. This process should be included in the Ameren-IL Electric Emergency Restoration Plan (EERP). Ameren-IL should implement this recommendation within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

G. Field Restoration

1. Objectives

This section provides a description and Liberty's evaluation of the actual restoration activities that were part of the Ameren emergency organization responding to the 2006 storms. The activities included in this section are those directly involved in the restoration of power and not included in other sections, such as Section C, Organization Performance, or Section F, Support Organizations. This report provides an analysis of each of the basic restoration activities and their effect on the restoration of service to Ameren-IL's customers. The report addresses the following items in the ICC's Request for Proposals for this investigation:

- **4.3.2.5.25** Restoration personnel. What was the number of Ameren employees, contractors, and outside utility personnel working on service restoration during each day and broken down by line personnel, forestry personnel, supervisory personnel, etc.? What was the length of work hours for restoration personnel each day? Did any restoration personnel sustain any serious injuries?
- **4.3.2.5.30** Shortages. Did a shortage of material, equipment, or personnel affect Ameren's service restoration efforts?
- **4.3.2.5.31** Materials. What was the number of poles, wires, transformers, crossarms, etc. that each utility replaced during its service restoration efforts? What steps did the utilities take to ensure that the materials used for storm restoration were of acceptable quality and that they would provide safe and reliable service?
- **4.3.2.5.32** Delays. Did any factors delay or hasten the utilities' service restoration efforts?
- **4.3.2.5.33** Restoration time. How long did it take the utilities to restore service to customers? What could the utilities have done to shorten their restoration times? What should the utilities do to shorten restoration times after the next storm?

- **4.3.2.5.34** Restoration work quality. What have the utilities done to ensure that the work completed during storm restoration efforts by their personnel and by personnel for contractors and outside utilities is of acceptable quality, meets NESC requirements, and will provide reliable and safe electric service?
- **4.3.2.5.35** An evaluation of the utilities' field restoration. This task shall focus on the actual field restoration activities, such as the following: field restoration organization; reporting structure; coordination with other emergency response organizations such as the Illinois Emergency Management Agency, Emergency Services and Disaster Agencies, other utilities, police, and fire; use of vegetation management crews; switching, clearance, and tagging processes; work prioritization processes; crew deployment processes; restoration status reporting processes; work centers and staging sites; processes for communicating with restoration crews; meal practices; work hours; and the parking and security for restoration vehicles.

2. Background

Other sections of this chapter address functions and activities that either precede or support the field restoration process. All of those elements, pre-storm preparation, organization performance, outage information, communications, and support organizations, are essential to good storm restoration performance, but their primary focus is to support and facilitate field restoration.

"Field restoration" is the ultimate goal. It is the process of actually restoring power to the customers at their residences and places of business. No matter how well the utility performs the other functions and activities, unless it carries out field restoration in a safe, timely, and effective manner, the overall storm restoration process will not be successful. A utility may be well prepared and organized for a major outage event, with excellent support organizations and good processes in place and working for outage information and communications, but unless the field restoration is effective, the overall effort will fall short of expectations.

The field restoration process includes the following components – the field command centers (or "storm rooms"), the field workforce, the supply of material and equipment, the actual restoration work, and the coordination with other emergency response organizations. Field restoration following a major outage event differs from the normal routine outage restoration in both size and complexity. The significantly larger amount of outages and damage with the resultant necessary repair work, the large number of outside workers who must be managed, the extended working hours for a number of days, and the often-challenging working conditions, all combine to make major outage field restoration a challenging task. A successful field restoration effort depends on a well-designed and rehearsed plan, an effective field organization, an adequate number of experienced, trained, and dedicated workers, consistent and effective oversight and management, timely and adequate supplies of material, equipment and other support needs, and close coordination within the restoration organization and with other emergency response groups.

3. Findings and Analysis

Liberty's findings and analysis of the Ameren-IL field restoration performance in the two 2006 storms focused on the specific components contained in the following subsections:

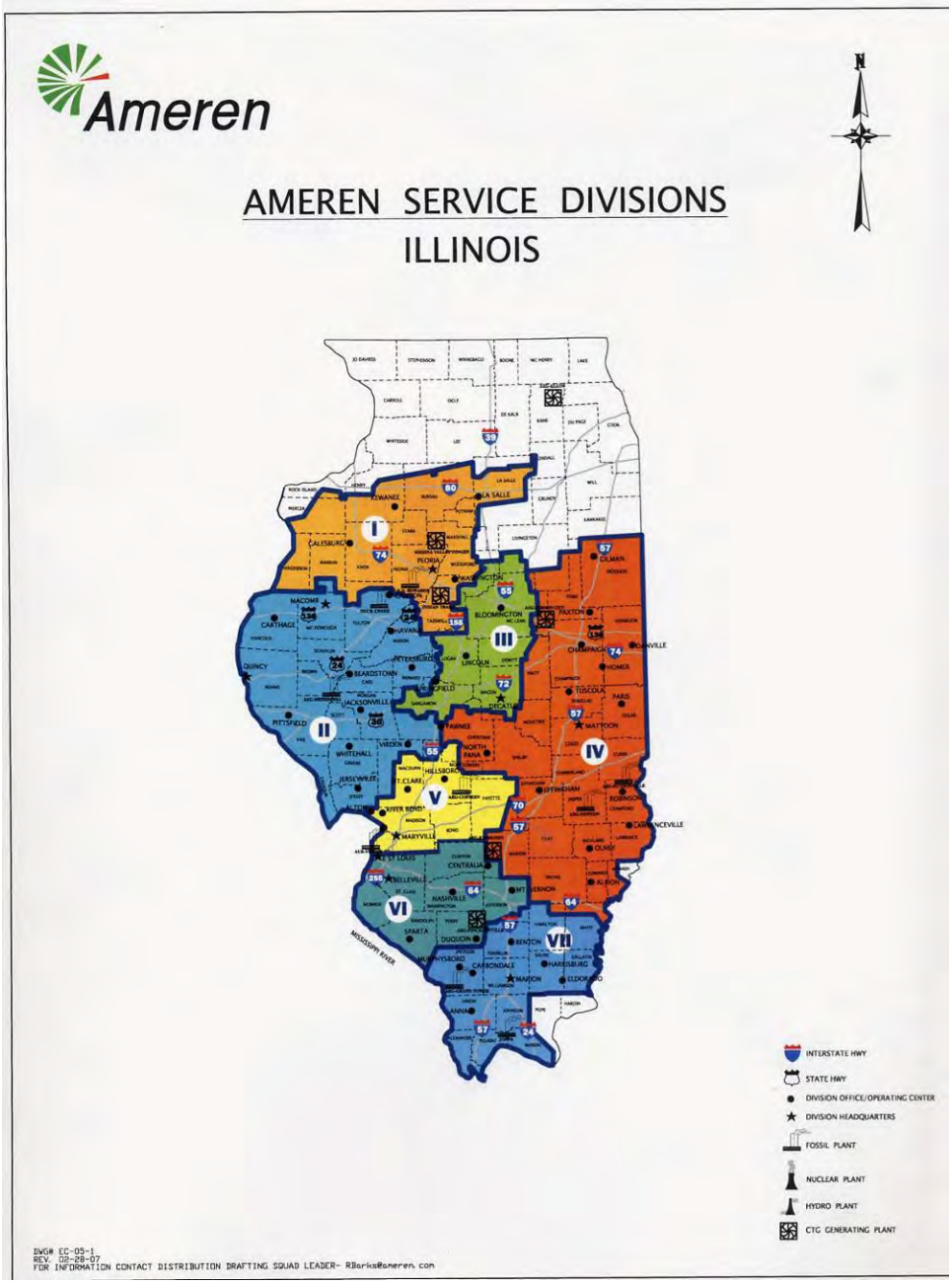
a. Field organizational structure and performance
b. Field workforce
c. Material Supply
d. Field restoration work

Liberty performed numerous interviews, submitted numerous data requests, and conducted field inspections to gather the information, develop the findings, and perform the analyses of Ameren-IL's performance in each of these areas.

a. Field Organizational Structure/Performance

The 2006 storms both had a significant impact on the Ameren-IL service area. The July 2006 storms primarily affected three of the seven Ameren-IL operating divisions—Divisions I, V, and VI. In the November/December 2006 storm, four operating divisions—Divisions III, IV, V, and VI—were hardest hit.[278] The map below shows the location of each of the divisions in 2006.[279]

[278] Response to Data Request #82, Attachment 82-Summary.
[279] Response to Data Request #123.


Ameren
AMEREN SERVICE DIVISIONS
ILLINOIS
N
I
II
III
IV
V
VI
VII
INTERSTATE HWY
STATE HWY
DIVISION OFFICE/OPERATING CENTER
DIVISION HEADQUARTERS
FOSSIL PLANT
NUCLEAR PLANT
HYDRO PLANT
CTG GENERATING PLANT
DWG# EC-05-1
REV. 02-28-07
FOR INFORMATION CONTACT DISTRIBUTION DRAFTING SQUAD LEADER- RBarks@ameren.com

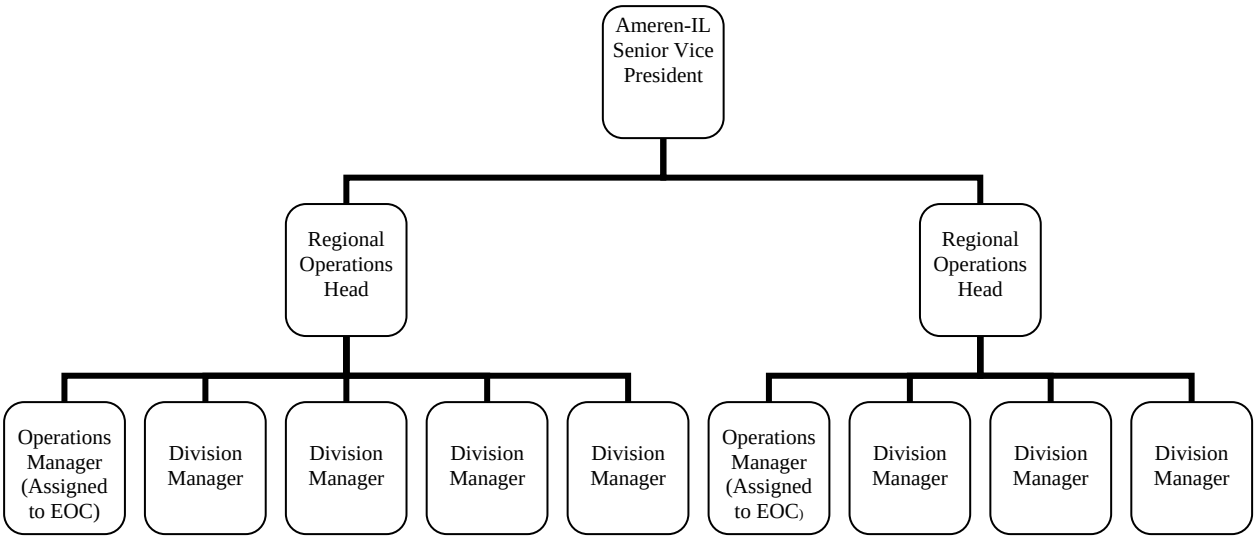
The table below provides details on the impact of the two 2006 storms on Ameren-IL's divisions and operating centers within those divisions.[280]

Impact of 2006 Storms – Ameren-IL

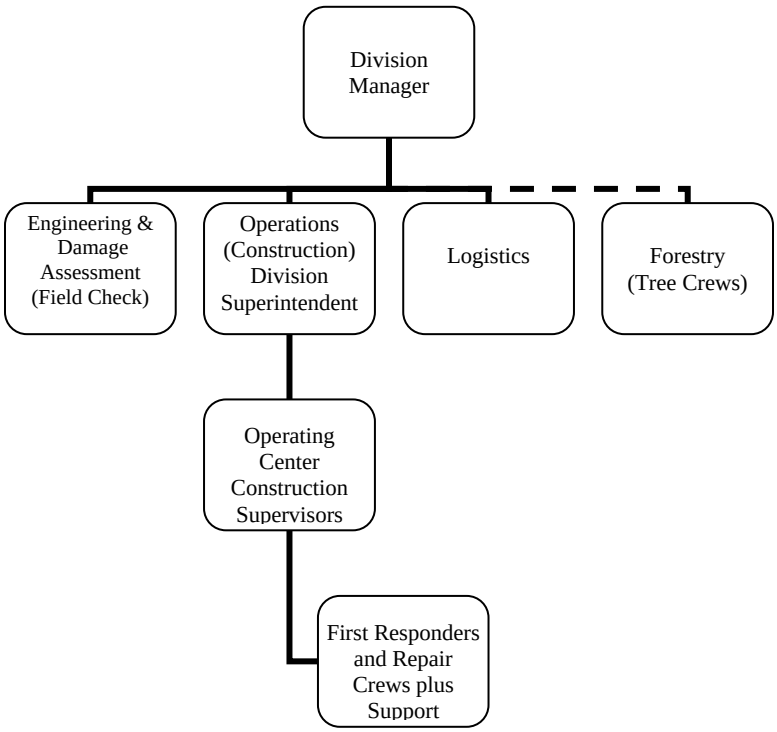
				Customer Outages		Feeder Outages		Services Down	
Division	Company	# Op. Centers	DDO Center	July	December	July	December	July	December
I	IP	3	Decatur	13,708	1,137	8	0	20	19
I	CILCO	2	Peoria	21,745	2,949	7	2	86	11
II	CIPS	9	Mattoon	9,450	19,834	8	5	44	244
II	IP	1	Decatur	2,707	1,132	0	0	10	2
III	IP	2	Decatur	4,709	74,267	1	49	10	2,287
III	CILCO	2	Peoria	9,856	16,293	5	16	66	552
IV	CIPS	3	Mattoon	10,342	30,820	10	20	16	416
IV	IP	1	Decatur	6,742	15,265	2	4	14	85
IV	CILCO	1	Peoria	68	2,282	0	0	2	13
V	IP	2	Decatur	85,865	88,043	77	58	1,121	2,792
V	CIPS(UE)	1	St. Louis	24,641	13,946	68	43	1,031	2,404
VI	IP	4	Decatur	60,047	76,200	34	45	464	2,113
VI	CIPS(UE)	1	St. Louis	34,485	21,910	*	*	*	*
VII	CIPS	5	Mattoon	15,362	5,810	16	1	54	3
VII	IP	1	Decatur	2,385	434	1	0	8	1
			Totals	302,112	370,322	237	243	2,946	10,942

To respond to the major outage event impacting the different operating divisions and operating center areas in these two storms, Ameren-IL set up its emergency response organization in accordance with their corporate and division emergency plans. Liberty presented the two organization charts shown below in Section C – Organizational Performance. This section reproduces them to depict the reporting structure through which management gave direction to and received status reports from the field organization. Liberty omitted a number of key functional areas and management positions from the first chart in order to focus on the reporting relationship within Ameren-IL from the Senior Vice President down through the Division Managers.[281]

[280] Responses to Data Requests #71, Attachment 71-A, and #82, Attachment 82-Summary. "DDO" is Distribution Dispatch Operations. * numbers included in Division V, CIPS (UE).
[281] Response to Data Request #5.



The following chart depicts the typical Ameren-IL operating division emergency organization.[282]



(1) Field Command/Reporting/Support Structure

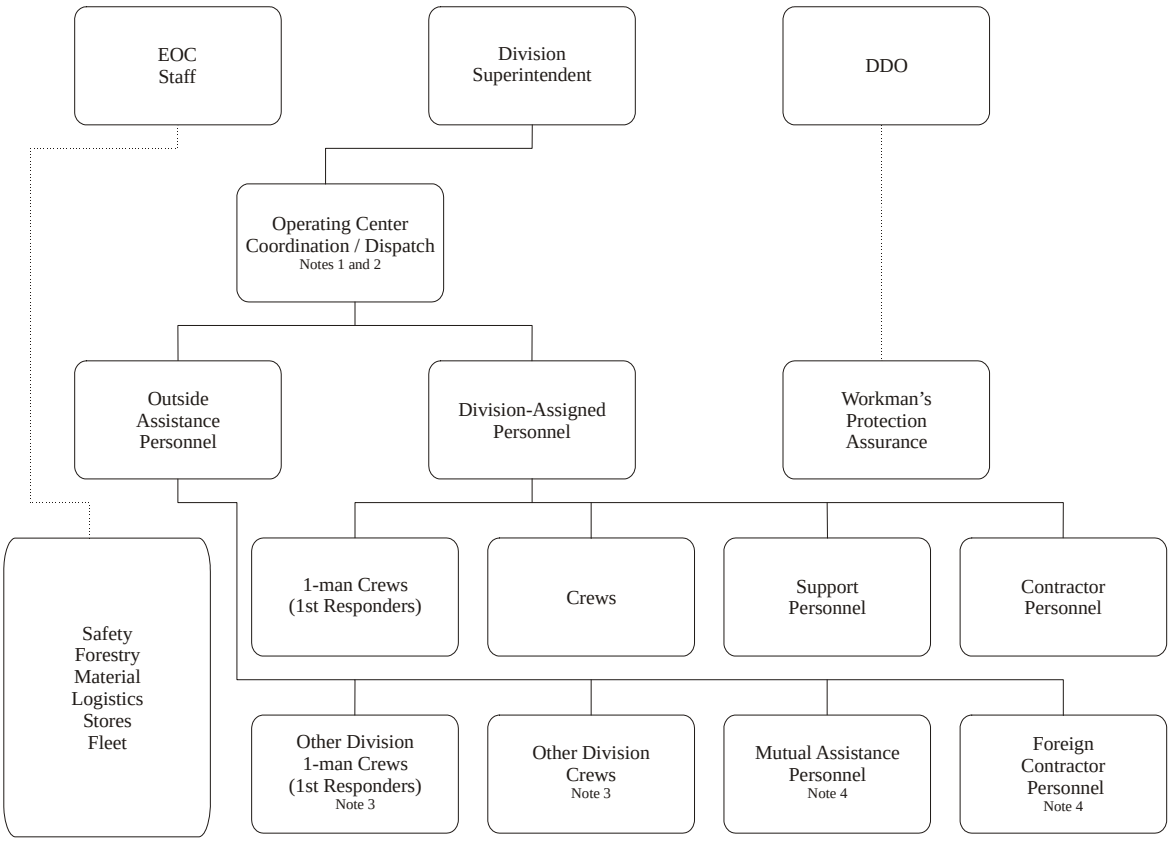
The "nerve centers" for the Ameren-IL field restoration effort were the operating division command centers, headed by the division managers and the division superintendents who coordinated engineering and damage assessment, logistics, and forestry (tree crews) with the line restoration workforce in the field. Construction supervisors headed the individual operating

[282] Response to Data Request #310.

centers (referred to in this report as the field command centers). For the most part, the division superintendents at the division command centers had direct responsibility for the restoration work in the field, and the construction supervisors running each operating center (field command center) reported directly to the division superintendents. In some cases, however, the division manager assumed a much more "hands on" approach in directing the restoration effort, and assumed the role of direct responsibility for the field operating centers. Recommendation IV-13 in Section C above encourages Ameren-IL to clarify the division manager's role during major outage response to provide more clarity, consistency, and efficiency in training and preparing the emergency response organization.

Ameren-IL had 38 operating centers spread among the seven divisions. The 2006 storms did not affect significantly all of these centers but hit hard at some centers in both storms.[283] Ameren-IL furnished the chart below to describe the field operating center organization and explain various response duties.[284]

Response at the Operating Center Level



Notes: 1. This level scalable to the number of operating centers within the division & to the characteristics of the storm response effort. Each is a mirror image of the operating center structure depicted.

2. Personnel assigned to either substations or specific feeders along with all associated OAS orders. Circuits "sweeps" completed using this method of coordination.

3. Other divisions responsible for supplying their own supervisors & necessary support personnel.

4. These personnel provided oversight by Ameren field representatives as appropriate to ensure crew safety and maintain coordination & worker productivity.

[283] Response to Data Request #71, Attachment 71-A.
[284] Response to Data Request #310.

The following is a summary of how Ameren organized, directed, supported, and operated the field response organization.

1. The operating center head (a construction supervisor) reported directly to the Division Superintendent. (See comments above concerning the need for clarity in this role between the division manager and division superintendent.)
2. The corporate Emergency Operations Center (EOC) provided support to the division and the local operating centers in the areas of safety, forestry (tree crews), material, logistics, stores, and fleet (including fueling). Not shown above but included in this support is security. In most of these areas, the division furnished personnel to augment and coordinate the EOC support. During the November/December 2006 storm, Ameren-IL transferred the responsibility for safety from the EOC to the division managers.[285]
3. The field operating centers and individual work crews received support and direction in the area of switching, clearances, and tagging from the Distribution Dispatch Operations (DDO) centers responsible for that geographic area. These procedures are part of the Workman's Protection Assurance (WPA) process, which provides for an efficient and safe process to identify and isolate segments of the electric distribution facilities so that personnel can repair and then return these facilities safely to service.
4. The operating center under the direction of a construction supervisor was responsible for "coordination/dispatch." This means the task of coordinating the different functions and work groups involved in the restoration in that operating center area. Functions such as damage assessment (field checking), forestry (tree crews), logistics, safety, security, fleet support (including fueling) all must receive coordination to maintain an efficient restoration process. The "dispatch" function is the actual direction provided by the field-operating center to the work crews. These crews have assigned, specific areas and/or Outage Analysis System (OAS) tickets to direct them to the work to perform. The dispatch process involves the prioritization of the restoration work and the matching of crew resources to the work required.
5. The workforce responsible for repairing the electric distribution lines has two basic groups—"Division-Assigned Personnel" and "Outside Assistance Personnel."

   The Division-Assigned Personnel are the Ameren-IL employees and outside contractor personnel normally assigned to the specific division in question. They are in four groupings. Utilities typically call the one-man crews (first responders) either "Servicemen" or "Troublemen." As the name implies, during major outage events, they are the first to respond. They perform switching and clearing procedures to restore power and provide an early report as to the nature and extent of the damage. The support personnel include all of those assigned to support the crew supervisors and personnel. They are not qualified or equipped to perform actual repair. The other personnel in this area are the line crew personnel—either Ameren-IL employees or contractor personnel.

   Included in the Outside Assistance Personnel are Ameren-IL employees from other Ameren divisions. This includes the one-man crew (first responders) as well as

[285] Interview #92 (November 15, 2007).

Ameren line crews. The other two categories are Mutual Assistance personnel[286] and "Foreign Contractor Personnel." Ameren uses the word "foreign" to designate those contractors who are not normally assigned to work in that division.

6. The footnotes mean the following:

Note 1: Ameren-IL can expand or reduce the organization depicted depending on the number of affected operating centers in any one division and the specifics of the outage event involved. For example, depending on the number of people assigned to assist a particular operating center, Ameren-IL can scale up or down the number of construction supervisors assigned to assist the operating center head.

Note 2: As part of the "Coordination / Dispatch" process, superintendents assign work crews specific geographic areas defined by either that area served by one specific feeder circuit, or that area served by an entire electric distribution substation. Superintendents assign the outage tickets—Outage Analysis System (OAS) orders—associated with the area to the crew that will be working there. With this method of assigning work areas, work crews are responsible to "sweep" their assigned circuits. This means that whether or not there is a specific OAS order for a particular location, the crew completes all needed repair and restoration on a given electric feeder circuit before moving to another circuit.

Note 3: Ameren-IL divisions sending help into another division will provide the necessary supervision and support so that the impacted division will not have that responsibility.

Note 4: Ameren provides Mutual Assistance and Foreign Contractor personnel with the appropriate oversight by Ameren field representatives to ensure safety, help with coordination, and enhance productivity.

Liberty concluded that the field operating center organization as described above, directed and supported by the corporate Emergency Operations Center and the Ameren-IL division organization, was well-designed and appropriate to manage the restoration effort for the two 2006 storms.

Liberty found that the Ameren-IL employees assigned to lead the restoration effort at the operating centers were without exception veteran operating employees with many years of experience in storm response. A construction supervisor normally assigned to that location headed most of the individual operating centers. However, Ameren-IL also used Division Superintendents to head up the effort at operating centers at some locations. The Division Superintendent sometimes headed up the operating center at the division headquarters town, and in several cases, Division Superintendents from divisions not heavily impacted took the lead at operating centers in other divisions where there was a need. For example, Ameren-IL sent the Division IV Superintendent to head up the E. St. Louis operating center in Division VI in the November/December 2006 storm. The Division I Superintendent took the lead at the E. St. Louis operating center in Division VI in the July 2006 storm, and worked as a field supervisor in Division III in the Springfield area during the November/December 2006 storm. The

[286] "Mutual Assistance" is a term used in the electric utility industry to describe the mutual agreement between utilities to come to each others' aid during major outage events on a "not for profit" basis. Mutual Assistance personnel are employees of an outside electric utility that has come to assist in the restoration effort.

Superintendent in Division V had the lead role at the division command center and also headed up the local operating center effort at the division headquarter town of Maryville during the July 2006 storm. In interviews, Liberty learned that this proved to be too large of a role for one individual, and in the November/December 2006 storm, a local construction supervisor headed up the Maryville operating center while the Superintendent handled the division command center.[287] In addition to the supervisors (Superintendents) used by Ameren-IL to head up the local operating centers, Liberty found that the other supervisory personnel used in the field operations to coordinate and direct the restoration workforce were well experienced in storm response.[288]

(2) Field Command Centers / Staging Sites

Field Command Centers

The facilities used to house the field command centers (operating centers) are an important part of a successful response to a major outage event. These facilities need to meet a certain criteria and have the appropriate equipment and services to support the functions of the field command center. Liberty toured six of the field command-center facilities (referred to as "storm rooms") at locations affected by one or both of the 2006 storms. The locations visited were E. St. Louis, Maryville, Belleville, Pana, Champaign, and Decatur. Liberty also interviewed Ameren-IL employees at each of these locations who were stationed at those facilities and were involved in the restoration effort.

During the tours and interviews, Liberty sought answers to the following:

1. Accessibility of the Storm Room
    a. Is the storm room facility dedicated for that purpose alone?
    b. How quickly can it be set up?
2. Back-up power supply – is there an Uninterruptible Power Supply (UPS) or back-up generator available for the storm room?
3. Accessibility to support groups
    a. Logistics
    b. Engineering / Field Checking
    c. Forestry (Tree Crew coordination), etc.
4. Equipment at the Storm Room
    a. Computers
    b. Printers/Plotters
    c. Fax Machines
    d. Telephone – line lines, cell phones, satellite phones
    e. Company Radio, commercial band radio, television, etc.
5. Traffic flow
    a. Is storm room located to avoid interruptions from customers and/or routine business activities?

[287] Interviews #17 (October 25, 2007), #69 (October 30, 2007), and #72 (November 29, 2007).
[288] Interviews #121 (January 14, 2008), #122 (January 14, 2008), #123 (January 10, 2008), #124 (January 15, 2008), #125 (January 10, 2008), and #126 (January 14, 2008).

b. Is the storm room located to avoid or minimize unnecessary traffic from restoration workers?

The chart below reflects Liberty's assessment of the six storm rooms that it visited.[289]

Rating System: 1 – Good; 2 – Acceptable; 3 – Needs Improvement

	East St. Louis	Maryville	Belleville	Pana	Champaign	Decatur
Accessibility	2	1	2	2	1	1
Back-up Power*	1-UPS	1- partial UPS	1- partial UPS	1- partial UPS	1- partial UPS	2- b/u generator
Support Groups	1	1	1	2	1	1
Equipment	1	1	1	1	1	1
Traffic Flow	3	1	2	3	1	1

UPS – storm room facility completely on Uninterruptible Power Supply
Partial UPS – computers on UPS, rest of storm room facility on back-up generation
b/u generator – entire storm room facility (including computers) on back-up generation.

In conducting these tours and interviews, Liberty found that regardless of the nature of the storm room center facilities, the Ameren-IL employees manning the facility made good use of what they had and there was no apparent negative effect on performance. Liberty's ratings and suggestions with regard to the storm center facilities address opportunities for improvement of the facilities that are subject to use as a command center. The ratings do not reflect Liberty's assessment of the performance of the storm center staff during the 2006 storms.

With regard to accessibility, Liberty found that all of the facilities inspected could be set up and running as a storm center within thirty minutes or less. The storm room at the Champaign office is dedicated for that purpose and is not used for anything else. Equipment is in place for immediate access. In fact, all the storm rooms inspected had equipment in place at all times, thus minimizing set-up time. In addition to Champaign, Maryville and Decatur received a higher rating because their storm room facility is located in a conference room separate from other work stations in the building. At East St. Louis, Belleville, and Pana, at least part of the storm center staff was located in the Construction Supervisors' work area. This is not ideal, but acceptable.

All the storm rooms inspected had Uninterruptible Power Supply (UPS) protection on their computers, with the exception of Decatur. The East St. Louis facility had UPS protection on its entire storm room facility, while back-up generation protected the Decatur storm room facility entirely. UPS protected the computers at the other facilities, with the remaining equipment on back-up generation. The Decatur arrangement is acceptable, but Ameren-IL could improve it by adding UPS to protect the computers. As its name indicates, UPS protects equipment from experiencing any outage, while facilities on back-up generation will experience a brief outage when switched over to the generator.

[289] Interviews #121 (January 14, 2008), #122 (January 14, 2008), #123 (January 10, 2008), #124 (January 15, 2008), #125 (January 10, 2008), and #126 (January 14, 2008).

All of the inspected storm rooms rated "good" with regard to access to support groups except for the Pana storm room, which had the Forestry crew coordinator located in a local restaurant separate from the Pana office. Again, as pointed out earlier, the staff assigned to the Pana storm room did not have trouble with this arrangement, but to assure the best access possible to this important support group, it would be preferable to have the coordinator at the Pana facility.

All the inspected storm rooms had the requisite equipment in place and functioning during the restoration efforts. This includes computers, printers/plotters, fax machines, telephones, radio, etc. At least two of these facilities—Champaign and Decatur—had satellite telephones available.

The ratings on Traffic Flow somewhat mirrored the assessment of the storm room accessibility. The three locations that had separate areas – conference rooms – set up for the storm room were better arranged to maintain good control of traffic flow. At Belleville, a part of the storm room staff was in the Construction Supervisors work area, which could be closed off as required. This is acceptable, but a separate location for the storm room is preferred. Liberty rated the facilities at East St. Louis and Pana with regard to traffic flow as "needs improvement" because the reception areas at these two locations were used as part of the storm room. This arrangement makes it extremely difficult to control traffic flow from others in the building or even those from outside who get access to the facility. Again, Liberty found no evidence that any of the working arrangements noted at the six inspected locations negatively affected the storm response.

Based on the inspection of this representative sample of facilities, Liberty found that the Ameren-IL field-command center facilities used during the two 2006 storms were adequate to good overall, but that there are opportunities for improvement.

Staging Sites

"Staging sites" as employed by Ameren-IL during the two 2006 storm restoration efforts are areas equipped with:[290]

- Storm material trailers
- Transformers, poles, wire, other major material
- Fork trucks, lighting
- Dumpsters, portable toilets, ice, water, etc.

The primary purpose of the staging site as used by Ameren-IL in the two 2006 storms was for the storage and handling of needed electric system repair material. Utilities use staging sites during a major outage event to get the material and equipment closer to the work site in order to eliminate unnecessary travel by the repair crews. The storm material trailers as mentioned above contained enough material to outfit 50 distribution poles in a 12,000-volt electric distribution line. Ameren-IL assigns stores supervisors at all staging sites where it locates material trailers. Staging sites require security and 24-hour, on-call access to assigned personnel. Ameren-IL provides 24-hour coverage at the site if necessary. As stated in the Ameren corporate Electric Emergency Restoration Plan (EERP), Ameren may need to arrange for meals, fuel, and laundry services in addition to the items mentioned above. The EERP also states that, "consideration should be

[290] Response to Data Request #123, Attachment 23-B, page 38.

given to bussing construction personnel to and from staging areas and hotels should space allow."[291] Liberty found that during the 2006 storms, Ameren-IL did not use the staging sites to feed crew personnel or park crew trucks.

Ameren-IL opened and operated two staging sites in the July 2006 storm—one in East St. Louis, IL and one in Trenton, IL. In the November/December 2006 storm recovery effort, Ameren-IL again used two staging sites—one in Swansea, IL and one in Collinsville, IL. Ameren reported "staging sites that were not owned by Ameren were secured at the time of need by face-to-face communications."[292]

Liberty found that the staging sites served their intended purpose during the Ameren-IL response to the two 2006 storms. The performance of the staging site personnel was effective in accomplishing the intended purpose of material storage and handling. However, Ameren-IL could have made better use of these sites by arranging for the crews to take their morning and evening meals there, using caterers to prepare and serve the meals, and by parking the crew vehicles at the staging sites each night and using shuttles to get the crew personnel to and from their lodging. This is a widely accepted electric utility best practice during major outage events, and has proven to be quite efficient. The utility saves time and money in traveling and feeding crews, fueling vehicles at a few staging sites rather than multiple lodging establishments, and providing security for these vehicles after hours. Liberty also found that the approach used by Ameren-IL during the 2006 storms response to secure the staging sites by face-to-face communications at the time of need was ill advised. To wait until the time of need runs the risk of creating bottlenecks and delays in securing acceptable sites for this critical function.

(3) Field Operations: Communications, Status Reporting, Work Prioritization, Crew Deployment, Coordination with other Emergency Response Organizations

This segment of the report deals with five key components of the field restoration process. Communications is of course critical to any successful restoration effort. Communications with workers in the field, communications between workers, communications with key support groups, and upward communications to those who are directing the restoration effort at a higher level all are important to the safe, timely, and effective restoration of service during a major outage event. A specific part of these communications deals with the timely and accurate updates of the status of the restoration effort. The process of gathering this information on a regular basis during each day from the restoration workers in the field is critical not only to keeping all constituents apprised of the progress being made, but also plays a big part in updating the Outage Analysis System (OAS) which is a key tool in the restoration effort. Work prioritization and crew deployment are also key components that when done effectively have a significant positive impact on restoration time. In major outage events, a number of other emergency response organizations are involved, and coordination with these groups is a very important part of any electric utility's restoration effort. Included in these emergency response organizations are the Illinois Emergency Management Agency, emergency services and disaster agencies, other

[291] Interview #89 (January 9, 2008); Response to Data Request #153; Ameren Electric Emergency Restoration Plan (EERP), Sections 9.2 and 9.3.
[292] Response to Data Request #153.

utilities, and local police and fire departments. Liberty discusses below its findings regarding the performance of the Ameren-IL field restoration organization in each of these component areas.

Communications

Section E of this chapter deals with Ameren-IL's communications on a broad level. In this segment, Liberty addresses the communications specific to the field restoration effort.

With regard to communications from the field command centers to workers in the field, and communications between workers in the field, Ameren-IL normally uses its voice radio system. This worked satisfactorily so long as the communications were between units on the same radio system. However, in a number of instances during the 2006 storms restoration efforts, Ameren-IL response personnel who were on different radio systems were working in the same geographic area. The Ameren corporate Electric Emergency Restoration Plan (EERP) in effect at the time of the 2006 storms described the voice radio system as follows:[293]

"Ameren's voice radio system consists of four distinct and different systems. Currently there is no interoperability between these systems.

- Ameren UE utilizes an M/A-Com EDACs 800MHZ trunked radio system.
- Ameren CIPS continues to utilize a conventional low band system.
- Ameren CILCO utilizes a Motorola SmartNet system based on the 800MHZ frequency range.
- Ameren IP utilizes a Motorola 800 MHZ trunked radio SmartZone system."

Liberty found that while some inter-system communications was possible between radio units on the Ameren-UE, Ameren-CILCO, and Ameren-IP systems, units on the Ameren-CIPS system could only communicate with other units on that system. Because of this situation, personnel used cellular telephones almost exclusively for communications between field command centers and workers in the field and between workers. Liberty found no evidence that this limitation on the voice radio system caused any significant delay in restoration, or caused any undue safety concerns. Ameren-IL reported that the cellular telephones worked "O.K.," although there was a lot of traffic in the Metro area (the area east of St. Louis in the Ameren-IL service area) that caused delays.[294]

Ameren-IL's resourcefulness in using cellular telephones in place of the normal voice radio system is commendable. However, this was certainly not the arrangement of choice. Voice radios are to be preferred for the type communications involved. Storms often damage cellular telephone towers limiting the capability of the cellular system in that area. In addition, in urban areas in times of emergency such as these, cellular traffic is extremely heavy, can create problems getting a call through, and can result in delays in important communications. While there is always a risk of losing the radio system, and back-up alternatives such as cellular telephones must always be at hand, it is essential that Ameren-IL move as expeditiously as possible to get all of their voice radios on the same system. Liberty learned that Ameren-IL has

[293] Response to Data Request #64, Attachment 64-A, Section 13.4.
[294] Interview #81, November 28, 2007.

already taken steps to install a new radio system and expects the project to be complete by November 1, 2008.[295]

Liberty found that the communications between the field command centers and key support groups such as logistics, engineering / field checking, forestry (tree crews), etc. were good during the Ameren-IL restoration effort following the two 2006 storms. As pointed out in the segment above dealing with the inspection of the field command center facilities at six different locations, some support group coordinators were located in the same facility with the field "storm room." Where this was not the case, there were regular communications by telephone between the field command centers and support coordinators or the coordinators would make frequent visits to the field command-center facility.[296] Liberty found no negative effect on the restoration efforts resulting from communications (or problems in communications) with the field command centers and the support groups.

Ameren-IL normally handled the upward communications from the field command centers to the division command center by telephone conversations numerous times during the day as the need arose. Some divisions held conference calls on an occasional, as-needed basis, but this was not a common practice at Ameren-IL during the two 2006 storm restoration efforts.[297] Liberty found that these communications worked well, but recommends that Ameren-IL consider a more structured, scheduled approach to the telephone communications between the division and field command centers. There will always be the need for unscheduled communications between these command centers, but by scheduling regular conference calls and/or specific times for status calls, there is an opportunity to gain efficiency in the operation of the division and field command centers. This more structured and scheduled approach to communications is widely used by electric utilities and is a best practice.

Status Reporting

The preceding segment included comments about the communications of restoration status between the field and division command centers. This segment deals with the process employed by the Ameren-IL field organization to report timely and accurately as it completed restoration work so that the Outage Analysis System (OAS) was current and Ameren-IL could furnish accurate restoration status information throughout the organization.

The issue of restoration or outage status reporting proved to be one of the most challenging facets of the overall Ameren-IL response to the two 2006 storms. Section D of this chapter goes into detail concerning the issues related to the Outage Analysis System (OAS), Ameren's computerized outage-management system. This segment will not repeat all of those issues. Rather, the focus here is on the process in place in the field during the two 2006 storms to report the ongoing status as crews completed outage tickets and restored power.

[295] Interview #81 (November 28, 2007), and response to Data Request #797.
[296] Interviews #121 (January 14, 2008), #122 (January 14, 2008), #123 (January 10, 2008), #124 (January 15, 2008), #125 (January 10, 2008), and #126 (January 14, 2008).
[297] Interviews #68 (November 1, 2007), #69 (November 29, 2007), #70 (November 1, 2007), #72 (October 30, 2007), and #73 (October 29, 2007).

Many of the Ameren-IL employees involved in the response to the two 2006 storms were not adequately trained or properly equipped to use OAS during a major outage event. Ameren identified these issues as affecting the process to update OAS during the restoration effort:[298]

- At several locations, the decision was made to "sweep" each major feeder or electric circuit. This means that all power was restored on each circuit before moving on to another circuit. During this process, the crews often did not update OAS to identify the order(s) they were working. In some instances, this resulted in OAS not being updated until the end of the day. There were a number of OAS orders that were "massed closed" on July 23, 2006, during the restoration effort because the crews who were "sweeping" circuits had assumed that all of these orders would be closed when they reported the circuit as restored. In fact, Ameren-IL should have closed each individual order.
- Not all field supervisors had laptop computers equipped with "air cards" to allow them to update outage status on a real-time basis from the field.
- Field supervisors chose to give priority to restoration of service over reporting outage status timely.
- Crews did not report a "feeder" (major electric circuit) breaker as restored until they cleared all outage tickets in that area. This resulted in a delay in reporting the restoration of a large number of customers.
- Poor weather and road conditions during the November/December 2006 restoration effort had a negative impact on outage status reporting. These conditions caused a delay in getting needed resources into affected areas and resulted in employees having to assume duties for which they were ill prepared to handle.

All of these issues are familiar to electric utilities that have computerized outage-management systems and that have experienced a major outage event. There are several remedies to address these issues, and Liberty found that Ameren-IL is actively addressing them. Additional training on the use of OAS is essential and has been conducted following the two 2006 storms. (See Section IV-D, Outage Information for details on the training done.) Ameren-IL should address the equipment issues, making sure that it properly equips appropriate field personnel to perform the necessary update processes from the field. The issues related to the weather are common, and the only way to address the problem of delayed arrival of needed personnel is to stage proactively these employees in areas anticipated to be affected.

Liberty recommends that Ameren-IL establish the storm role of "reporter" or "OAS liaison," assigned to repair crews. The primary, if not the sole, responsibility of this individual would be to update OAS as the crew completes the orders, using laptop computers with air cards to interface with OAS. In those instances where a laptop computer is not available, the "reporter" should have a contact individual at an operating center to which he or she relays the information. It is impractical to expect the supervisor of the field crews to be able to take time away from the critical responsibility of service restoration, crew performance, and employee and public safety to be able to update the outage management system as orders are being completed. Ameren-IL could easily train in advance employees who do not have outage response duties but possess the qualifications needed for this type work and move them into these positions during major outage

[298] Responses to Data Requests #155 and #579.

events. A sufficient number of these employees should be trained so as to provide "reporters" for all crews working during the storm effort.

Work Prioritization / Crew Deployment

The prioritization of pending work and the appropriate deployment of crews to restore power to the largest number of customers in the safest and quickest manner possible is a critical function of the field restoration process. Liberty found that Ameren-IL employees directing the field restoration effort did a good job in this function during the two 2006 storm restoration efforts. These employees were, without exception, experienced, knowledgeable utility "storm veterans" who knew what needed to be done and did it.

The fact that Ameren-IL did not identify "critical customers" in its Outage Analysis System (OAS) hampered the prioritization of work effort. The field command centers did not have important information that would have helped in the prioritization process. Section IV.D of this chapter contains the conclusion that "Ameren did not identify critical customers in Outage Analysis System prior to the July and December 2006 storms." As a result, each division had to identify and prioritize critical customers on their own as the storm progressed.

Since the 2006 storms, Ameren created a list of critical customers in Outage Analysis System by circuit, based on SIC (Standard Industry Classification) codes. Ameren identified Health Care / Life Quality facilities, First Responder Agencies, Critical Social Infrastructure, and Emergency Shelter Sites. A Critical Customer List is available by Division, SIC, and Priority that specifies the customer name, SIC, City, Address, Feeder, and Transformer. Another list details any out-of-service Critical Customers, specifying address, Outage Analysis System order #, Estimated Restoration Time, and other trouble ticket information. Division Engineering is responsible for keeping the Critical Care information up-to-date.[299]

Not only were the critical customers not entered into the Outage Analysis System (OAS), but also the operating centers did not have circuits that served critical loads identified in advance and therefore did this as the storm restoration progressed.

The fact that there were delays in getting outside help to the area initially affected crew deployment. In the July storms, sources of outside help were unable to come to the aid of Ameren because of the extreme heat that was causing significant service problems throughout the Midwest. In the November/December storm, Ameren-IL should have been more proactive in seeking outside help prior to the onset of the storm. (See Section IV.B, Pre-Storm Preparation, Conclusion 9.) After the storm hit, weather conditions limited travel and delayed many of the crews coming to Ameren's aid. The result of this delay in getting help to the affected areas meant that initial crew deployment was especially challenging. Initially there simply were not enough crews to deploy to major outage locations. This was not a usual situation; in fact, it is very common for electric utilities to encounter this situation at the outset of major restoration efforts. Again, Liberty found that the employees directing the field restoration effort did a good job in deploying the workers assigned to them. Ameren-IL followed the utility best practice of "collapsing" crews into areas still without power when these crews are released from other

[299] Response to Data Request #547.

locations.[300] This can be quite challenging for the field command centers to effectively manage these additional resources received many times with fairly short notice. Liberty found that Ameren-IL managed this process without any noticeable problems.

The restoration approach known as "sweeping" the circuit has been discussed earlier. The decision facing the field command centers and the crews was whether to (1) restore power working entirely from Outage Analysis System (OAS) orders, moving from location to location in an attempt to always be working on the order(s) involving the most customers, or (2) to assign a crew to remain working on one specific electric feeder circuit until it restored all power. The advantage of the latter is that it reduces lost time for crews to move from location to location, and helps minimize the chance that small isolated outage cases could be overlooked. Ameren addresses this approach in its Electric Emergency Restoration Plan (EERP) in Section VI – Extensive Damage Recovery. In Chapter III of this report, Liberty recommends that Ameren revise the EERP to allow more flexibility in the use of the circuit "sweep" approach. (See Chapter III, Emergency Plans, Conclusion 5 dealing with EERP Section 6.) Liberty found that Ameren-IL used this approach in several different field command centers during the two 2006 restoration efforts,[301] and recommends that Ameren-IL use it more often. It is a widely-accepted utility work approach and is considered a best practice during major outage response.

In its critique of the November/December 2006 restoration effort, Ameren-IL concluded that it needed more help in managing the large numbers of outside crews brought in during such an event. Ameren-IL used retired employees and some employees from the power generating plants, but it needed more.[302] Ameren should implement a much more aggressive process to identify in advance and train employees not normally assigned a role in major outage response in order to assist in this area.

Another utility best practice in crew deployment and coordination was implemented in several locations during the restoration efforts following the two 2006 storms. This is the practice of using the members of the local crews as crew coordinators for outside crews. Rather than using these personnel for "hands on" restoration work, Ameren-IL broke up local crews and assigned individual members to guide and coordinate the outside crews. In this case, Ameren-IL "upgraded" the crewmembers to the classification of Utility Foreman.[303]

Liberty found that there were some constraints in some of the labor contracts between the different Ameren-IL companies and the labor union representing the line workers. One provision impacted Ameren-IL's ability to relocate personnel from one legacy company into the service area of another legacy company unless all line personnel in the target area had been called out to work. A labor provision dealing with "numbered crews" put some restrictions on how Ameren-IL could use personnel on those crews, even during major outage events. Another labor contract provision specified that employees could "volunteer" to go to a work assignment in another legacy company, but they could not be required to go. For the most part, these provisions did not negatively affect the availability and performance of Ameren-IL workers during the response to

[300] Interview #69 (November 29, 2007).
[301] Interviews #17 (October 25, 2007), #69 (November 29, 2007), #72 (October 30, 2007), #123 (January 10, 2008).
[302] Response to Data Request #85, Attachment 85-B.
[303] Interviews #69 (November 29, 2007), #72 (October 30, 2007).

these two major outage events. One division reported that management was willing to send 50 percent of its workforce to aid another division, but less than that number volunteered to go initially. This happened in both the July 2006 and the November/December 2006 storms. In both cases, more employees volunteered later and the division met its 50 percent target. The same division reported that it sent its employees to work in a location 45 miles away from headquarters. Even though lodging was offered for them at that location, if any of the workers wanted to come home each night, the company brought them in.[304]

Such labor provisions represent serious restrictions on a utility's ability to respond adequately to a major outage event. Ameren-IL management and labor are to be commended for working through these provisions and minimizing the potential negative impact on service response. Ameren-IL should place a high priority on negotiating more flexibility in their labor contracts in the area of emergency response. Negotiations between Ameren-IL were ongoing at the time Liberty began this project and were concluded late in 2007. Liberty does not have any specific information on changes made to any contract provisions, but Ameren-IL reported in one interview that the new labor contracts addressed some of these issues.[305]

Coordination with Other Emergency Response Organizations

Ameren-IL reported that during the July 2006 storm, the Illinois Emergency Management Agency (IEMA) set up a Unified Command Center in Alorton, IL. Ameren-IL provided update briefings at scheduled times during each day to IEMA and various other state agencies (Illinois State Police, Illinois Department of Transportation, Illinois Department of Public Health and others). County officials were also located at the center. Additionally, the IEMA staff at the center was in constant communications with the Ameren-IL liaisons to resolve concerns over a number of issues. Ameren-IL forwarded coordinated information to the IEMA Springfield location and to the Illinois Commerce Commission (ICC) staff at the IEMA office. This arrangement worked so well, according to Ameren, that it has been adopted as a best practice for major outage events such as the July 2006 storm. Liberty did not receive a confirmation that the IEMA remote center was used during the November/December 2006 restoration effort.

Ameren-IL advised that following the 2006 major outage events, it established a Community and Public Relations group. This group is now working with the Ameren-IL Regulatory Affairs department "to provide timely, accurate, and consistent information to all interested parties and to provide liaison capability to local governments and command centers from a single, unified work group."[306]

An important issue in the coordination with other emergency response agencies is the receiving, prioritizing, and promptly responding to calls from police and fire departments reporting wires down. Ameren-IL reported that it gave these agencies a special number to call that would place their call in a high priority in the Call Center "queue." Ameren also gave fire and police agencies the option of faxing in these reports to the Call Center. The call center added information to the

[304] Interviews #69(November 29, 2007), #75 (October 31, 2007) and #76 (October 29, 2007).
[305] Interview #69(November 29, 2007).
[306] Response to Data Request #761.

Outage Analysis System (OAS) order to help prioritize these tickets. Ameren-IL reported that these orders received high priority by dispatchers, electric troublemen, and Field Checkers assigned to investigate wire down reports.[307]

However, as discussed in Section IV.E, Communications, Liberty found that Ameren did not have enough people at the call centers to handle the wire down calls from emergency officials, resulting in long wait times and delays in response in the field. One division identified this issue as an opportunity for improvement, stating the "need to assign person to a community to work with fire/police."[308]

Based on the above findings, Liberty concluded that Ameren-IL did a good job in coordinating with other emergency response agencies during the two 2006 major outage events, with the exception of the handling of emergency "wire down" calls from fire and police officials.

b. Field Workforce

This segment of the report addresses the size and quality of the workforce assembled as "boots on the ground," *i.e.*, personnel assigned to line or tree crews who performed the actual hands- on work to repair electric facilities and trim, cut, and clear trees to facilitate those repairs.

(1) Workforce size/qualifications

Workforce Size

Liberty addressed the size of the total workforce in Ameren-IL in the response to the two 2006 storms in Section C (Organizational Performance) of this chapter. In summary, Liberty found that while the impact of the November/December storm was slightly greater than the July storm, the restoration workforce for the winter storm was more than twice the size of the July workforce. The greatest increase was in the number of contract linemen, which was almost seven times more in the November/December 2006 storm than in the July 2006 storm. Liberty compared the size of Ameren-IL's workforce with that of other utilities and noted that comparisons can be problematic. Nevertheless, Liberty concluded that the size of the Ameren-IL restoration workforce used to respond to the July 2006 storm was smaller in comparison to the other two utilities, significantly smaller than the Ameren-IL restoration workforce that responded to the November/December 2006 storm, and smaller than desirable given the scope and severity of the July 2006 storm.

The tables below show the number of field restoration workers available each day during the restoration efforts in the July 2006 storms and the November/December 2006 storm.[309]

[307] Response to Data Request #154.
[308] Interview #73 (October 29, 2007).
[309] Response to Data Request #754.

Restoration Workers by Day – July 2006

date	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27	7/28
Line Contractor	148	178	251	271	271	271	271	271	271
Mutual Assistance	0	0	0	140	140	44	44	44	44
Ameren	423	423	423	423	423	423	423	423	423
Tree Crew	215	261	303	303	322	322	349	349	349
Total	786	862	977	1,137	1,156	1,060	1,087	1,087	1,087

Restoration Workers by Day – December 2006

date	12/1	12/2	12/3	12/4	12/5	12/6	12/7	12/8	12/9
Line Contractor	157	157	1,029	1,071	1,144	1,359	1,405	1,870	585
Mutual Assistance	0	20	189	189	231	255	255	301	0
Ameren	398	398	394	394	379	417	444	444	278
Tree Crew	414	587	587	589	591	613	613	591	55
Total	969	1,162	2,199	2,243	2,345	2,644	2,717	3,206	918

These two tables clearly reflect the difference in the size of the Ameren-IL field restoration workforce for the two storms. They also show the time required in each restoration effort to get outside help to the affected area.

During interviews with Ameren-IL division and operating center leaders involved in the response to the two 2006 storms, Liberty heard from one division that there was a delay in receiving outside help. In the case of the November/December 2006 restoration effort, this division did not receive any outside help until Monday, December 4, even though it made a request for help Friday morning, December 1. There was a report from one individual that even though the amount of outside help in the November/December 2006 storm response met his expectations, there was not enough help available in one operating center area in his division.[310]

Ameren-IL also reported that the number of Ameren line supervisors (not including supervision furnished with Mutual Assistance utilities and line contractors) was 49 in the July 2006 restoration and 48 in December 2006. These numbers reflect the normal Ameren-IL complement of line supervisors. Ameren did not furnish any information concerning numbers of Ameren personnel who were assigned to guide/coordinate outside crews. With an increase in total workforce between July and December of almost 200 percent, more help of this nature would have been important and necessary.[311]

Based upon the above, and consistent with its conclusions and recommendations in earlier sections of this chapter, Liberty found:

- The Ameren-IL field restoration workforce was much smaller than appropriate to respond adequately to the July 2006 storms.
- The Ameren-IL field restoration workforce was of adequate size to respond appropriately to the November/December 2006 storm.

[310] Interviews #70 (November 1, 2007), #71 (November 2, 2007), and #72 (October 30, 2007).
[311] Response to Data Request #754.

- Several factors delayed the arrival of the outside help in the response to both the July 2006 and the November / December 2006 storms.
- The amount of Ameren-IL line supervision between July 2006 and December 2006 did not increase even though the total workforce doubled.

Workforce Qualifications

This segment addresses the qualifications of the personnel involved in the field restoration efforts at Ameren-IL following the two 2006 storms. This includes the Ameren-IL employees engaged in directing, coordinating, and supporting the field restoration work done by line and tree crews, the personnel comprising the line and tree crews, and those involved in the Engineering / Field Checking process. A later section of this report address the amount and quality of work accomplished; the focus here is on the qualifications of the employees to do the work assigned to them in field restoration.

To determine this, Liberty conducted a number of interviews, reviewed Ameren-IL critiques of the restoration efforts, and toured six field command centers, meeting with employees involved in different functions within field restoration. Liberty was impressed with the experience and knowledge of the Ameren-IL employees interviewed. Ameren-IL as a company has a good reservoir of experienced, knowledgeable, and dedicated employees to call upon to respond to major outages. Liberty found no evidence of any deficiency in the overall qualifications of the Ameren-IL employees responsible for field restoration following these two storms.

With regard to the qualifications of the Mutual Assistance utility workers who responded to Ameren-IL, Liberty reviewed the list of utilities and found that these were well-established organizations with experienced personnel similar to the Ameren-IL employees.[312]

The contractor crews, both line and tree, that assisted during these two efforts were comprised of both contractors who were working on the Ameren-IL property prior to the onset of these storms, and those brought in from outside. Ameren had previously accepted those already working for Ameren-IL as qualified to perform line and tree work on the property. The group located at the Ameren General Office in St. Louis that manages and coordinates contractor relations for Ameren on a year-round basis handled the recruitment of outside line and tree contractors. All of the contractors brought in from outside met Ameren's qualifications. Some of them were contractors working for Mutual Assistance utilities who released them to come to Ameren's aid.[313]

Ameren-IL raised the question of qualifications of outside contractors brought in to aid in the restoration during its critique of the November/December 2006 storm restoration. The primary concern raised here was that the more new contractors brought in, the greater the likelihood that some of these crews will have too many "non-climbing" personnel (groundmen, equipment operators, and support personnel.) Following the critique discussion, Ameren took steps to address this, asking the field organization to send in assessments of contractors deployed in their

[312] Response to Data Request #123, Attachments 123-B and 123-C.
[313] Interviews #88 (January 9, 2008) and #95 (January 10, 2008).

area during the restorations. The field organization was to forward this information to the group in the Ameren general office that manages all contractor relations, and they were to address any concerns with the contractors.[314] Nobody from Ameren-IL mentioned this issue to Liberty during interviews and tours of facilities. However, it is familiar to all utilities that have had to bring in large numbers of outside contractors. Ameren should follow through to ensure that this is not a problem for them in the future.

Notwithstanding this matter, Liberty found no evidence of any deficiency in field restoration performance in the Ameren-IL response to the two 2006 storms resulting from unqualified personnel, whether Ameren employees, Mutual Assistance utility personnel, or contractors.

In responding to these two major outage events, it was necessary for Ameren-IL to bring in non-union contractors to assist. This is a very sensitive issue with the union employees at Ameren and with the unions themselves. Generally, Ameren has always avoided bringing in non-union personnel to work on their property. Due to the severe nature of these outage events, Ameren-IL made the decision to bring in non-union help. Ameren held discussion with union representatives, and to the credit of the union leadership, the Ameren-IL employees, and Ameren-IL management, this issue was handled with very little difficulty. The non-union personnel were the first that Ameren released at the end of the restoration effort.[315]

(2) Working Hours and Meal Practices

Ameren-IL furnished the following information concerning the working hours and meal practices of the field restoration employees.[316]

> *Field restoration personnel are assigned to work in approximate 14-18 hour shifts with the remainder of the 24-hour period devoted to rest. During the 2006 storms, the amount of rest was adjusted to compensate for the extreme climatological stresses (extreme heat and humidity; extreme cold, winds, and icing) under which personnel labored in both of the storm restoration events.*
>
> *While most field restoration personnel work a 'day' shift, there are limited numbers of personnel who work through the evening and night-time hours, effecting repairs and maintaining a field presence on a 24/7 basis during the restoration event. Staffing for the evening and night-time hours is determined by the nature of the event, i.e. the time of day that the storm damage occurred, the day of the week during which the damage occurred, the time of day when personnel originally responded to the call for restoration response, the elapsed time of completion of current work, etc.*
>
> *Generally, a typical day for field personnel engaged in emergency restoration is structured with a wake-up call around 04:30-05:30 (assuming the personnel will have been rested for 5-7 hours previously). Personnel will be fed breakfast at a*

[314] Responses to Data Request #8, Attachment 8-D, and Data Request #85, Attachment 85-B.
[315] Interview #72 (October 30, 2007).
[316] Response to Data Request #156.

> *pre-arranged site or restaurant and will receive a safety briefing and their first orders for the day at that time. As well, in those areas where permitted by labor agreement, personnel may pick-up a boxed lunch to be carried to the job-site with them. In the event that these lunches have not yet been delivered by the caterer, they will be delivered to the personnel in the field later in the morning. Personnel will work continuously, taking time for their noon-time meal as the job permits. In the evening – at the end of approximately 16 hours of work – personnel close down their work and report any remaining pertinent job-related data to their supervisor. They then return to a pre-arranged restaurant or other site for their evening meal and are sent to rest. Personnel from the immediate area that incurred the damage are sent home; all other personnel are lodged in hotels, motels, and in some extreme cases (July 2006), in college and university dormitories.*

With regard to working hours, Liberty found that it is Ameren-IL's practice to keep union employees on duty for 16 hours with 7 hours off for rest so that all of the hours they work during the restoration effort will be on "premium" (double) time.[317]

Liberty mentioned above the matter of using the staging sites to feed the field restoration personnel their morning and evening meal as well as to park the crew trucks. The meal provisions as described above and as employed during the two restoration efforts are in keeping with widely accepted practice throughout the utility industry. The box lunch arrangement is very important and is a utility best practice. This provides the personnel with nourishment at the midpoint of their workday without the lost time associated with getting them to some eating location. Where feasible, it is best to have the box lunches ready for the workers when they leave in the morning en route to the work site. This eliminates the necessity for people to bring the lunches to the work site when they could put their time to better use.

The working hour schedule for field restoration workers as described above is also common utility practice. During protracted restoration efforts that span over several days, it is not practical, and more importantly it is not safe to work employees out in the field for more than 16 hours. It is important that the work and rest hours be closely managed to ensure that the workers are rested and able to handle safely and efficiently the repair and restoration of electric facilities. The one area where Ameren-IL's work hours differ from some utilities is the limiting of rest time in order to keep the workers on premium pay. There are many differences among utilities regarding overtime pay during major outage events, and union contracts obligate some to pay double time for all hours worked during major outage events. Other utilities take the same approach as followed by Ameren-IL, and have an understanding with the employees and unions that the work and rest hours will keep the workers on double time throughout the entire restoration effort. Still others have agreed with the union that the primary emphasis will be to give the employees adequate rest, and the work and rest hours are managed so that the employee does not qualify for double time. The present practice is apparently widely accepted at Ameren-IL, and it may not be practical to try to change this, especially in light of some of the other issues that management needs to address with the unions concerning flexibility in emergency response.

[317] Interview #69 (November 29, 2007), #126 (January 14, 2008).

Liberty concluded that the working hours as established and employed by Ameren-IL during the 2006 restoration efforts align with the practice of other utilities and only recommends that Ameren-IL's management review this practice to ensure that it serves the best interests of the employees and customers during major outage restoration.

(3) Daily Crew Reporting Process

An important part of managing the field restoration workforce is to get daily reports on the status of completed work, scheduled work remaining for the next day, any problem areas, and any outstanding issues. This is especially true in light of the large number of workers, the majority of whom have come in from other locations and are not familiar with the area or the host utility's territory and work procedures. Management of this reporting process has to minimize the time required of all concerned and to avoid creating a "bottleneck" by bringing the crews to the field command locations.

Liberty found that Ameren-IL followed no set procedure in the daily reporting process during the two 2006 restoration efforts. There is no specific procedure detailed in the Ameren corporate Electric Emergency Restoration Plan (EERP) or in the two Ameren-IL division plans reviewed by Liberty. In some locations, crew leaders came in to the field command center to make reports, and at other locations, this was handled by telephone. The Ameren-IL field restoration organization was set up so that there were Construction Supervisors assigned to coordinate repair crew work in certain areas. These supervisors maintained ongoing communications with crew leaders during the day and therefore had the information normally covered in the daily reports.[318]

Liberty found that Ameren-IL adequately managed the daily crew reporting process during the two 2006 restoration efforts, and there was no obvious loss of productivity or delay in restoration resulting from the approach taken by Ameren-IL. There is an opportunity to establish a specific process and ensure that this important task is handled more consistently in future major outage restorations.

(4) Receiving and Orienting Outside Crews

The number of outside field restoration workers brought in to assist Ameren-IL following the two 2006 storms has been discussed earlier in this Section. All electric utilities receiving large numbers of workers from outside of their service area face the challenge of how to transition this outside help smoothly, safely, and effectively into the restoration effort. The Ameren corporate Electric Emergency Restoration Plan (EERP) contains the following provisions for managing outside resources:

> *Section 11 – Handling Outside Crews*
> *The purpose of this section is to assist Division personnel in preparing to handle outside crews. Outside crews are crews coming from other utilities or contractors that have not previously worked on Ameren property.*

[318] Interviews #70 (November 1, 2007), #74 (October 29, 2007), #122 (January 14, 2008), #123 (January 10, 2008).

11.1 Checkpoints
These locations will be carefully selected to allow for easy highway access and serve to short stop incoming crews before actually assigning them work. Outside resources will meet with their Ameren Liaisons to discuss hotel arrangements, receive their safety briefing, meet their Squad Leaders and Crew Guides, locate fueling stops, and learn where they will be working. These sites will need to be capable of accommodating large numbers of line trucks and have paved or gravel surfaces. (truck stops, schools, shopping centers, commuter parking areas are suitable sites.) Once crews have been briefed and contacts have been made, they will be directed/guided to their hotels or work areas dependent on time of day.

11.2 Checkpoint Coordinator
This individual will work closely with the Division Coordinator and Division Logistics Coordinator to make sure that the checkpoints are operational. They will make certain that the Safety Coordinators, Liaisons, Field Supervisors, Squad Leaders, and Crew Guides work together to properly receive outside assistance crews.

11.3 Ameren Liaison
This individual will meet the outside crews at the checkpoint site and be their main point of contact for logistical issues. They will coordinate the lodging, security, meal issues, laundry issues, and any other issues needing attention that fall outside the area of field work. They will also cover the details in the outside crew guide before any actual work is performed. They must be available 24 hours a day to provide assistance to outside resources as required.

11.4 Safety Coordinator
This individual will work closely with the Check Point Director to make certain that Outside Assistance Crews clearly understand that SAFETY is the priority while working on Ameren property. They will conduct a thorough safety briefing with all personnel before they engage in any work activity on our property. They will serve as the point of contact for any and all safety related matters to the Outside Assistance Crews and their supervisors.

This section of the corporate EERP also provides for the use of Squad Leaders and Crew Guides to work at the direction of the field-restoration command center and help coordinate and support the outside crews.[319]

These provisions as set forth above are well designed and if followed should help facilitate the smooth, safe, and effective transition of these outside resources into the restoration effort. In reviewing the critique of the November/December 2006 restoration effort and in conducting interviews with those who were involved in managing the outside resources, Liberty found that in most instances Ameren-IL did not use Checkpoints.[320] Ameren-IL stated that the main intent of the Checkpoint is to establish a separation of the arriving outside crews from the restoration

[319] Response to Data Request 64, Attachment 64-A, Section 11.
[320] Response to Data Request #8, Attachment 8-D, Interview Request #88 (January 9, 2008).

work centers, and that this separation was maintained by either meeting the outside crews at their lodging upon arrival, or meeting with them separately at staging sites.[321]

In an effort to help with the orientation of outside crews during the November/December 2006 restoration effort, Ameren distributed a document including important contact information, safety expectations, information concerning Ameren's Workman Protection Assurance (WPA) process of handling the clearing and switching of electric power line facilities, and other helpful information. This document was under development at the time of the November/December 2006 storm; Ameren-IL distributed it in draft form. This proved to be very helpful in the orientation process. Ameren-IL has since completed this document and has been using it for orientation of outside workers since 2007.[322]

Liberty found that Ameren-IL could have improved its performance in receiving and orienting outside crews arriving to assist in the two 2006 restoration efforts. By following the Checkpoint provisions in the corporate Electric Emergency Restoration Plan (EERP), this could have been handled in a more consistent manner to ensure a smooth, safe, and effective transition of the outside crews into the restoration workforce. The draft document outlining needed information, which Ameren distributed to outside crews in the November/December 2006 restoration, was a helpful addition to the orientation process.

c. Material Supply

An indispensable component of the field restoration process is the timely supply of material in the required quantity and quality to ensure that there is no delay in restoring power and no compromising of the reliability of the electric system. Liberty discussed material supply to the field restoration organization in Section IV.F, Support Organizations. That section included a summary tabulation of the materials issued during the 2006 storms to provide a sense of the significant workload on the Stores/Material Support organization. In Illinois, and during the restoration from the two major storms in 2006, Ameren-IL issued over 2,200 poles, nearly 4,500 cross arms, over 2 million feet of wire and cable, and over 1,400 transformers.[323]

In that prior section of this report, Liberty concluded that the support organization fulfilled its role during the storms, and found no instances in which a material shortage or delivery problem slowed the restoration.

Liberty also reviewed the steps Ameren-IL took to ensure the quality of materials used during the storms. Those steps included the following.[324]

- Ameren-IL had already approved for use the materials coming from its warehouses.
- The storm trailers were pre-equipped with Ameren-approved equipment and materials.
- Ameren inspected materials coming directly from suppliers and from neighboring utilities prior disbursement to line crews.

[321] Interview #88 (January 9, 2008).
[322] Response to Data Request #8, Attachment 8-D, Interview #88 (January 9, 2008), and Interview #95 (January 10, 2008).
[323] Response to Data Request #71, Attachment 71-F.
[324] Response to Data Request #757.

- Ameren engineering approved all non-standard materials prior to allowing the materials on site for distribution.
- Ameren supplied the materials to both in-house and foreign crews.

Liberty concluded that Ameren-IL's supply of the quantity and quality of materials during the 2006 storm restorations was adequate.

d. Field Restoration Work

(1) Field Checking (Damage Assessment)

The corporate Electric Emergency Restoration Plan (EERP) defines the duties of the Field Checker in a major outage restoration. These duties are:

- Inspect outage sites to assess type and degree of damage involved
- Determine what sorts of repairs are needed and list any required materials
- Communicate findings with Field Check Dispatcher
- Perform safety over-watch (barricade and secure sites) on downed wires until relieved. Advise customers of immediate safety concerns on their property.

An area distribution estimator or an engineer normally fills the position.[325]

During the July 2006 restoration effort, Ameren-IL had 95 employees in the Field Checker role. In the November/December 2006 storm, that number grew to 169.[326] This increase was in keeping with the increased damage and number of workers in the November/December 2006 restoration.

Damage assessment is extremely important in the field restoration process. Ameren's Electric Emergency Restoration Plan (EERP) lists three stages (or phases) of damage assessment, initial field damage assessment (high level), detailed damage assessment, and heavily localized damage assessment.[327] Ameren-IL provided the data in the table below related to completion of damage assessments.[328]

[325] Response to Data Request #64, Attachment 64-A, Section 3.6.
[326] Response to Data Request #76.
[327] Response to Data Request #64, Attachment 64-A, Sections 4.2, 4.3, and 4.4.
[328] Response to Data Request #77.

Field Checkers Completion Date

Division	Operating Center	July 2006 Storm (storms hit July 19 and July 21)	Nov./Dec. 2006 Storm (storm hit on November 30)
I	All	July 20	December 2
II	All	July 20	December 3
III	Decatur	July 20	December 5
III	Springfield/Lincoln	July 21	December 6
III	Bloomington	-	December 4
IV	All	-	December 8
V	All	July 28	December 9
VI	E. St Louis	July 27	December 8
VI	Belleville	July 28	December 7
VI	Mt Vernon/Centralia	July 28	-
VI	Sparta	-	December 3
VII	All	-	-

These data show Ameren-IL did not complete damage assessment in Divisions V and VI in July 2006, and in Divisions IV, V, and VI in December 2006, until the last few days of the restoration effort. Even considering the magnitude of the damage in these two events, the target for completing damage assessment should have been within the first three days.

The Ameren-IL damage assessment process following a major storm puts a high priority on finding, isolating, and clearing public safety hazards such as wires that are down or hanging dangerously low. Field Checkers, often being the first responders into the affected areas, call in to the dispatcher any such hazards found and remain there until relieved to keep the public from making contact with the wires. Ameren-IL uses Public Safety Advisors (PSAs) and Cut-and-Clear crews to respond to these situations so that the Field Checkers can proceed with damage assessment. There are assigned storm response roles for dispatchers to coordinate the work of Field Checkers, Public Safety Advisors, and Cut-and-Clear crews. All utilities responding to damage after a major storm confront these hazards. The Ameren-IL approach is a utility best practice. Given the dual responsibility of assessing the damage to facilities and responding to protect the public from hazardous conditions, and the length of time required to complete the damage assessment in heavily impacted areas, Ameren-IL needs to increase the number of field checkers to meet the workload demands in a timely manner.

The Ameren-IL critiques of the two 2006 restoration efforts and interviews with leaders of the field restoration efforts revealed the following:[329]

- In some instances there were too many checkers reporting to one dispatcher.
- Ameren-IL pulled Field Checkers off duty to become crew guides.
- In several cases, the Outage Analysis System (OAS) did not contain enough damage assessment information after the Field Checker completed the assessment.
- Some of the Field Checkers had not received training prior to their assignment to that role.

[329] Responses to Data Requests #8, Attachments 8-C and 8-D, and #85, Attachment 85-B.

- There was a shortage of Public Service Advisors in the July 2006 restoration.
- Ameren-IL called off Cut-and-Clear crews to work on other assignments.

Liberty found that the Ameren-IL Field Checking (Damage Assessment) process as described in the corporate Electric Emergency Restoration Plan (EERP) is adequate and, if executed as intended, should meet the challenge of a major outage event. The roles of Public Safety Advisor (PSA) and Cut-and-Clear crews, along with the dispatchers to communicate with them are utility best practices. However, Ameren-IL's staffing of these positions was inadequate to meet the demands of storms of this magnitude in a timely manner. The damage assessment in the heavily impacted divisions took too long to complete.

(2) Switching, Clearance, and Tagging Processes

The safety of the workers and public are paramount in the field restoration effort. Procedures followed by utility repair crews to isolate a damaged line, render it safe, repair it, and return it to service are crucial tasks. The words used here—switching, clearance, and tagging—refer to operating equipment that controls the flow of power, giving and receiving permission (clearance) to work on a line, and identifying the lines being worked on by installing a highly visible devices (*e.g.*, flag, tag) at points where the lines could be energized. The details of how exactly this is accomplished vary among utilities, and it is essential that when utilities bring in outside resources to assist on major outage restoration that they go through orientation to familiarize them with the host utility's processes.

At Ameren-IL, the Workman Protection Assurance (WPA) covers these tasks. According to the Ameren corporate Electric Emergency Restoration Plan (EERP), the WPA processes, including switching, remain under the control of the Distribution Dispatch Office (DDO) responsible for that area, although the EERP notes that, "special cases may warrant a differing approach."[330]

With many crews working to repair lines and restore service, the workload on the dispatch offices can overwhelm the dispatchers and cause long delays while crews wait to receive clearances or switching instructions. Liberty's investigation determined that there were delays caused by the process used by Ameren-IL in the July 2006 restoration effort. The notes from the critique of the July 2006 restoration contained the following comment. "There were a number of occasions when the issuance of WPA caused delays to field workers; several cases where the delays were extensive."[331] The critique notes from the December 2006 restoration indicated, "We were not aware of a great many delays relative to the issuance of WPA during this restoration." The notes commented that Ameren-IL increased dispatcher staffing, and used additional dispatchers to help write switching orders in the December effort. The notes also mentioned that some of the outside crews were unwilling to accept the WPA restrictions and only accepted them in a "global sense."[332]

During the two 2006 restoration efforts, Ameren-IL sought to address the concerns with WPA and switching procedures with the use of individuals designated as a "functional agent." These

[330] Response to Data Request #64, Attachment 64-A, Section 2.3.
[331] Response to Data Request #8, Attachment 8-C.
[332] Response to Data Request #8, Attachment 8-D.

individuals would normally be someone at the job level of superintendent and would undergo detailed training. Ameren-IL expected them to demonstrate proficiency in the process before receiving the designation. This approach had some success in relieving the workload on the Distribution Dispatch Office and reduced some of the delay in getting switching instructions.[333]

This is a very serious but common issue faced during major outages. Utilities must address it with a great deal of care. Safety of workers and the public is paramount. Ameren-IL mentioned Occupational Safety and Health Act (OSHA) requirements in the critiques of both of the 2006 restoration efforts, and it is essential that those requirements are adhered to at all times. It is also very much in the best interest of Ameren-IL and its stakeholders that any appropriate action be taken to modify the existing process so as to not delay the restoration process unnecessarily. Ameren-IL mentioned these delays in its critique of the July storms but not for the November storm. Liberty concluded that in the two 2006 restoration efforts, Ameren-IL managed the switching, clearance, and tagging process responsibly and in accordance with its Workman Protection Assurance (WPA) process, which Ameren-IL designed to meet OSHA requirements. Ameren-IL should continue to seek ways to modify the process and minimize delays while not compromising safety.

(3) Safety Performance

No matter how well a utility performs the other components, if its safety performance is not good, the field restoration process has not been successful. A key measure of the performance of the field organization is the number of employee and vehicle safety incidents experienced during the restoration effort.

Liberty discusses the performance of the Ameren Safety support group Section IV.F, Support Organizations. As noted there, the field safety professionals were under the direction of the Ameren corporate Safety group during the July 2006 restoration, but were under the Ameren-IL division managers in the November/December 2006 effort. Ameren-IL described how it managed safety under the division managers using the safety professionals.[334]

> *The role of safety professionals during emergency response and restoration events is to ensure that safety remains a primary focus and a top priority for all company and contractor personnel. They report directly to the Division Manager in each division and are assigned to travel to the specific areas within the Division that have been impacted by the emergency event. The role of safety during emergency response events is being further clarified and defined as the Ameren-Illinois organization implements a separate and defined emergency response plan structured on the precepts of the Incident Command Structure.*
>
> *Oversight and direction to the Safety Professionals during the November/December 2006 storm restoration effort was provided through daily direct contact with the Division Manager in two forms: 1) face-to-face meetings*

[333] Response to Data Request #8, Attachment 8-D.
[334] Responses to Data Requests #747 and #753.

and 2) telephone calls. In some cases, meetings took place in the field or at meal locations.

During the "ramp-up" phase of the restoration effort (the transition from normal business operations to emergency response), the Division Manager met with the Safety Professional assigned to his division and outlined performance expectations. Those expectations included:

- Provide safety training and orientation for foreign crews (contractors and those utilities providing "mutual assistance")
- Ensure that each worker understand that safety is the number one priority at all times and that safety can not be sacrificed for customer service, production or any other reason
- Provide crew safety briefings
- Make crew visits and conduct **J**ob **B**ehavior **O**bservations (JBO)
- Ensure that all workers have appropriate **P**ersonal **P**rotective **E**quipment (PPE) and further ensure that all such equipment is used at all times (as appropriate for the job at hand).

The safety professionals had the following additional duties:

- Provide morning and evening safety briefings (typically at meal locations)
- Ensure that all workers, regardless of company affiliation work safely and follow safety rules, procedures, and work practices at all times
- Direct or assist with incident investigations (employee or public incidents)

Ameren-IL indicated that division managers met with the safety professionals at least twice per day to discuss any safety incidents that occurred and any other safety issues or concerns. Examples of these issues included the availability of high visibility vests for one of the mutual aid companies and a near-miss incident. Ameren-IL did not require written reports on these matters.

The number of employee and vehicle safety incidents is a key measure of field restoration performance. Even with a well-defined and executed management and coordination plan, the number of safety incidents is the final word on how well safety performed. The table below shows the number of safety incidents in the two restoration efforts.[335] There were three basic employee groups comprising the field restoration workforce, Ameren employees, Mutual Assistance employees, and contractor employees. Interestingly, there were no safety incidents for Mutual Assistance workers in either of the two restoration efforts.

Employee safety incidents fall into one of three categories:

- Not Recordable – an incident that required no medical attention or needed only first aid.
- Recordable – an incident that resulted in an injury to the employee who required medical attention beyond first aid.
- Lost Time – an incident in which employee injury results in the employee not being able to report to work on the next scheduled work day.

[335] Responses to Data Requests #747 and #753.

Vehicle safety incidents fall into one of two categories:

- Non-preventable – a vehicle accident in which the employee driver was not at fault and could not have reasonably been expected to take successful evasive action. Three examples of non-preventable accidents on this list are: limb fell out of tree and struck truck, Ameren vehicle struck from behind by another vehicle, and line truck hauling pole on pole trailer struck public vehicle when it tried to pass line truck on the right as it was attempting to make a right turn.
- Preventable – a vehicle accident in which the employee driver was at fault. Two examples from this list are: employee backed into another vehicle, and employee ran into back of public vehicle.

Employee and Vehicle Safety Incidents
Ameren-IL - 2006 Storms
Legend: NR – Not Recordable, R – Recordable, LT – Lost Time, NP – Not Preventable, P-Preventable

	July 2006	Nov/Dec 2006	Total
Ameren-IL Employee Safety Incidents	NR – 4 R – 1 LT – 0 5	NR – 12 R – 4 LT – 1 17	NR – 16 R – 5 LT – 1 22
Contractor Employee Safety Incidents	NR – 2 R – 1 LT – 1 4	NR – 0 R – 3 LT – 0 3	NR – 2 R – 4 LT – 1 7
Total Safety Incidents	NR – 6 R – 2 LT – 1 9	NR – 12 R – 7 LT – 1 20	NR – 18 R – 9 LT – 2 29
Ameren-IL Vehicle Incidents	NP – 1 P – 0 1	NP – 4 P – 3 7	NP – 5 P – 3 8
Contractor Vehicle Incidents	NP – 0 P – 0 0	NP – 3 P – 1 4	NP – 3 P – 1 4
Total Vehicle Incidents	NP – 1 P – 0 1	NP – 7 P – 4 11	NP – 8 P – 4 12

There was a significant increase in employee and vehicle safety incidents in the November/December 2006 restoration effort. Given the large increase in workers and vehicles and the more adverse weather conditions such as icing, this result was not surprising. The most significant figures are the total number of recordable and lost-time employee safety incidents and preventable vehicle incidents. For the two restoration efforts combined, there were 9 recordable employee safety incidents, and 2 lost time incidents. Electric facilities were not directly associated with any of the employee safety incidents. They were all related to falls, cuts, sprains, etc. There were only four preventable vehicle incidents for the two storms. Again, given the large

number of workers and vehicles brought into the area with which they were not familiar, under very hazardous and challenging driving and working conditions, these numbers are very good.

Liberty concluded that the safety organization in both of the 2006 restoration efforts provided good oversight and maintained a strong emphasis on safety throughout the event. Moreover, Liberty found that the field-restoration safety management and performance met or exceeded expectations given the challenging circumstances.

(4) Length of Restoration

In reviewing the performance of any electric utility in its response to a major outage event, an ultimate question is whether the time required to restore power to all customers was reasonable given the circumstances. Stated another way, this question is: "Was the restoration time good, fair, poor, or unacceptable, and was the restoration time longer than it should have been, and if so, by how much?"

There has never been, and never will be a perfectly executed response to a major outage event. There will always be issues that arise and opportunities for improvement. The fact that Liberty found several items that Ameren-IL needs to address does not mean that the restoration time was unacceptable or even unreasonable. Obviously, all of these items collectively had some effect on service restoration time, but often the utility response organization is able to offset some of this impact and hold the restoration time within reasonable or acceptable limits.

In making this assessment, Liberty compared the restoration time of the two 2006 Ameren-IL efforts to that of two utilities affected by Hurricane Isabel on the East Coast in 2003. Liberty used this comparative data in Section IV.C, Organizational Performance, in its review of the size of the Ameren-IL restoration workforce. Liberty selected these two utilities for comparison based on the availability of data and the comparable length of the restoration times.

In that earlier section, Liberty noted that several factors such as the type of storm, the terrain involved, and utility work rules make comparisons problematic. In addition, the November/ December 2006 storm was a winter ice storm with the significant restraints on travel and working conditions inherent with this type storm. The July 2006 storm was actually two storms. One hit the Ameren-IL area on July 19, 2006, and the second one, of similar in intensity to the first, hit the Ameren-IL area on July 21. In some locations, the second storm caused restoration re-work.[336] In addition, to be considered when comparing the performance of different electric utilities in responding to different storms are factors such as customer density of the affected area and the amount of available outside help within a certain travel time. Notwithstanding these comparison difficulties, Liberty made the following observations:

1. The restoration rates for Companies A and B are twice as great as the rate for Ameren-IL in the July 2006 response.
2. The type of storm experienced by Ameren-IL in July 2006 compares favorably to the impact of a hurricane – absent the storm surge and torrential rains – so the working conditions in the response to the July 2006 storm and Hurricane Isabel are comparable.

[336] Interviews #13 (October 3, 2007), #15 (November 14, 2007), #18 and #19 (October 25, 2007).

3. The reasons for the difference in the restoration rates as noted in (1) above are primarily the much smaller Ameren-IL workforce and the impact of the July 21, 2006 storm.
4. The restoration rates for Companies A and B were 20 percent to 25 percent greater than that of the Ameren-IL response to the November/December 2006 major outage event.
5. Even with a larger workforce than Companies A and B when compared to customer outages, Ameren-IL was not able to match the restoration rate of those two companies due to the significantly more difficult working conditions found in the November/December 2006 winter storm compared to those faced in the wake of a hurricane or windstorm.
6. The length of the restoration by Ameren-IL in response to the July 2006 storm, even considering the second storm on July 21, was too long. A restoration length of eight days would meet what one should expect for this type of outage event. Ameren-IL took ten days.
7. The length of the restoration by Ameren-IL in response to the November/December 2006 winter storm was reasonable. To restore over 370,000 customers in eight days under the type of severe working and traveling conditions that Ameren-IL encountered is well within expectations for this type of outage event.

The dedication and persistence of the entire Ameren-IL emergency response organization is commendable. Employees worked long hours for many days in very difficult conditions. If it were not for this type dedication and hard work, the restoration effort would have taken longer and all Ameren-IL stakeholders would have suffered. While Liberty found that the July 2006 restoration effort took too long, it was not due to the lack of hard work by the employees involved.

In Chapter III dealing with emergency plans, and in this chapter, which addresses storm restoration performance, Liberty has reached a number of conclusions and made recommendations addressing issues that affected the restoration time and performance in these two events. Ameren-IL should address these in order to improve as an emergency response organization. The single biggest factor that caused the July 2006 restoration to run too long was the small size of the workforce. Ameren-IL should carefully review the issues that caused the lengthy restoration time to improve future performance.

(5) Quality of Repair Work

To help ensure the quality of the restoration repair work, Ameren-IL indicated that its construction supervisors, construction superintendents, or qualified journeymen accompanied foreign contractor crews and Mutual Assistance utility crews "a majority of the time."[337] In some cases, Ameren-IL gave foreign crews copies of standards books and generally instructed them to rebuild according to the pre-damaged configuration. Ameren-IL's field engineering performed post-storm reviews to check that foreign crews used proper construction methods. Ameren-IL noted that it has not identified any major outages since the 2006 storms directly attributable to the repairs made during the restoration from those storms.

[337] Response to Data Request #760.

According to Ameren-IL, the Transmission Maintenance Engineering staff directed all repairs to the transmission system. Transmission maintenance engineers were on site prior to beginning restoration work, were on site during a large portion of the actual restoration work, and performed on-site inspections after work completion.[338]

During interviews with many individuals knowledgeable of the quality of repair work, none mentioned the issue of repair work quality.[339] Liberty's interview questions generated many comments and Ameren-IL's employees were very open in their responses. Given this openness and the large number of interviewees, the absence of input concerning an issue can be as significant as input that identifies an issue. Moreover, Ameren's post-event critiques never mentioned the quality of repair work as an issue.[340] The critique of the November/December restoration took place more than four months after completion of the repair work for the July 2006 storm. It is reasonable to assume that if there had been any significant problems in the quality of the July repairs, those matters would have been apparent by then and Ameren-IL would have mentioned such issues in the critique notes.

Liberty concluded that Ameren-IL had an appropriate approach in managing the quality of repair work during the two 2006 restoration efforts, and that repair work quality during these two restoration efforts was acceptable.

4. Conclusions

1. There is a need for clarity and consistency in defining the role of the Ameren-IL Division Manager in the emergency response organization, especially concerning the issue of direct responsibility for the field operating centers. (Recommendation IV-12, Section IV.C, Organizational Performance)

In interviewing all seven of the Illinois Division Managers, Liberty noted that the actual role of that manager in the division emergency organization varied from division to division. Some of them were very "hands on" in running the restoration effort, spending the large majority of their time at the division storm command center. Other division managers saw their role as supporting the Division Superintendent who actually ran the restoration effort in the division. These division managers spent a large portion of their time visiting crews and operating centers, and making contacts with key citizens and elected officials. This difference in approach is not uncommon among mid-level utility management, and there are advantages to each approach. Because of the talent and experience level of the incumbents in these division manager positions, Ameren-IL should make an effort to determine the optimal role for the Division Manager during major outage events, and seek consistency in their storm assignment.

The issue of who has direct responsibility for the field operating centers is crucial to the effective performance of field restoration. There is a need for clarity and consistency among all of the

[338] Response to Data Request #760.
[339] For example, Interviews #17 (October 25, 2007), #21 (October 24, 2007), #69 (November 29, 2007), #72 (October 30, 2007), #73 (October 29, 2007), #74 (October 29, 2007), #82 (November 29, 2007), #88 (January 9, 2008), #95 and (January 11, 2008).
[340] Response to Data Request #8, Attachments 8C – 8H; and Data Request #85.

Ameren-IL divisions to facilitate the training and preparation of the emergency response organization and to ensure an effective response to major outages.

2. The Ameren-IL field operating center organization was well designed and appropriate to manage the restoration effort for the two 2006 storms.

The field operating center organization in place for the two 2006 storms provided flexibility that allowed the staffing to be expanded or reduced depending on the situation. Support and direction ensured that the field workers had what they needed and that they performed work in a safe and effective manner. This included support from the corporate Emergency Operations Center (EOC) and the Distribution Dispatch Operations (DDO) center, as well as support and direction from the division command center. Ameren-IL personnel also provided appropriate supervision for the Mutual Assistance utility and contractor personnel. The field-operating center provided the coordination and dispatch functions necessary to prioritize the restoration work and coordinate the different functions and work groups.

3. The Ameren-IL employees used to head up the local field operating centers and to coordinate and direct the restoration workforce in the field were seasoned utility operating veterans with many years' experience in storm response.

Ameren-IL used experienced construction supervisors normally assigned to that specific operating center to head up the storm effort or brought in division superintendents from other divisions not heavily affected by the storm. In addition to these supervisors, the other supervisory personnel used in the field operations to coordinate and direct the restoration workforce were well experienced in storm response.

4. In at least one instance during the July 2006 storm response, one individual headed up the restoration effort at both the division level and at the local operating center at the division headquarters. This was too large of an assignment for one person. (Recommendation IV-34)

Liberty found that the individual assigned this dual role in the July 2006 storm was an extremely talented and well-experience employee in storm response. However, his assigned role was too much for one person, and the general practice among utilities in major outage response is to avoid such dual roles. Ameren-IL addressed this situation for the November/December 2006 storm, but Ameren-IL should address it in their Electric Emergency Restoration Plan (EERP).

5. Ameren-IL field command center facilities used during the two 2006 storms were adequate, but there are opportunities for improvement. (Recommendation IV-35)

Liberty toured six Ameren-IL facilities used as storm centers during the 2006 storms and conducted interviews with employees assigned to work at those location. Liberty assessed the accessibility of the storm room and how quickly it could be made operational, the back-up power arrangement protecting the facility, the access to support groups at the facility, the available necessary equipment to support the storm room activities, and the control of traffic in and around the storm room. Of the 30 ratings given (five assessment areas for six facilities), 22 were "good," 6 were "acceptable," and only 2 rated "needs improvement." The primary areas of improvement

were in the location and accessibility of the storm room. Liberty found no indication that the situations noted had a negative effect on command center performance. Liberty found that Ameren-IL's field command-center facilities were adequate to good overall, with some improvement opportunities.

6. Ameren-IL's use of staging sites during the response to the two 2006 storms accomplished the intended purpose for material storage and handling. Ameren-IL can make better use of these sites. Ameren-IL obtained some sites only after it needed them. (Recommendations IV-36 below and IV-32 above)

Ameren-IL used two staging sites in the July 2006 storm, and two in the November/December 2006 storm. The primary purpose of the staging sites as employed by Ameren-IL was for the storage and handling of material and equipment needed for storm repair. Ameren-IL located the staging sites to get the needed supplies as close to the work site as possible and minimize crew travel. The performance of the staging site personnel was effective in accomplishing the intended purpose. Even though the corporate Electric Emergency Restoration Plan (EERP) mentions the possible need for arrangements for meals and fuel, and recommends consideration be given to bussing crew personnel to and from the staging sites to the hotel, Ameren-IL did not use the staging sites to feed crews or to park and fuel vehicles. Using staging sites for these purposes is a widely accepted electric utility best practice during major outage events, and has proven to be quite efficient. The utility saves time and money in traveling and feeding crews, fueling vehicles at a few staging sites rather than multiple lodging establishments, and providing security for these vehicles after hours. Ameren-IL also reported that it secured sites not owned by them only at the time of need by face-to-face communications. This approach runs a very real risk of creating bottlenecks and delays in securing and opening these sites that are critical to the effective response to a major outage event.

7. Ameren-IL's radio systems could not all communicate with each other. Communications between field workers and between the field command centers and field workers during the 2006 storms were almost entirely by cellular telephone. (Recommendation IV-37)

Section 13.4 of the Ameren corporate Electric Emergency Restoration Plan (EERP) in use at the time of the 2006 storms detailed the limitation of the existing voice radio system in which there was no interoperability between any of the four separate radio systems in use in the Ameren-IL service area. As Ameren-IL brought in repair crews using these different radio systems to affected areas, the field command centers could not communicate with them, nor could local crew guides. For this reason, Ameren-IL almost exclusively used cellular telephones for communications during the restoration efforts. This is not desirable because cellular telephone towers can be damaged or otherwise lose service during major storms. In addition, in urban areas in times of emergencies, cellular traffic can be extremely heavy causing problems getting a call through. Ameren-IL is actively pursuing the installation of a new radio system for its service area and expects the project to be complete by November 1, 2008.

8. The communications between the Ameren-IL field command centers and the support groups during the two 2006 storm restoration efforts was good.

The communications between the field command centers and key support groups such as logistics, engineering / field checking, and forestry (tree crews) were good during the Ameren-IL restoration effort following the two 2006 storms. Some support group coordinators were located in the same facility with the field "storm room." Where this was not the case, there were regular communications by telephone between the field command centers and support coordinators or the coordinators would make frequent visits to the field command-center facility. Liberty found no negative effect on the restoration efforts resulting from communications (or problems in communications) with the field command centers and the support groups.

9. The communications between the Ameren-IL division and field command centers worked well during the two 2006 restoration efforts, but there is an opportunity for improvement. (Recommendation IV-38)

The upward communications from the field command centers to the division command center normally used telephone conversations numerous times during the day as the need arose. Some divisions held conference calls on an occasional, as-needed basis, but this was not a common practice at Ameren-IL. Liberty found that these communications worked well, but recommends that Ameren-IL consider a more structured, scheduled approach to the telephone communications between the division and field command centers. There will always be the need for unscheduled communications between these command centers, but by scheduling regular conference calls and/or specific times for status calls, there is an opportunity to gain efficiency in the operation of the division and field command centers. This more structured and scheduled approach to communications is widely used by electric utilities to good effect, and is best practice.

10. The Ameren-IL field organization did not report the status of outage repair and update the Outage Analysis System in a timely, complete, and accurate manner during the two 2006 storm restoration efforts. (Recommendations IV-14, IV-15, and IV-16 above)

The issue of restoration or outage status reporting proved to be one of the most challenging facets of the overall Ameren-IL response to the two 2006 storms. Many of the Ameren-IL employees involved in the response to the two 2006 storms were not adequately trained or properly equipped to use OAS during a major outage event. Contributing factors were the process of "sweeping" electric feeder circuits (completing all repairs and restoring all power on a given circuit rather than working individual OAS orders), the demands on the field supervisors' time, and a misunderstanding on the part of some supervisors as to how to close the OAS orders. Ameren-IL has already undertaken an aggressive training regimen in the use of OAS for appropriate employees. It should also take steps adequately equip those employees who will have the responsibility of updating OAS from the field. Ameren-IL should also dedicate more human resources to handle adequately the workload associated with this important function during a major outage event.

11. Ameren-IL employees directing the field restoration effort did a good job in work prioritization and crew deployment during the two 2006 storm restoration

efforts. There are opportunities for improvement by better advance identification of circuits serving critical loads and by wider use of the circuit "sweep" approach to restoration during a major outage event. (Recommendation IV-39)

The employees directing the field restoration effort did a good job in prioritizing the work and deploying the workers assigned to them. These employees were, without exception, experienced and knowledgeable utility "storm veterans" who knew what needed to be done and did it. Ameren-IL followed the utility best practice of "collapsing" crews into areas still without power when released from other locations. It can be challenging for field command-centers to manage effectively the additional resources received many times with short notice. Liberty found that Ameren-IL managed this process without any noticeable problems. Ameren-IL failed to identify "critical customers" in the Outage Analysis System prior to the July or November storms. As a result, each division had to identify and prioritize critical customers on their own as the storm progressed. Ameren-IL used the circuit "sweep" approach in several different field command centers during the two 2006 restoration efforts. Liberty recommends a more frequent use of this widely accepted utility work approach that is a best practice during major outage response.

12. Ameren-IL did not have enough help in the deployment and coordination of the large number of outside workers brought in to assist in the two 2006 major outage restorations. (Recommendation IV-39)

In the November/December 2006 restoration effort, Ameren-IL needed more help in managing the large numbers of outside crews. Ameren-IL used retired employees and some employees from the power generating plants, but it needed more. Ameren-IL should implement a much more aggressive process to identify in advance and train employees not normally assigned a role in major outage response in order to assist in this area.

13. The practice of using members of local crews to serve as guides and coordinators for outside crews was successful but not widely implemented. (Recommendation IV-39)

In this technique, rather than using local crews strictly for "hands on" restoration work, the utility breaks local crews and assigns individual members as guides and coordinators for the outside crews. Ameren-IL used this practice in some locations. This practice is widespread among electric utilities and is a best practice by those who use it.

14. Some labor contract provisions constrained Ameren-IL's ability to deploy restoration workers effectively. (Recommendation IV-40)

One provision affected Ameren-IL's ability to relocate personnel from one legacy company into the service area of another legacy company unless all line personnel in the target area had been called out to work. A labor provision dealing with "numbered crews" puts restrictions on how Ameren-IL could use personnel on those crews, even during major outage events. Another labor contract provision specified that employees could "volunteer" to go to a work assignment in another legacy company, but they could not be required to go. For the most part, these provisions did not negatively affect the availability and performance of Ameren-IL workers during the response to these two major outage events.

Such labor provisions represent restrictions on a utility's ability to respond adequately to a major outage event. It is commendable that Ameren-IL management and labor worked through these provisions and minimized the potential negative effect on service response. Ameren-IL should place a high priority on negotiating more flexibility in their labor contracts in the area of emergency response.

15. Ameren-IL did a good job in coordinating with other emergency response agencies during the two 2006 major outage events. Communications problems hampered the receipt of wires down reports from fire and police departments. (Several recommendations in section IV.E above and Recommendation IV-41 below)

During the July 2006 storm, the Illinois Emergency Management Agency (IEMA) set up a Unified Command Center in Alorton, IL. Ameren-IL provided update briefings at scheduled times during each day to IEMA and various other state agencies (Illinois State Police, Illinois Department of Transportation, Illinois Department of Public Health and others). County officials were also located at the center. Additionally, the IEMA staff at the center was in constant communications with the Ameren-IL liaisons to resolve concerns over a number of issues. In addition, coordinated information was forwarded to the IEMA Springfield location and to the Illinois Commerce Commission (ICC) staff at the IEMA office. According to Ameren-IL, this arrangement worked so well that Ameren-IL adopted it as a best practice for major outage events such as the July 2006 storm. Liberty did not receive a confirmation that the IEMA remote center was used during the November/December 2006 restoration effort. Ameren-IL should continue to pursue this with IEMA and establish a clear understanding of when this remote center will be used and the procedure to coordinate Ameren-IL's role in its opening and operation.

As reported in Section IV.E, Communications, Ameren had serious telephony problems during the storms that, among other things, delayed the receipt of wires down reports from fire and police departments.

16. The July 2006 restoration workforce was too small. The December 2006 restoration workforce size was adequate but lacked adequate line supervision. (Recommendations IV-5 and IV-13 above)

With regard to the size of the Ameren-IL field restoration workforce in the response to the two 2006 storms:

- The Ameren-IL field restoration workforce was much smaller than needed to respond adequately to the July 2006 storm, due in large part to the limited availability of outside resources at the time.
- The Ameren-IL field restoration workforce was of adequate size to respond appropriately to the November/December 2006 storm.
- Several factors delayed the arrival of the outside help in the response to both the July 2006 and the November / December 2006 storms.
- The amount of Ameren-IL line supervision between July 2006 and December 2006 did not increase even though the total workforce increased almost 200 percent.

There was a significant disparity in the numbers of the total line and tree restoration workers for the July 2006 and December 2006 storms. The data also reflected the delay of several days in getting outside help into the impacted area.

There were delays in getting outside help. In the case of the November/December 2006 restoration effort, one division did not receive any outside help until Monday, December 4, even though it made a request for help on Friday morning, December 1. There was a report from one individual that even though the amount of outside help in the November/December 2006 storm response met his expectations, there was not enough help available in one operating center area in his division.

Ameren-IL reported that the number of its line supervisors (not including supervision furnished with Mutual Assistance utilities and line contractors) was 49 in the July 2006 restoration and 48 in December 2006. These numbers reflect the normal Ameren-IL complement of line supervisors. Ameren-IL did not furnish any information concerning numbers of Ameren-IL personnel assigned to guide/coordinate outside crews. With an increase in total workforce between July and December of almost 200 percent, more help of this nature would be important.

17. The field restoration workforce had good qualifications. Some outside contractors may have assigned too many "non-climbing" personnel. (Recommendation IV-42)

The experience and knowledge of Ameren-IL personnel involved in a variety of field restoration functions during the 2006 storms was impressive. Ameren-IL has a good reservoir of experienced, knowledgeable, and dedicated employees to call upon to respond to major outages. Liberty also based its conclusion on a review of the Mutual Assistance utilities and interviews with the Ameren-IL employees who managed contractors and who recruited the outside contractors for assistance during the storms.

Ameren-IL raised a possible issue that new contractors may have brought in too many "non-climbing" personnel (*e.g.*, equipment operators, support personnel). Ameren-IL was in the process of investigating this matter. This issue is familiar to all utilities that have had to bring in large numbers of outside contractors. Ameren should follow through to ensure that this is not a problem for them in the future.

Liberty found no evidence of any deficiency in field restoration performance in the Ameren-IL response to the two 2006 storms resulting from unqualified personnel, whether Ameren employees, Mutual Assistance utility personnel, or contractors.

18. Ameren-IL management, employees, and union leadership cooperated to allow the use of non-union contract personnel to work on Ameren-IL property during the restoration effort following the two 2006 storms.

In responding to these two major outage events, it was necessary for Ameren-IL to bring in non-union contractors to assist. This is a very sensitive issue with the union employees at Ameren and with the unions themselves. Ameren has typically avoided bringing in non-union personnel to work on their property. Due to the severe nature of these outage events, Ameren-IL made the decision to bring in non-union help. Management held discussions with union representatives,

and, to the credit of the union leadership, Ameren-IL employees, and Ameren-IL management, they handled this issue with very little difficulty. The non-union personnel were the first that Ameren-IL released at the end of the restoration effort.

19. The working hours and meals practices as employed by Ameren-IL in the field restoration effort was in keeping with practices common to a number of utilities. Ameren-IL should review these practices for possible opportunities to improve. (Recommendation IV-43)

The meal provisions employed during the two restoration efforts are in keeping with widely accepted practices in the utility industry. The box lunch arrangement is very important and is a utility best practice. This provides the personnel with nourishment at the midpoint of their workday without the lost time associated with getting them to some eating location. The working hours employed by Ameren-IL during the 2006 restoration efforts align with the practice of other utilities. Liberty suggests that Ameren-IL review this practice to ensure that it serves the best interests of the employees and customers during major outage restorations.

20. Ameren-IL adequately managed the daily crew reporting process during the two 2006 restoration efforts. There is an opportunity to establish a specific process and ensure that Ameren-IL handles this important task more consistently in future major outage restorations. (Recommendation IV-44)

Ameren-IL followed no set procedure in the daily reporting process during the two 2006 restoration efforts. There is no specific procedure detailed in the Ameren corporate Electric Emergency Restoration Plan (EERP) or in the two Ameren-IL division plans reviewed by Liberty. In some locations, crew leaders came in to the field command center to make reports, and at other locations telephone calls served. The Ameren-IL field restoration organization had construction supervisors assigned to coordinate repair crew work in certain areas. These supervisors maintained ongoing communications with crew leaders during the day and therefore had the information normally covered in daily reports.

21. Ameren-IL's performance in receiving and orienting outside crews arriving to assist in the 2006 restoration efforts could have been better. (Recommendation IV-45)

In most instances in the two 2006 restoration efforts, Ameren-IL did not use Checkpoints to receive and orient the arriving outside crews as set forth in the corporate Electric Emergency Restoration Plan (EERP). Ameren-IL indicated that the main intent of the Checkpoint is to establish a separation of the arriving outside crews from the restoration work centers, and that it maintained this separation by either meeting the outside crews at their lodging upon arrival, or meeting with them separately at staging sites. By following the Checkpoint provisions in the corporate Electric Emergency Restoration Plan (EERP), Ameren-IL could have handled this in a more consistent manner to ensure a smooth, safe, and effective transition of the outside crews into the restoration workforce.

22. The timing, quantity, and quality of materials and repair items served the storm restoration work well.

Ameren-IL issued over 2,200 poles, nearly 4,500 cross arms, over 2 million feet of wire and cable, and over 1,400 transformers during the two restoration efforts. The Stores/Material Support group fulfilled its role during both storms. Ameren-IL had reasonable processes in place with regard to the quality control of repair materials. Liberty found no evidence that availability or quality of repair materials delayed the restoration.

23. Aspects of Ameren's Field Checking (Damage Assessment) process are utility best practices. However, during the 2006 storm restorations, staffing of Field Checkers was inadequate and some damage assessment took too long. (Recommendation IV-46)

Field Checkers have several important duties including the initial inspection of outage sites to assess the type and degree of damage. Ameren's definition and use of Filed Checkers, Public Safety Advisors, and Cut-and-Clear crews are utility best practices. However, the responsibilities of Field Checkers during the 2006 storm restorations were too much for the number of individuals assigned. Ameren-IL did not complete damage assessment in some divisions until the last few days of the restoration.

24. During the 2006 restorations, Ameren-IL's strong commitment to worker and public safety was evident from its management of switching, clearance, and tagging. However, the Workman Protection Assurance (WPA) switching process caused delays in the restoration work. (Recommendation IV-47)

Ameren-IL's approach to controlling switching during the two 2006 restoration efforts demonstrated its strong commitment to worker and public safety. The WPA switching process caused some delays in the July storms. Ameren-IL sought to address this with the limited use of a concept known as "functional agent" that would move control of some switching out to qualified and trained personnel in the field. This met with some success.

25. Ameren-IL's safety management and performance during the 2006 storm restorations was very good.

Ameren-IL maintained a strong safety orientation throughout the 2006 storm restorations. There were nine recordable employee safety incidents and two lost time incidents. None of these incidents related directly to electric facilities. There were only four preventable vehicle incidents during the restorations. Considering the number of field workers and hazardous condition, this safety performance was very good.

26. The length of the restoration to the July 2006 storm was too long. The length of the restoration to the November/December 2006 storm was reasonable. (Recommendations IV-5 and IV-13)

The length of the restoration following the July 2006 storms was ten days. Even considering the effects of the second storm, this was too long by about two days. The time required to restore all

power following the November/December storm was eight days. Considering the number of customers affected and the working and travel conditions, this performance was reasonable.

The dedication and persistence of the entire Ameren-IL emergency response organization during both of the 2006 events is commendable. Employees worked long hours for many days in very difficult conditions. While Liberty found that the July 2006 restoration effort took too long, it was not due to the lack of hard work by the employees involved.

In Chapter III dealing with emergency plans, and in this chapter addressing storm restoration performance, Liberty made recommendations addressing issues that affected the restoration performance in these two events. Ameren-IL should address these in order to improve as an emergency response organization. The single biggest factor that caused the July 2006 restoration to run too long was the small size of the workforce. Ameren-IL should carefully review the issues that caused the inadequate workforce size and take steps to improve future performance.

27. The approach taken by Ameren-IL in the area of quality control of repair work during the two 2006 restoration efforts was appropriate.

Construction supervisors, construction superintendents, or qualified journeymen accompanied foreign contractor crews and Mutual Assistance utility crews. Ameren-IL used standards books and general instructions to workers not familiar with Ameren-IL methods. Ameren-IL's field engineering performed post-storm reviews to check that foreign crews used proper construction methods. The Transmission Maintenance Engineering staff directed all repairs to the transmission system and performed on-site inspections after work completion. Neither interviewees nor Ameren's post-storm critiques mentioned the quality of repair work as a problem.

5. Recommendations

IV-34 Revise corporate Electric Emergency Restoration Plan (EERP) to ensure that Ameren-IL assigns separate individuals to head up the division storm response and the response at a local operating center.

As part of the overall effort to improve the corporate Electric Emergency Restoration Plan (EERP), and clarify the different storm roles in the division response organization, Ameren should clearly communicate that the roles of heading up the division response and heading up the local operating center response at division headquarters will be with separate individuals. Ameren-IL should incorporate this change in the EERP and clearly communicate it to affected employees within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-35 Inspect all Ameren-IL divisions to ensure that the facilities to be used as command centers can be transitioned from normal business operations to emergency response quickly and effectively so as to facilitate a timely ramp-up of emergency response within the organization.

Some possible items to consider include, but are not limited to the following:

- provide quick accessibility to and set-up of the storm room
- provide the protection of all sensitive storm-room computer equipment on an Uninterruptible Power Supply (UPS)
- locate all key support function coordinators in close proximity to the storm room staff
- furnish all necessary equipment such as computers, fax machines, printers/plotters, land-line telephones, cellular telephones, satellite telephones, company radio, and commercial radios and televisions
- isolate the storm room from unnecessary traffic (personnel located at that facility or those from outside)

Ameren-IL should complete the inspection of these facilities within six months and accomplish the necessary modifications/improvements within twelve months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-36 Identify and contractually secure potential-staging sites not owned by Ameren for each operating center area.

Ameren-IL should change the EERP to reflect these practices within three months of the date of this report. It should secure contracts for potential staging sites within nine months of the date of this report. As part of the changes to the EERP, Ameren-IL should require a semi-annual review of these contracts to ensure that they remain current and that the sites will be available when Ameren-IL needs them.

In its comments on the draft report, Ameren-IL accepted this recommendation but proposed a longer implementation schedule and less frequent review of the contracts.

IV-37 Install the new voice radio system that will have all of the Ameren-IL service area operating on the same system.

Ameren-IL has already acquired the new system and expects the installation to be complete by November 1, 2008.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-38 Establish as normal operating procedure regularly scheduled conference calls between the division and field command centers during major outage events. Revise the corporate Electric Emergency Restoration Plan (EERP) accordingly.

Ameren-IL should make these changes to the EERP and communicate them to all appropriate parties within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-39 Improve field restoration practices.

a. Establish as normal procedure for major outage response the advanced identification of circuits serving critical customers. This process should be included in the Ameren-IL Emergency

Response Plan. Ameren-IL should have established lists, and periodic reviews, of the circuit designations for critical customers and loads, and should complete implementation within six months of the date of this report.

b. Ameren-IL should make better use of the "sweeping" of circuits approach to power restoration. Ameren-IL should define this process in the Emergency Response Plan and complete implementation within nine months of the date of this report.

c. Ameren-IL should have advanced identification of and training for employees who do not have a role in major outage response to assist in the deployment and coordination of outside crews. It should include this provision in the Emergency Response Plan and complete implementation within nine months of the date of this report

d. Ameren-IL should make more use of members of local crews as guides and coordinators for outside crews, include this in the Emergency Response Plan, and complete implementation within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-40 Negotiate changes in labor contracts to allow more flexibility in responding to major outage events.

Ameren-IL has only recently completed labor negotiations on the existing contracts between the legacy companies and the unions. Any gains made in these negotiations in the area of more flexibility in emergency response should be managed carefully in order to realize the maximum benefit possible in improved service response. Ameren-IL should continue discussions with the unions to address issues affecting the ability to respond to major emergencies. If possible, Ameren-IL should seek mid-term agreements to gain more flexibility prior to renegotiating the contracts. Ameren-IL should report to the Illinois Commerce Commission (ICC) on the results of the recently negotiated changes in improving service response, and on the status of ongoing discussions with the unions to gain more flexibility. Ameren-IL should make the report to the ICC within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-41 Work with the Illinois Emergency Management Agency (IEMA) to use the remote Unified Command Center during major outage events.

Ameren-IL should work with IEMA and establish a clear understanding when they will use this remote center and the procedure to coordinate Ameren-IL's role in its opening and operation. Ameren-IL should report to the Illinois Commerce Commission (ICC) providing details of the understanding reached between Ameren-IL and IEMA. Ameren-IL should complete this report to the ICC, the revision of the corporate and division Electric Emergency Restoration Plans, and the communication of the changes to the plan within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-42 Implement the necessary procedures to ensure that outside contractors brought in to assist in the response to major outage events do not have a disproportionate number of "non-climbing" personnel.

The appropriate Ameren-IL department should take steps to communicate the company's expectations in advance to all contractors who have assisted in the past or could be used in future major outage restorations. During the actual recruitment process in a major outage restoration, this group should require information on each crewmember indicating whether each is qualified to do electric journeyman work. Ameren-IL should formalize the procedure and contact contractors within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-43 Review the practice of managing the work and rest hours of field restoration workers that results in employees remaining on premium pay during the entire major emergency restoration.

Ameren-IL should review this practice to ensure that it serves the best interests of both employees and customers during major outage restoration efforts. Ameren-IL should report the results of this review as well as planned action (if any) to the Illinois Commerce Commission (ICC) within six months from the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-44 Establish and implement a specific procedure for daily reports from field restoration repair crews during major outage events.

Ameren-IL should review the practices used to gather information from and give information to field-restoration repair crews during major outage events. Ameren-IL should decide on the best procedure to follow to ensure that this daily reporting is timely, accurate, and effective. Ameren-IL should then establish the procedure in the corporate and division Electric Emergency Restoration Plans (EERPs) and communicate it to all appropriate employees. Ameren-IL should complete these steps within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-45 Implement the Checkpoint provisions in the corporate Electric Emergency Restoration Plan (EERP) during major outage restoration efforts.

Ameren-IL should identify and secure Checkpoint sites in advance for use during major outage events. Ameren-IL should pre-identify and train employees to perform the various Checkpoint roles. Ameren-IL should use annual drills and refresher training on these roles. Ameren-IL should complete the initial steps of this recommendation within six months of the date of this report and keep the designations and training current each year.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-46 Identify and train in advance an adequate number of employees to serve as Field Checkers and Public Safety Advisors (PSAs) during a major outage restoration.

Ameren-IL should thoroughly review the number of personnel that it may need to fill the roles of Filed Checkers and Public Safety Advisors. Ameren-IL should identify in advance people who could fill these roles and train them to do so. In addition, Ameren-IL should review and respond to the issues concerning field checking and damage assessment noted in the critiques of the 2006 storm restorations. Ameren-IL should complete this recommendation within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-47 Design and implement acceptable options that are compatible with Workman Protection Assurance for more timely switching during major outage restorations.

Ameren-IL should review the procedures followed by other utilities, design, and provide for alternative switching and clearance options that will protect worker and public safety and minimize switching delays during major outage restoration. Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

H. Post-Storm Activities

1. Objectives

This section provides a description and Liberty's evaluation of Ameren's activities after the 2006 storms. More specifically, it covers the ramp-down, cleanup, and post-storm critique activities and performance. Liberty evaluated the effect of each of these activities on restoration of service and the potential effect on Ameren-IL's response to future, major outage events. The report addresses the following item in the ICC's Request for Proposals for this investigation:

- **4.3.2.5.36** An evaluation of the utilities' post-event processes such as ramp-down, clean-up and post-event critiques.

2. Background

In analyzing performance in athletic contests, two common phrases are the ability to "finish well," and "it's not over 'til it's over." These two phrases also apply to an analysis of an electric utility's response to a major outage event. The goal of a utility in such an event is to restore power to the customers as safely, promptly, and efficiently as possible. In the interest of speeding the recovery effort, the utility assembles a large workforce and makes repairs as expeditiously as possible. At some point in time—as the utility restores power to more and more customers—the utility reduces the workforce, de-activates command centers, and re-deploys workers to areas

still having restoration problems. This "ramp-down" of the emergency response organization requires the same orderly process as the activation of restoration effort.

After restoring the last customer and "declaring victory," the utility still has work to do. In the course of trimming and removing damaged trees and repairing or replacing damaged facilities, the utility may decide to temporarily forego some work that it will need to do soon but that is not necessary to safely restore service to an area. The "clean up" phase of post-event activities involves the important task of coming back and performing the work that it left undone. This phase also requires an orderly, safe, timely, and effective process.

Finally, to ignore past mistakes and opportunities for improvement is a sure way to continue to make the same mistakes and to fail to improve in restoration performance. Hopefully, the utility made notes throughout the event to capture things that worked well and things that did not. The utility should hold post-event critiques as soon as possible after the conclusion of the restoration effort while the issues are still fresh in mind. The fact that the two major outage events affected Ameren-IL in slightly more than four months underscores the importance of a timely, comprehensive post-event critique with prompt and thorough follow-up. To the extent that Ameren-IL did this following the July 2006 event, the response to the November/December 2006 event should have shown some improvement.

3. Findings and Analysis

This section presents Liberty's findings and analysis of the post-event activities of Ameren-IL in the two 2006 storms as contained within the three basic processes:

a. Ramp-Down
b. Clean-Up
c. Post-event critiques

Liberty analyzed the content of these three processes as well as Ameren-IL's performance of each activity and each overall process.

a. Ramp-Down Process

The tables below help to show the challenge facing Ameren-IL in the ramp-down process. They show the number of personnel in the Ameren-IL restoration workforce for the two 2006 storms:[341]

[341] Response to Data Request #76.

Total Restoration Resources in Illinois
July 2006 Storm
(Total Customer Outages: 302,112)

Ameren Linemen	423
Contractor Linemen	271
Mutual Assistance Linemen	140
Vegetation Clearing Personnel	349
Field Checkers/Damage Assessors	95
Stores/Material Management	50
Distribution Dispatch	45
Crew Supervision/Crew Dispatch	100
Fleet Services	35
Safety Professionals	10
Total Defined	**1518**
Field and Logistics Support	≈225
Grand Total	**1740+**

Total Restoration Resources in Illinois
Nov/Dec. 2006 Storm
(Total Customer Outages 370,322)

Ameren Linemen	444
Contractor Linemen	1870
Mutual Assistance Linemen	301
Vegetation Clearing Personnel	613
Field Checkers/Damage Assessors	169
Stores/Material Management	50
Dispatch (Damage Assessment & Vegetation Management)	63
Fleet Services	35
Safety Professionals	8
Total Defined	**3553**
Field and Logistics Support	≈250
Grand Total	**3800+**

(1) Ramp-Down Process Content

Ameren-IL had no formal written plan for the ramp down process for the two 2006 storms. Ameren-IL described its ramp-down process as follows:[342]

> *As the numbers of customers affected in a division are being reduced and restoration of all customers is expected in the next 24 hours, the Emergency Operations Center (EOC) and the local division will develop a resource release plan. The EOC will determine whether any other Ameren location will require the*

[342] Response to Data Request #83.

use of these resources and they should be transferred or they can be released. If they can be released the following order is typically used:
1. Mutual Aid Resources[343] *are released first.*
2. Outside Contract Crews, based on where they came from (i.e. furthest away released first).
3. Outside Ameren resources. These are crews from other Ameren divisions. They are usually released such that they are available in their own area the next business day to perform work.
4. Local Contract crews are released next. In Ameren Illinois, the normal work force is complemented with contractors on a daily basis. These are contractors who when released will be back in the same division performing normal construction and maintenance activities.
5. Last to be released are the local division resources. They usually will require rest, therefore the decision to hold a small contingent of contractors over is sometimes made. In particular, although the distribution system outages were all restored, there was the need for several following days to re-connect customers who had their service wires down with damage to their own facilities which required customer repairs to be completed first.

The EOC generally doesn't shut down while resource ramp down is occurring, but once it's determined no significant business value is being obtained and all areas are restored then it ceases it's (sic) function. Even though the EOC may have formally shut down, members of the EOC still may be performing a subset of the EOC duties in coordinating various activities. As part of the shut down process, the EOC will notify the appropriate governmental agencies as well as complete all event documentation.

The local division field centers also don't ramp down until the outside resources have been released and all distribution outages have been restored. A formal transfer is then made between the affected division and the appropriate Distribution Dispatch office."

The ramp-down process described above is appropriate and in keeping with typical industry practices. A key part of the Mutual Assistance agreement among utilities is that the receiving utility will be sensitive to the needs of the sending utilities and release their resources as soon as possible. Since the Mutual Assistance utilities are providing assistance on a non-profit basis, it is appropriate to release these resources before releasing contractor resources from other areas that are obviously making a profit on the work and therefore are more willing to stay longer. The plan for closing the corporate Emergency Operations Center (EOC) and division and local operating centers likewise follows a logical and practical course of action.

The obvious concern was that Ameren did not have this written policy beforehand; it was not contained within the Electric Emergency Restoration Plan (EERP). It appeared that Ameren-IL

[343] "Mutual Aid Resources" refers to personnel and resources sent to aid Ameren under the Mutual Assistance agreement. This informal agreement between electric utilities provides that participating utilities will come to the aid of impacted utilities to the extent they are able on a "not for profit" basis.

prepared this good description only because Liberty requested it. Without such a formal written plan, there is no assurance that Ameren-IL will remember it and follow it at the close of the next major outage event.

(2) Ramp-Down Process Performance

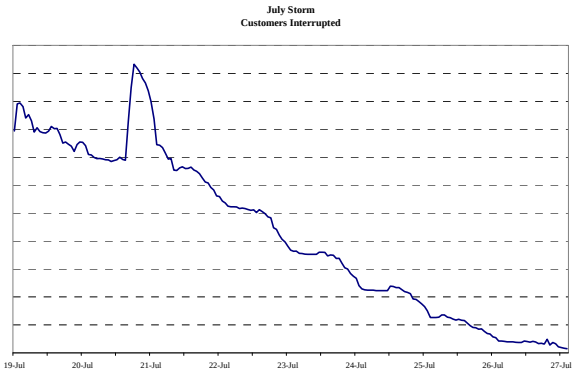
Ameren-IL followed the ramp-down process described above during the two 2006 storms. In assessing Ameren-IL's performance, Liberty considered:

- The reduction in numbers of customers still without power in the final days of the restoration effort shows whether Ameren-IL released resources too soon.
- Input received from those assisting concerning the release of their resources in the final days of the restoration effort shows whether Ameren-IL held resources too long.
- Input received during interviews with Ameren-IL management personnel concerning the closing of command centers describes the ramp-down of the command centers.

Reduction in number of customers without power – final days of restoration effort

Liberty examined the pattern of customer restoration during the 2006 storms, focusing on the final few days of restoration. The charts below show this pattern for the July storms.[344]

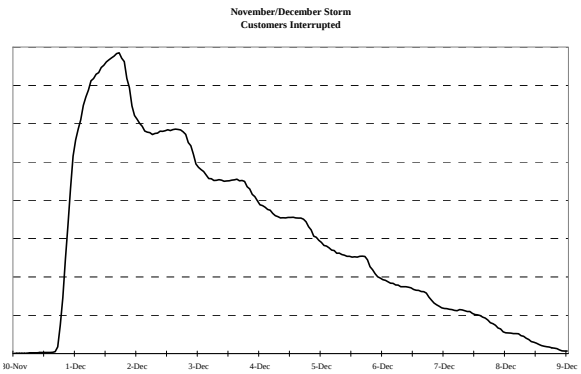
[344] Response to Data Request #265.

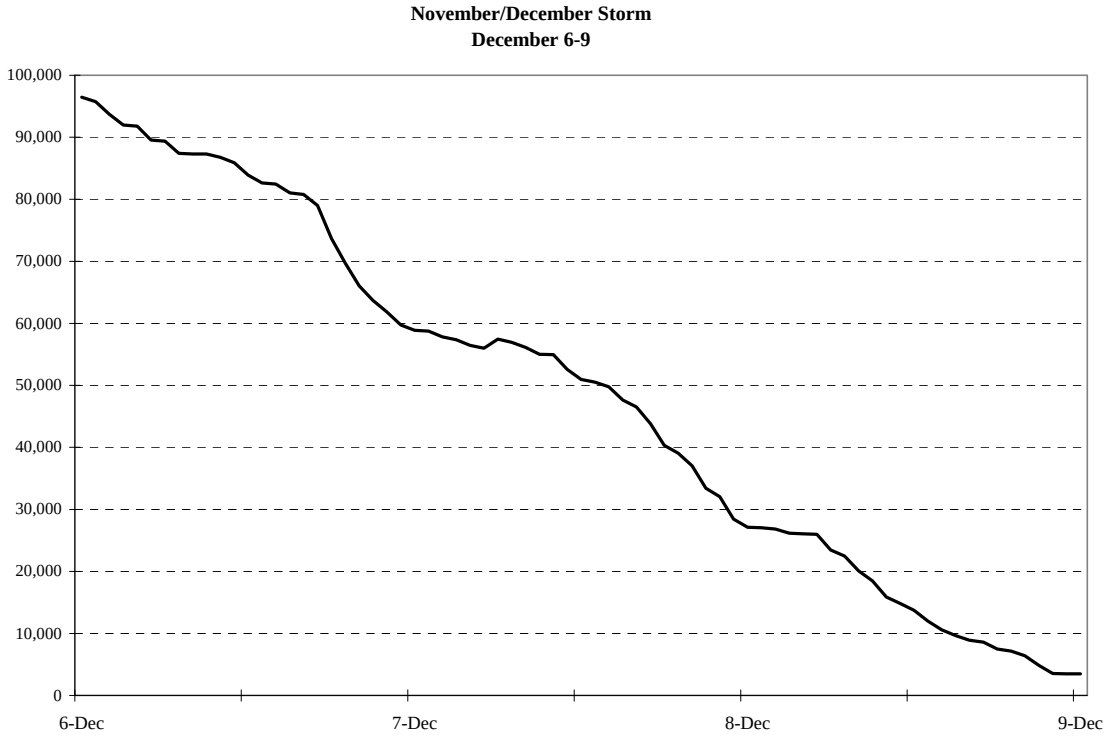


Section G (Field Restoration) of this chapter covers the overall rate of reduction of customers without service. The question here is whether the ramp-down negatively affected the rate of reduction in the final stages of the restoration. Releasing work forces too soon could cause a flattening of the curve beyond that expected. For the July storms, there was some flattening of the curve in the last days of restoration, but Liberty found the pattern to be typical of large storm restoration.

The next charts show the overall pattern and the final days of restoration for the November 2006 storm.[345]

[345] Response to Data Request #265.





Liberty found very little flattening of the restoration curve and concluded that Ameren-IL's ramp-down did not negatively affect the restoration of service to customers for either of the 2006 storms.

Input from those assisting Ameren-IL concerning the release of their resources in the final days of the restoration effort

Ameren had no formal procedure to solicit feedback from those sending resources to help from outside during the two 2006 storms, either Mutual Assistance utilities or outside contractors.[346] In the absence of any formal effort to seek and capture feedback, Ameren was unable to learn from any mistakes or oversights or to act on any suggestions for improvement. Ameren advised

[346] Interview Requests #82 (November 29, 2007) and #95 (January 10, 2008).

that it recently developed and implemented a questionnaire for contractors.[347] From interviews with Ameren representative responsible for the Mutual Assistance utility contacts, Liberty learned that Ameren made some informal contacts with some Mutual Assistance utilities seeking feedback, but they recalled nothing significant from those contacts.[348] In addition, Liberty received no negative input from any of the Ameren-IL division management personnel interviewed regarding the release of outside resources. Based on these interviews, Liberty found no evidence of any negative effect on restoration of the manner in which Ameren released resources in the final days of the restoration efforts.

Input from management personnel concerning the closing of command centers

Other than the actual staff of the Emergency Operations Center (EOC), there are two key constituent groups affected by the process of the closing of command centers. These are the Ameren-IL division and field management and the management of the Distribution Dispatch Operations (DDO) centers. The closing of command centers affects the first group if the closing occurs too soon or too late. In the case of closing too early, division and field management have to reactivate and take charge of command centers again. In the case of closing too late, there is an unnecessary tying up experienced operations management personnel. For the Distribution Dispatch Operations (DDO) centers, an early closing puts an extra workload on dispatch centers not staffed for the increase. If Ameren did not conduct the closings in a well-coordinated manner, DDO centers may not have the status of the restoration in each area.

Liberty interviewed management personnel from both of these groups and explored the issues of closing command centers and transferring dispatch responsibilities back to the DDO centers. Liberty found no evidence of any deficiencies in the performance of the closing of Ameren-IL command centers at the end of the two 2006 storms.

b. Clean-Up Process

Liberty defines the clean-up process as the work done after all customers have had service restored. This work includes:

- repair all hazards and potential outage-causing damage on electric facilities left undone during the actual restoration
- cut or trim all potentially hazardous and outage-causing damaged trees left undone during the actual restoration
- perform additional tree trimming in the affected area

(1) Clean-Up Process Content

Ameren did not provide Liberty with any information concerning a post storm clean-up process, either formal or informal. In response to a specific data request, Ameren suggested that Liberty seek this information in interviews with the appropriate Ameren personnel.[349] Liberty found no

[347] Interview Request #95 (January 10, 2008).
[348] Interview Request #82 (November 29, 2007).
[349] Response to Data Request #83.

evidence of any written clean-up process, either formal or informal. This is not to say that some clean-up as defined above was not done, but that Ameren had no written plan for such clean-up at the close of the restoration efforts following the two 2006 storms.

The clean-up process is an important part of the post-event activities of any electric utility following a major outage event. Ameren-IL should develop a specific clean-up plan and include it in their corporate Electric Emergency Restoration Plan (EERP).

(2) Clean-Up Process Performance

In interviews conducted with Ameren field operations management personnel and with those overseeing the tree-trimming crews, Liberty found that Ameren-IL followed a reasonable and effective approach to clean up and repair of damaged electric facilities as well as to trim and cut potentially hazardous or outage-causing damaged trees and tree limbs. Liberty found that Ameren-IL did not consider additional tree trimming in the impacted area beyond that of the damaged trees and limbs.[350] While this latter issue is obviously a business decision, part of a comprehensive clean-up effort is to at least consider whether the utility should conduct additional tree trimming in the affected area in the aftermath of a major outage event.

c. Post-Event Critique Process

(1) Post-Event Critique Process Content

Post-event critiques form an important element in the post-event activities of an electric utility following a major outage event. Liberty covered Ameren-IL's post-event critique process in detail in Chapter III of this report. The comments below are excerpts from Chapter III dealing with post-event critiques.

- "A storm critique should be performed for every major restoration effort."
- Those items that "helped improve safety or shorten the restoration" should be continued and "shared with and implemented in other areas."
- Those items "that did not provide the expected benefit" should be modified or eliminated.
- "As soon as practical after the completion of an event, each Division/Department should perform a critique." It lists examples of issues, including "crew movements, crew support, field checking, staging sites or other logistics… (and) interaction with other departments, the EOC, or other Divisions."
- The responsibility for scheduling the organization-wide critique lies with the EOC. Participants in this critique should include "one or two individuals from each Division, Dispatch, Asset Management, Stores, and other support groups involved in the Operation."
- The EOC is also responsible for the management of the organization-wide critique meeting "and ensuring that all the ideas from the meeting are captured, documented, and distributed to affected departments."

[350] Interview #94 (January 14, 2008).

- Ameren enters information from this critique into an information web site, and EOC has the responsibility to see that personnel complete this task.
- "When storm activity is very high and frequent, one critique may serve to address issues on several restoration efforts."[351]

Although the wording of this subsection stresses the importance of these critiques as well as the goal of ensuring that Ameren captures and implements the positive items throughout the organization and the negative items are either improved or eliminated, the plan does not provide any detail of the necessary actions to get that done. The wording says that these items should be "discussed" and that the Emergency Operations Center (EOC) should make sure that the "ideas…are captured, documented, and distributed." (See 6th bullet above.) Missing are the process to assign specific responsibility and a tracking process to verify that those responsible take the necessary steps in a timely manner.

Ameren should revise the EERP to establish the process that will ensure that it performs post-event critiques and captures and tracks action items to completion.

(2) Post-Event Critique Process Performance

Ameren reported that it held critiques for the overall Ameren-IL response for both the July 2006 and the November/December 2006 storms. In addition, Ameren reported that three divisions – Division IV, V, and VI – held post-storm critiques, as did the Ameren-IL Field Checkers, Supply Chain, and Logistics functions.[352]

Based on this information, as well as responses gained through other Liberty interviews with key Ameren-IL division and functional area representatives, Liberty found that Ameren-IL did not consistently follow the process for post-event critiques for the 2006 storms. Only three of the seven Ameren-IL divisions submitted critiques, even though at least one more division had significant outages during the November/December 2006 storm, and all divisions participated in the restoration effort. In addition, several key functional areas did not perform critiques, most notably the Emergency Operations Center.[353]

In response to Liberty's data request concerning updates to emergency plans as a result of "lessons learned" in the subject restoration efforts, Ameren reported that it put significant changes in place since 2006 including "the split of the Distribution Operations function into a Missouri organization and an Illinois organization." In addition, Ameren-IL reported that it had created an Ameren Illinois Emergency Operations Center in Decatur, Illinois, and that this change "will be leading to changes in the emergency response plan for Illinois as well as the divisional storm response plans."[354] However, in a subsequent interview with the Ameren-IL CEO, it became clear that Ameren-IL did not make these particular changes because of

[351] Response to Data Request #64, Subsection 2.7, page 7.
[352] Response to Data Request #8, attachment DR8 Summary.
[353] Interviews #84 (November 28, 2007), #88 (January 9, 2008), #92 (November 15, 2007), and #95 (January 1, 2008).
[354] Response to Data Request #65, attachment DR65 Summary.

Ameren's experience in the 2006 storms. Rather, Ameren-IL began planning these changes in the spring of 2006, before the July 2006 storm.[355]

In summary, even though the EERP sets out a post-event critique process, Ameren-IL did not consistently perform critiques.

4. Conclusions

1. Although Ameren-IL followed an appropriate procedure in managing its ramp-down process at the conclusion of the two 2006 storms, there was no formal written plan to provide guidance and ensure that it handled the ramp-down process in an appropriate, safe, timely, and effective manner. (Recommendation IV-48)

Liberty reviewed the steps taken by Ameren as outlined in its response to a data request and found that they were appropriate and in keeping with industry practice. Ameren acknowledged that they had no formal written plan, either in the Ameren corporate Electric Emergency Restoration Plan (EERP) or as a separate plan. Without such formal written guidance, there is no assurance that the procedure followed in the 2006 storms will be followed in subsequent major outage events.

2. The ramp-down process as performed by Ameren-IL in the two 2006 storms did not negatively affect the restoration of customers in the last days of the storm.

Liberty analyzed the data furnished by Ameren that showed the number of customers still without power during the last days of each restoration effort. The restoration rate curves showed little or no "flattening" or lessening in restoration progress during the last days of either restoration. This indicates that Ameren performed the ramping down of restoration forces in such a way as to avoid any negative impact on the restoring of customers.

3. Ameren had no formal procedure to solicit feedback from those sending resources to help from outside during the two 2006 storms, either Mutual Assistance utilities or outside contractors. The absence of such a formal procedure is a deficiency in Ameren-IL's post-event activities process. (Recommendation IV-49)

Ameren had no procedure for soliciting feedback from those sending outside resources to help in restoration.[356] In the absence of any formal effort to seek and capture feedback, a utility is obviously unable to learn from any mistakes or oversights or to act on any suggestions for improvement. Ameren advises that a questionnaire for contractors has now been developed and implemented.[357] From interviews, Liberty learned that Ameren made some informal contacts with some Mutual Assistance utilities seeking feedback, but they recalled nothing significant from those contacts.[358]

[355] Interview #15, November 14, 2007.
[356] Interview Requests #82 (November 29, 2007) and #95 (January 10, 2008).
[357] Interview Request #95 (January 10, 2008).
[358] Interview Request #82 (November 29, 2007).

4. Ameren-IL performed the process of closing command centers at the end of the two 2006 storm restoration efforts in a manner that avoided negative impact on operations.

Liberty interviewed management personnel from Ameren-IL division and field operations and Distribution Dispatch Operations (DDO) centers. A deficient closing of command centers would affect these two groups. The division and field operations would be impacted by either having to re-activate the centers if closed too soon, or by having key operations management personnel tied up unnecessarily if closed too late. The DDO centers would be impacted if command centers were closed too soon by having extra workload fall on their dispatch personnel when not staffed for it, or by a poorly-coordinated closing of command centers with insufficient or erroneous information received concerning the status of the restoration in each area. Liberty found no evidence of any deficiency in any of these areas in the closing of the command centers at the end of the restoration efforts in the two 2006 storms.

5. Ameren-IL had no clean-up plan, either formal or informal in place during the restoration efforts following the two 2006 storms. (Recommendation IV-50)

Ameren did not provide Liberty with any information concerning a post storm clean-up process, either formal or informal. In response to a specific data request, Ameren suggested that Liberty seek this information in interviews with the appropriate Ameren personnel.[359] Liberty found no evidence of any specific clean-up process. This is not to say that some "clean-up" was not done, but that Ameren had no specific plan for such clean-up at the close of the restoration efforts following the two 2006 storms. The clean-up process is an important part of the post-event activities of any electric utility following a major outage event. Ameren-IL should develop a specific clean-up plan and include it in their corporate Electric Emergency Restoration Plan (EERP).

6. Ameren-IL followed a reasonable and effective approach to post-event clean up and repair of damaged electric facilities as well as the trimming and cutting of potentially hazardous or outage-causing damaged trees and tree limbs.

Liberty conducted interviews with Ameren field operations management personnel and with those overseeing the tree-trimming crews. Although there was no clean-up plan, Ameren-IL field operations management, working with the support organizations coordinating tree trimming and line crews, performed a reasonable and effective clean-up of damaged electric facilities, trees and tree limbs.

[359] Response to Data Request #83.

7. The Ameren-IL post-event critique process as contained in the corporate Electric Emergency Restoration Plan (EERP) during the two 2006 major outage events did not ensure that Ameren-IL would perform these post-event critiques. There was no process to ensure capturing and tracking action items to completion. Ameren-IL did not consistently follow the process for post-event critiques for the 2006 storms. (See Chapter III of Liberty's report, Recommendation III-3 and Recommendation IV-51)

Although the wording in the EERP stresses the importance of these critiques as well as the goal of ensuring that Ameren captures and implements the positive items throughout the organization and the negative items are either improved or eliminated, the plan did not provide any detail of the necessary actions to get that done. The wording says that these items should be "discussed" and that the Emergency Operations Center (EOC) should make sure that the "ideas…are captured, documented, and distributed." Missing are the process to assign specific responsibility and a tracking process to verify that those responsible take the necessary steps in a timely manner.

In response to a Liberty data request, Ameren reported that it held critiques for the overall Ameren-IL response for both the July 2006 and the November/December 2006 storms. In addition, Ameren reported that post-storm critiques were held by three divisions – Division IV, V, and VI – and Ameren-IL Field Checkers, Supply Chain, and Logistics functions.[360]

Based on this information, as well as responses gained through other Liberty interviews with key Ameren-IL division and functional area representatives, Liberty found that Ameren-IL did not consistently follow the process for post-event critiques for the 2006 storms. Only three of the seven Ameren-IL divisions submitted critiques, even though at least one more division had significant outages during the November/December 2006 storm, and all divisions participated in the restoration effort. In addition, several key functional areas did not perform critiques, most notably the Emergency Operations Center.[361]

In response to Liberty's data request concerning updates to emergency plans as a result of "lessons learned" in the subject restoration efforts, Ameren reported that significant changes have been put in place since 2006 including "the split of the Distribution Operations function into a Missouri organization and an Illinois organization." In addition, Ameren-IL reported that it had created an Ameren Illinois Emergency Operations Center in Decatur, Illinois, and that this change "will be leading to changes in the emergency response plan for Illinois as well as the divisional storm response plans."[362] However, in a subsequent interview with the Ameren-IL CEO, it became clear that Ameren-IL did not make these particular changes because of Ameren's experience in the 2006 storms. Rather, Ameren-IL began planning these changes in the spring of 2006, before the July 2006 storm.[363]

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[360] Response to Data Request #8, attachment DR8 Summary.
[361] Interviews #84 (November 28, 2007), #88 (January 9, 2008), #92 (November 15, 2007), and #95 (January 1, 2008).
[362] Response to Data Request #65, attachment DR65 Summary.
[363] Interview #15, November 14, 2007.

In summary, even though the EERP sets out a post-event critique process, Ameren-IL did not consistently perform critiques.

5. Recommendations

The following recommendations are applicable to all three Ameren-IL companies.

IV-48 Develop a formal written ramp-down plan to provide guidance in releasing resources and de-activating command centers and include it in the corporate Electric Emergency Restoration Plan (EERP). (Also, see Recommendation III-3)

The EERP should include specific steps Ameren-IL will take with responsibility assigned by position for carrying out these steps. A specific priority order for the release of outside resources should be included in this plan. The plan should address the steps Ameren-IL will take in the closing down of command centers to ensure that this is properly communicated to the appropriate individuals and groups and that off-hours on-call individuals are identified for each deactivated command center. This plan should be completed and included in the Electric Emergency Restoration Plan (EERP) within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-49 Develop a formal process to solicit feedback from contractors and Mutual Assistance utilities furnishing outside resources concerning all aspects of their experience with the Ameren-IL restoration effort, but especially the ramp-down process in which their resources were released. (Also, see Recommendation III-3)

Specific forms to be sent to contractors and Mutual Assistance utilities should be a part of this plan, as well as the assigned responsibility to send out these forms and follow up to ensure that responses are received. This plan should also include the resolution process whereby feedback gained is analyzed, action steps developed and assigned and final resolution reached timely and completely. Any questionnaires or other forms developed and implemented since the two 2006 storms should be incorporated in this plan. Ameren-IL should complete this within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-50 Develop a formal written clean-up plan to guide activities in the aftermath of all major outage events. Incorporate this plan into the Ameren-IL Electric Emergency Restoration Plan (EERP). (Also, see Recommendation III-3)

This plan should specifically define the different aspects of the clean-up process with assigned responsibilities and general timelines for accomplishment. The plan should provide some guidance to help determine what should be considered appropriate as “clean-up” of damaged facilities, trees, and tree limbs. Additionally, the plan should provide guidance as to the possible use of additional tree-trimming resources in the aftermath of the storm beyond the clean-up of damaged and potentially outage-causing trees and tree limbs. Ameren-IL should complete this within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

IV-51 Revise the EERP to establish the process that will ensure that it performs post-event critiques and captures and tracks action items to completion. (Also, see Recommendation III-3)

The EERP should clearly communicate the expectation of Ameren-IL top management that every individual emergency response function at the corporate, state, and division level should hold a critique with notes from those critiques submitted in writing to a designated coordinator, and that this should be done within a time specified in the EERP. Furthermore, the process as outlined in the EERP should clearly set out how Ameren-IL will collect critique items in a database and track action items to completion. Ameren-IL should complete this recommendation within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

V. T&D Planning, Design, Protection, and Construction

A. Objectives

This chapter contains Liberty's evaluation of Ameren-IL's planning, design, and construction of transmission, distribution, and substation facilities in general, and any aspect of T&D planning, design, or construction that contributed to the ill effects of the 2006 storms. It includes evaluations of T&D lightning and animal protection systems and practices, T&D line- and substation-fault protection designs, and T&D equipment ratings. Liberty reviewed the engineering resources available to perform planning, design, and construction tasks, the degree of engineering centralization, and differences in engineering practices among the Ameren-IL utilities. This chapter also includes an assessment of the design criteria for physical loading on structures and overhead lines, including a determination of whether the loadings created by the 2006 storms exceeded the design criteria.

Objectives from the ICC's Request for Proposals covered in this chapter include:

- **2.3.2.5.5** Planning, design, and construction of electric delivery systems
- **2.3.2.5.6** Workforce adequacy
- **2.3.2.5.11** Lightning protection
- **2.3.2.5.12** Animal protection
- **2.3.2.5.16** Compliance with NESC rules and good utility practices
- **2.3.2.5.17** Actions to better prepare systems for future storms
- **2.3.2.5.18** Physical load of support structures.

Liberty sought to determine whether the Ameren-IL companies met the following evaluation criteria:

1. The T&D planning processes should be consistent with good utility practices.
2. The companies should consider all appropriate variables in the planning process and should perform sensitivity analyses where appropriate.
3. System equipment ratings should include all physical components that may have been limiting the provision of reliable service.
4. The companies should use a reasonable planning horizon.
5. The companies should review the accuracy of prior forecasts and have changed the planning methods as appropriate to better account for conditions that affected load.
6. Planning should include reliability guidelines or objectives that anticipate events that the companies can reasonably expect to occur.
7. Design standards should be complete, consistent with good engineering practices, and capable of providing reliable electric service.
8. The design process should provide for effective peer review, feedback from construction and operations, and controlled design changes.
9. Design should provide processes for equipment and material review, testing, and inspection to ensure durable and reliable performance.
10. T&D system construction standards should be consistent with good utility practices.
11. The companies should effectively communicate and implement construction standards.

12. The companies should effectively ensure compliance with construction standards by all parties, and construction practices should continue to improve system reliability.
13. The companies should meet all industry standards for the design of system protection schemes.
14. The companies should meet standard utility practices in testing and maintaining protection systems.
15. The companies should use standard utility practices in the use of fuses, sectionalizers, reclosers, and other similar devices to isolate faulted feeder segments and improve reliability.
16. The companies should meet all industry standards for the design and installation of the lightning protection systems on T&D systems.
17. The companies should meet standard utility practices in testing and maintaining lightning protection systems.
18. The companies should be able to detect, isolate, and restore service after a lightning related fault as quickly as utilities with similar installations and conditions.
19. The companies should have effective programs to control the number of outages caused by animals.
20. The companies should apply the resources and management attention to animal protection consistent with goals for reducing outages caused by animals.
21. The design criteria for environmental loadings on overhead lines and supporting structures should be consistent with appropriate codes and standards.
22. Fundamental weaknesses in planning, design, construction, or protection should not have been a root cause of the 2006 storm damage or the length of service restoration times.
23. There should be sufficient engineering resources to plan and design the electric delivery system.

B. Background

Utilities should construct their T&D systems so that they can accommodate growth in electrical load while maintaining system reliability. It may take anywhere from a few months to a few years from the time a utility recognizes the need for additional capacity in its T&D systems to the time that the construction is complete and the system can accept the expected load. Therefore, it is critical to system reliability that the utility's planning is thorough and timely. Planning should combine known factors such as historical electric loadings and weather patterns with estimates of future conditions such as new customer additions and changes in customer usage patterns.

Utilities should design their T&D systems to provide reliable service in a safe and efficient manner. The materials selected, the loads placed on those materials and equipment, and the layout and support, all contribute to the degree of success utilities have in meeting safety and reliability objectives. The distribution system normally represents a large percentage of an electric utility's investment. Engineering design decisions affect the level of this considerable investment. Over the years, the utility industry has developed standards that attempt to optimize the balance between safety, reliability, and cost.

A utility must perform construction on its distribution system to replace worn out or damaged equipment and to provide for additional electric load. When the utility connects new customers or additional loads from existing customers to feeders, the circuits may overload to the point that they cannot accept loads from other circuits during emergencies. Therefore, upgrading existing circuits by installing or replacing distribution circuit components; *i.e.*, wires, cables, switches, fuses, and transformers, with equipment of higher ratings, or even constructing new distribution circuits, becomes necessary to maintain system reliability. In addition, although not required for capacity reasons, the relocation of utility distribution facilities sometimes is necessary when the facilities physically conflict with public improvement projects, such as widening of roadways. A utility must also prepare plans and designs, budget capital funds, and conduct construction for new circuits or upgrading existing circuits to add capacity for new business or reinforce the system for load growth from existing customers, and remove existing circuits and construct new circuits for public improvement projects. Liberty's experience is that some utilities move reliability to a lower priority than new business and public improvement jobs because of revenue considerations. In many instances, the reliability projects are not completed.

A short circuit, or fault, is the accidental contact of two energized power lines or an energized power line and a grounded object. Many events can cause short circuits, such as fallen trees, high winds, or an unfortunate squirrel. Lightning can cause faults in electrical power circuits by making a connection between two or three live power lines (of differing phases) or, more commonly between one live line becoming connected to ground. This arc (or fault) will continue until a circuit breaker protecting the line opens. A "flashover" is a fault caused by a lightning strike. The utility needs to have proper placement of lightning arresters and should replace failed and obsolete arresters with modern, more reliable designs. In addition, line and substation grounding must be appropriate to provide for reliable lightning arrester performance.

Utilities must protect lines when faulted by lighting, animals, trees, and wind and ice load. Power systems have protective devices that operate to de-energize a line, or a section of a line, when trees or abnormal conditions cause a short circuit. The purposes of these devices include minimizing damage to the utility's equipment, minimizing electric shock hazard to the public by downed lines, and minimizing the number of customer outages that might occur during a storm. How a utility applies its relays, circuit breakers, fuses, reclosers, sectionalizers, and fault locators can significantly affect reliability and restoration times during and after storms.

A persistent problem that affects electric service reliability on distribution systems is wildlife. Outages can occur when the wings of large birds bridge across wires or when squirrels or snakes climb up the bushings of a transformer or circuit breaker. In areas with a large numbers of trees that can bring wildlife closer to electric facilities, the number of wildlife-related interruptions can be significant. Animal outages in substations can be catastrophic as there can be interruptions of entire circuits, multiple circuits, and damage to major equipment. Protecting an electric delivery system against wildlife outages is an ongoing process, one that involves the installation and repair of devices to thwart, and the design of systems to prevent, wildlife from affecting the proper operation of the electric system.

Resources and tools should be sufficient so that technical engineering in planning and design does not delay necessary construction work. Even more important is the experience of the engineering work force and the quality of its work products.

C. Chapter Summary

Liberty found that Ameren-IL's planning processes, load forecasting, and analyses of the capability and stability of the electric delivery system were generally acceptable and in line with industry practices. Liberty recommends that Ameren-IL make some changes in its use of weather data for load forecasting, and determine whether it is adequately prepared for an accident that causes a total loss of a substation.

In the area of transmission and distribution system design, Ameren-IL's practices were reasonable and consistent with the National Electrical Safety Code. Ameren-IL would benefit from greater standardization in practices across the three Illinois companies and from uniformity in standards and manuals. Ameren-IL's conservative practice of rating transmission and sub-transmission lines could lead to construction of new facilities before they are actually required.

Ameren-IL's standards for system protection were generally adequate. The new construction standards Ameren-IL uses for protection against outages caused by animals were adequate and in line with industry practices. The lightning protection provided for older and smaller substations and some older transmission lines did not appear to be adequate. In addition, the software and data Ameren-IL used for determining system performance under lightning conditions was out of date.

For construction activities, Liberty found that Ameren-IL's processes were generally adequate. It should improve some aspects of its cost estimating and cost reviews. Until recently, Ameren-IL did not have a sound quality-assurance function for construction work.

In general, Ameren-IL's T&D system planning, construction, and protection did not contribute to the significance of the 2006 storms. The way that Ameren-IL planned and designed the distribution system affected the consequences of the 2006 storms, but alternative planning criteria or design configurations are not practical. The fact that some tap lines off the main distribution system did not contain fuses likely made the effects of the 2006 storms worse. Liberty determined that the July 2006 storms were so severe that they may have created some areas in which environmental conditions exceeded the conservative design basis of the electric delivery system. The November/December 2006 storm did not exceed design basis conditions.

D. Planning

1. Process and Standards

a. Introduction

Simplistically, system planning involves constructing of a mathematical model of the power system, projecting customer demand amounts and locations, and testing the future system to determine whether it will withstand specified outage events. In that testing, line loadings must not exceed thermal limits and voltages must remain adequate. If testing shows violation of limits, new facilities may be required. The planner will determine alternate solutions by additional system testing.

For the purposes of system planning, Ameren-IL's electric delivery system contains three parts. The distribution system is the portion that operates at 15,000 volts and below, the sub-transmission system is the portion that operates at 34,500 and 69,000 volts, and the transmission system is the portion that operates at 138,000, 161,000, and 345,000 volts. This section of the report covers the standards and processes used in planning the Ameren-IL transmission and sub-transmission systems. Section V.E.3 covers the standards and processes used in planning the distribution system.

b. Transmission System Planning Standards

Ameren-IL's transmission planning standards are contained in the document titled "Ameren's Transmission Planning Criteria and Guidelines."[1] Ameren developed and standardized its transmission design criteria in 1997 to be in conformance with the North American Electric Reliability Corporation (NERC) standards.[2] Ameren applied its transmission planning standards to each of the three Illinois companies when Ameren acquired each of them.

NERC standards are single contingency standards that require line loadings and voltages to remain within applicable limits following a specified disturbance on the power system. That is, non-radial portions of the system require two or more overlapping outages before there are customer interruptions. NERC specifies many disturbances that utilities must study such as a line tripping out or a line fault accompanied by an inoperative circuit breaker. The legacy companies generally did not meet all of the NERC criteria. Ameren-UE and Ameren-IP were most conforming while Ameren-CILCO and Ameren-CIPS were least conforming. Ameren's current transmission planning criteria meets or exceeds all NERC requirements.[3]

c. Sub-transmission Planning Standards

Ameren-CIPS' planning criterion for circuits 34,500 volts and above was in its transmission planning criteria document, "Transmission System Planning Criteria," dated February 1, 1990. The design basis was a single contingency at peak load using emergency ratings with no loss of load except in radial circumstances. Ameren-CIPS also applied the criteria with two contingencies at 70 percent of peak load. Utilities do this type of testing to ensure that it can perform maintenance in off peak-load conditions.[4]

The Ameren-CILCO legacy document, "Central Illinois Light Company Transmission Planning Criteria," did not specify the contingencies for testing and was undated. Ameren-IL indicated that this meant a design with no loss of load at peak load and under single contingency conditions.[5]

Ameren-IP's document for sub-transmission planning criteria is "Sub-transmission Planning," September 23, 1988. The criteria call for no loss of load for a single contingency at peak-load

[1] Response to Data Request #60.
[2] Interview #178, May 30, 2008.
[3] Response to Data Request #773.
[4] Response to Data Request #59 and Interview #54, October 30, 2007.
[5] Response to Data Request #59 and Interview #54, October 30, 2007.

conditions except for radial lines. The Ameren-IP criteria also call for testing at off-peak conditions. Its system must be able to withstand a single contingency plus the outage of a generator at 80 percent of peak load without loss of load. The criteria also call for load power-factor correction to 0.98 with substation capacitors.[6]

At present, Ameren-IL has no one document for use in sub-transmission planning, but a single contingency on peak without loss of load is used system wide.[7] Ameren-IL established a distribution system planning criteria integration team in October 2007. Ameren-IL expected that the team would provide recommendations during the first half of 2008 regarding high priority actions necessary to develop and implement consistent planning criteria across Ameren-IL.[8]

d. Transmission System Planning Processes

The Transmission System Planning group, which is part of Ameren Services, performs transmission system planning for Ameren-IL. This group is in St. Louis. It is responsible for planning all Ameren-IL facilities that are in excess of 100,000 volts.[9] Ameren-IL's transmission system follows the NERC Reliability Standards and the Ameren Transmission Planning Criteria and Guidelines. Ameren performs annual analyses to determine near-term requirements (years one through five) and analysis of longer-term requirements (years six through ten).[10]

The Ameren system is generation rich in that 750 megawatts (MW) to 1,500 MW flows out of both IL and MO (i.e., a total of 1,500 MW to 3,000 MW); approximately 80 percent of the generation is base load generation. The direction the outbound power flows varies day to day depending on factors such as:[11]

- Northeast if nuclear generation in the ComEd system is down or on maintenance
- East if PJM is short on supply or if prices are high
- Southeast if gas prices at TVA or the Gulf are high
- Southwest if gas prices are high or if severe weather is at hand

Ameren considers all of these factors in its analyses.[12]

The transmission system-planning group performs transmission power flow and all operational and planning transient analyses. In addition, Operations may request specific analyses when transmission configurations are not normal. Ameren analyzes the various power flow directions and does so with different generation configurations. The group performs the analyses at 85 percent of the summer peak load using winter power-factor load, and at 35 percent summer peak load using unity power factor.[13]

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[6] Response to Data Request #59 and Interview #54, October 30, 2007.
[7] Interview #54, October 30, 2007.
[8] Response to Data Request #372.
[9] Interview #1, October 4, 2007.
[10] Response to Data Request #373.
[11] PJM is Pennsylvania New Jersey Maryland Interconnection LLC (Mid-Atlantic region power pool); TVA is Tennessee Valley Authority; MW is megawatt or one million watts.
[12] Interview #177, May 30, 2008.
[13] Interview #177, May 30, 2008. The power factor of an AC electric power system is the ratio of the real power to the apparent (voltage times current) power, and is a number between 0 and 1.

e. Sub-transmission Planning Processes

The responsibility of planning the sub-transmission system from 34,500 volts up to 100,000 volts and bulk substations[14] is with the Illinois Distribution System planning group. That group is part of the Distribution Planning and Asset Performance Department and consists of engineers with system planning experience from each of the legacy companies.[15]

Sub-transmission planners simulate single contingency outages on the sub-transmission and transmission system to identify sub-transmission issues. They perform studies annually, out five years in time, and out ten years in time. If the group finds a problem on the transmission system, they coordinate with the transmission system planners. Sub-transmission planners also recreate actual events to determine if the expected power system response in fact occurred.[16]

f. Analysis

The general layout of the Ameren-IL transmission system is looped facilities of 138,000 volts, 161,000 volts, and 345,000 volts. The looped system allows for the supply of electricity from more than one source. The planning criterion for this portion of the system is that, single events or outages and prescribed multiple events will not cause a loss of load or customer interruptions. In addition, these requirements exist after an initial single event has occurred. Extreme contingencies, such as loss of an entire major substation, may involve customer loss, but are not allowed to cause cascading outages. This design requirement forces a high level of redundancy to be built into the transmission system. Ameren-IL's system planning for the transmission system conforms to or exceeds national standards.

The layout of the sub-transmission system is either looped or radial. The looped portion allows for the supply of electricity from more than one source. A planning criterion for this portion of the system is that any single event or outage on the looped portion of the system will not cause a loss of load or customer interruptions. This design requirement forces redundancy to be built into the looped system. Radial parts of the sub-transmission system feed the distribution system without this redundancy, and single events or outages will cause interruptions to customers. Ameren-IL's system planning standard for sub-transmission is the same as that used by most electric utilities in the United States, but represents a reduction in system redundancy compared to some past legacy practices.

2. Load Forecasts

a. Introduction

A utility's load forecast is the estimate of demand for electric power on its system. It is the single most important piece of information used by utility system planners. A utility may spend

[14] A bulk substation is one where the high side voltage is between 138,000 volts and 345,000 volts and the low side voltage is either 34,500 volts or 69,000 volts.
[15] Response to Data Request #372.
[16] Interview #178, May 30, 2008.

millions of dollars based on the load forecast. Projections of weather, economic conditions, customer growth, and changing energy use patterns of customers all affect the load forecast.

b. Transmission Planning Load Forecast

Ameren bases its corporate load forecast, which it uses for financial planning, on a 30-year mean of the extreme weather data. The use of average weather results in a "50/50" or a 1 in 2 forecast. A 50/50 forecast is one is that is expected to be exceeded every other year. Similarly, a "90/10" forecast is one is that is expected to be exceeded once every 10 years. Some utilities use the corporate load forecast for transmission system planning purposes. Ameren-IL did not. For 2006 transmission system planning, Ameren-IL performed a load forecast for each of the three Illinois companies.[17]

For the 2006 forecast at Ameren-IP, planners conducted a 30-year load factor[18] analysis on the net energy for load data that the company supplied to the FERC on Form EIA411. They weather-normalized the forecast using load-temperature relationships previously developed for the design-day temperature.[19] Ameren-IP defined its design-day temperature as the 30-year, 2-day weighted average temperature.[20] This process generates a 50/50 load forecast.[21]

For Ameren-CILCO and Ameren-CIPS and the 2006 forecast, planners plotted the actual load against the 2-day weighted temperature. They forecast future load using the trend of historical temperatures for the summer peak demand.[22]

Ameren-IL did not perform load forecasts for the transmission planning areas in Illinois and did not perform benchmarking. Benchmarking, or "back casting," a load forecast is the use of actual economic data such as housing starts and population change for input to the load forecasting model to see how well the model forecasted load.[23]

Since July 2006, Ameren performed load forecasts for all operating companies using a daily peak-demand economic and weather model. Ameren used Moody's Energy.com as its data source, which supplies information by county. Ameren-IL incorporated efficiency trends and national and regional economic data into the forecast. Ameren used data from seven weather stations in the forecast. Planners used load-temperature relationships as a check on the forecast.[24]

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[17] Interview #56, October 30, 2007, and response to Data Request #242.
[18] Load factor is the ratio of the total yearly energy divided by the peak-hour energy multiplied by 8,760 hours. In other words, it is the ratio of actual energy use to maximum possible energy use at the maximum use rate every hour of the year.
[19] Weather normalization is a process in which the actual loads are increased or decreased to correct for weather that was above or below expected norms.
[20] Defined as 2 times today's average of the maximum and minimum temperatures, plus 1 times yesterday's average of the maximum and minimum temperatures, all divided by 3.
[21] Interview #56, October 30, 2007, and response to Data Request #242.
[22] Interview #56, October 30, 2007, and response to Data Request #242.
[23] Interview #56, October 30, 2007, and response to Data Request #242.
[24] Interview #56, October 30, 2007.

The model used historic hourly demand, captured the build-up in peak load when there were multiple hot days in a row, considered load variations by day of the week not caused by weather, and captured peak-load growth due to increased energy use. Ameren-IL used normalized weather data over a 30-year period[25] using a rank-and-average method.[26] Ameren-IL considered diversity among the three companies.[27] To avoid capacity shortages that may result by a system peak occurring in late June or early September, Ameren-IL used the maximum monthly peak for the period June through September. This produced a 50/50 load forecast.[28]

In 2008, Ameren-IL made one additional modification to its load forecasting methods. Ameren-IL now uses a 10-year rolling average weather to represent normal weather to capture the change in climate observed in the service territory.[29]

The Transmission Planning Group uses the substation load splits developed by the Distribution Planning group to distribute the transmission-planning load forecast in the transmission system-planning model.[30]

c. Distribution Planning Load Forecast

Distribution system planning uses the actual peak load that occurred at each substation, and applies temperature correction factors to obtain 90/10 weather-based projected loads. Planners take into account discrete load changes from spot load additions or deletions and load transfers. The Energy Services group developed the temperature correction factors some years ago. Planners use one of four tables depending on the load type and on how sensitive the loads at the particular substation are to temperature variation.

Distribution planning uses data from eleven weather stations operated by the National Weather Service. They rank 100 years of temperature data and the 90th percentile becomes the 90/10 weather-based design temperature.

d. Analysis

Ameren-IL uses a 50/50 weather load forecast for transmission planning. Utilities originally used a 50/50 forecast for consistency with financial planning or because the system was winter peaking. A winter-peaking system is a more forgiving if extreme weather causes the load to exceed the load forecast. The reason for this is that the colder temperatures that bring the high demand also increase the thermal rating of system equipment. However, in a summer-peaking system, the higher ambient temperature lowers equipment ratings and can result in a system that cannot meet the demand.

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[25] Ameren defined 1971 through 2000 as its 30-year weather normal period.
[26] Averaging all January 1st values, January 2nd values, etc. produces a relatively smooth series of normal temperatures. By ranking each month from highest to lowest value and then averaging the results, the hottest days are averaged and the coldest days are averaged, providing meaningful data.
[27] "Diversity" in this context is where the Ameren-IL total load is less than the sum of the load of the three operating companies. The response to Data Request #377 showed that this diversity was 1 percent or less.
[28] Response to Data Request #376.
[29] Response to Data Request #376.
[30] Interview #57, October 30, 2007.

Ameren-IL calculated that from 2002 through 2006, a 90/10 system load forecast would have been about 3.5 percent to 5.8 percent higher than the same forecast using a 50/50 weather basis.[31] For the purposes of a simplified example, assume that the one-in-ten year weather occurs and creates a peak demand on a system designed to serve a 50/50 peak load. Loads are 5 percent higher and equipment ratings are approximately 5 percent lower due to the higher design base temperature (from the 90/10 forecast) resulting in a 10 percent increase in duty. If the system is growing at 2 percent per year, the power system must carry loads that are 5 years beyond what the planners have designed. Ameren-IL is summer peaking and Liberty notes that many major power systems that are summer peaking have increased their weather-based design temperature to the 90/10 probability.

For transmission planning, Ameren uses the substation-load distribution factors to distribute the load forecast to the total transmission system. Such a process is very common in the utility industry and is suitable for some system studies. However, portions of the transmission system may peak under different conditions than the system as a whole. Ameren-IL does not use the distribution load estimates to study individual transmission areas.

For the distribution planning load forecast, Ameren-IL uses 100 years of weather data. However, in recent years, say for example the last ten, are warmer, and provide a better predictor of weather in the coming years. Ameren-IL uses the most recent 10 years of weather data in the transmission planning load forecast.

3. System Planning Models and Software Programs

a. Introduction

A utility must analyze the electric delivery system to ensure that various outage conditions do not cause equipment to exceed ratings, circuit breakers have the capability to interrupt fault conditions, and system disturbances do not cause instability. Utilities use sophisticated models and computer software to perform these analyses.

Power flow analyses calculate power flows on every system element and voltage at every node modeled. Planners simulate various outage conditions and determine the power flows and voltages. They then compare these power flows to the power ratings of the actual equipment in service to ensure that equipment will operate within its capabilities. Planners also compare the voltages at system nodes to ensure that they are adequate for operation of customer equipment.

In a short-circuit analysis, planners calculate fault currents at every substation under various conditions to ensure that the calculated values do not exceed the rated interrupting capability of circuit breakers.

In transient stability studies, planners use models and software to study the dynamic response of the power system to disturbances. These studies are similar to power flow analyses except that they include the time-dependent characteristics of the system. The models measure the reaction

[31] Response to Data Request #243.

of the system at each of many very small increments of time, such as 1/100th of a second. Planners can determine if and how long it takes the system to return to a steady state condition.

In each of these models, the system representation must be of sufficient size and detail, and the software of sufficient sophistication, to ensure that planners obtain reasonable and representative results.

b. Short Circuit Models and Software Programs

Ameren uses a single short-circuit model for both its Ameren-IL and Ameren-MO operating companies. The model comprises all of Ameren's transmission system and most of the sub-transmission system in both states. For Illinois, the model includes the entire 69,000-volt and the networked 34,500-volt system down to the distribution voltage bus. For areas outside of the Ameren system, the model includes the tie-lines, the adjacent system tie-line bus, and one additional bus into the neighboring system and an equivalent[32] of the remainder of interconnected system to these buses. By representing one bus beyond the line-line bus, Ameren-IL can perform tie-line studies with neighboring utilities. Ameren-MO and Ameren-IL continuously update their copies of the model for system changes that take place. It performs a data-lock update annually.[33] To assess the distribution system short circuit capability, Ameren uses an equivalent of the higher voltage system and models the details of the distribution system.[34]

Ameren performs all transmission and sub-transmission short circuit studies using the Advanced System for Power Engineering (ASPEN) software, a state-of-the-art program used by many utilities. All legacy companies used the ASPEN software.[35]

For distribution short circuit studies, Ameren-CIPS and Ameren-CILCO used the Electric Power Research Institute's (EPRI) Distribution Engineering Workstation (DEW). Ameren-IP used Power Technologies Incorporated PSS/U and Cooper Power System's V-PRO software. Ameren-IP will convert to the DEW in 2009. All of these software programs are in common use in the utility industry.[36]

c. Power Flow Models and Software

To perform its power flow analyses, Ameren starts with the Multi-Regional Modeling Working Group (MMWG) model that contains approximately 100,000 buses and models virtually the entire country's power grid above 100,000 volts. This is the same model used by the Midwest Independent System Operator (MISO) and SERC Reliability Corporation (SERC) for their system analyses.[37] To this model, Ameren adds its own 69,000-volt network and an equivalent of the 34,500-volt system for transmission system analyses.

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[32] A reduced mathematical model that responds the same as the larger representation it replaced.
[33] Interviews #163, #164, #166, and #167, May 1, 2008.
[34] Interviews #163, #164, #166, and #167, May 1, 2008 and response to Data Request #344.
[35] Responses to Data Requests #727 and #728.
[36] Response to Data Request #729.
[37] Interview #178, May 30, 2008.

To assess the sub-transmission system and the need for bulk power transformers, Ameren uses the same model and replaces the 34,500-volt equivalent with a model for the actual network. It also models all distribution substation transformers down to distribution voltages.[38] To assess the distribution system and the need for distribution substation transformers, Ameren uses an equivalent of the higher voltage system and models the details of the distribution system.[39]

Ameren uses an industry standard software package called the Power System Simulation Engineering (PSSE) program from Power Technologies Incorporated (PTI) for transmission and sub-transmission power-flow analysis.[40] For distribution power-flow studies, Ameren-CIPS and Ameren-CILCO used the Electric Power Research Institute's DEW. Ameren-IP used PTI's PSS/U and Cooper Power System's V-PRO software. Ameren-IP will convert to the DEW in 2009. Utilities across the country use all of these software programs.[41]

d. Transient Stability Models and Software

The transient stability model is the same model as that used for power flow analysis, but with additions such as detailed representations of all electric generators.[42] All Ameren stability analyses use the PSSE program. Because of user friendliness, Ameren also uses Power Tech's Transient Stability Analytical Tool (TSAT) as a screening tool. For small signal oscillation analysis (long-term dynamic analysis), Ameren uses Power Tech's Small Signal Analytical Tool (SSAT).[43]

e. Analysis

Ameren uses models for short circuit, power flow, and transient stability analyses that are comparable to industry-wide accepted practice. Across the industry, these models produce reasonable and representative results.

Ameren uses software packages to conduct short circuit, power flow, and transient stability analyses that the utility industry uses and accepts. These models are state-of-the-art.

Ameren starts the annual short circuit model cycle with a common model for both Ameren-MO and Ameren-IL. Ameren-MO and Ameren-IL make continuous updates to their copy of the model throughout the year. Ameren performs a data lock step annually. The use of a single model would eliminate the need for annual data lock step adjustments and allow both Ameren-IL and Ameren-MO to use up-to-date models throughout the year. Liberty believes that the chance for error introduction into the results of the two models is small if there were no transmission system changes across the Mississippi River. The limited river crossings act as a natural separation between Ameren-MO and Ameren-IL.

[38] Interview #178, May 30, 2008.
[39] Interviews #163, #164, #166, and #167, May 1, 2008 and response to Data Request #344.
[40] Interview #178, May 30, 2008.
[41] Response to Data Request #344.
[42] Interview #177, May 30, 2008.
[43] Interview #177, May 30, 2008.

Ameren models two buses beyond its system in its short circuit models so that it can conduct tie-line studies with neighboring utilities. Impedance relays are set to "look" beyond one bus away from the Ameren-IL system for backup coordination. This practice allows for proper relay backup coordination.

4. Loss of Substation Event

a. Introduction

Many utilities do not have specific, written contingency plans for the total destruction of a substation. They would rely on standard contingency planning, spare parts, mobile equipment, and on-the-spot problem resolution if such an event occurred. However, the total loss of a substation for a lengthy period is not such a low probability event that utilities can ignore it. Fires, vehicular accidents, or severe weather conditions such as a tornado could destroy a substation. Liberty believes it is good utility practice to have assessed these possibilities so that the utility (a) knows in advance situations that could present significant problems, (b) learns whether it has sufficient mobile equipment, and (c) makes changes to its system or equipment that would prevent very long service interruptions. Such changes might include gaining access to additional mobile equipment or providing additional protection to certain substations.

b. Ameren-IL's Substations and Mobile Equipment

Ameren-IL has nearly 1,500 substations of various sizes. However, only about 12 percent of them are the larger, transmission and transmission/distribution substations.[44] Because of the geographic and demographic nature of Ameren-IL's service territory, many of its substations are single unit substations serving small towns or individual customers on an isolated basis.

As of July 2006, Ameren-IL had 35 portable substations and 2 portable switchgear units.[45] It received a third portable switchgear unit in 2007 and expected another portable substation in 2008. Most of the portable substations contained a transformer, a high-side switch, and a low-side circuit breaker. Portable switchgear is simply a line of feeder breakers on wheels. Most of the mobile substations are small units that would be suitable for single-unit rural applications. To cover the loss of a single transmission transformer, Ameren-IL has four large, spare transformers that reduce either 345,000 volts or 230,000 volts to the 138,000-volt system.[46]

Ameren-IL does not have any mobile generators. It has access to mobile generators from vendors and has contracted for the use of them in the past.[47] Ameren-IL indicated that, if necessary, it would also rely on generators from neighboring utilities or purchase them.

The most common utility use of portable substations and generators is for use during construction and maintenance projects. Utilities typically provide enough of this equipment for those projects and carry spares for long-lead items such as large transformers.

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[44] Response to Data Request #7.
[45] Response to Data Request #300.
[46] Response to Data Request #246.
[47] Response to Data Request #477.

c. Ameren-IL's Loss of Substation Planning

Ameren-IL has no specific written restoration plans for the loss of a substation.[48] Ameren-IL indicated that it would rely on load transfer ties, mobile equipment, and spare equipment to restore a substation. For large, bulk supply substations, Ameren-IL plans for the loss of a single line or transformer, and would rely on spare equipment for restoration. For transmission substations, Ameren-IL plans that the complete loss of a substation would not cause a collapse of the transmission grid, but such an event could cause extended service interruptions.

Load transfer capability typically is only available in urban areas. Portable substations and switchgear may be in use at a construction or maintenance project when an event occurs. Spare equipment is normally available only for long-lead time items. Spare parts are normally available only for long-lead time items, items that frequently fail, and components that utilities use often in construction.

Ameren-IL's planning for the total loss of a substation is similar to many other utilities. The nature of its service territory makes it less susceptible to very large and extended outages from the loss of a substation. However, Ameren-IL has not performed an assessment of this event to determine whether it has specific problem substations, sufficient spare equipment, or sufficient mobile equipment. An evaluation of a total substation loss event would also provide for general restoration plans as opposed to immediate problem solving, and could point to areas where additional substation protection or pre-event preparation would reduce the risk of an extended outage, particularly an outage that could interrupt service to critical customers.

5. Conclusions

1. Ameren-IL's transmission planning standards and processes meet or exceed NERC requirements.

Ameren revised its uniform transmission planning standards to meet or exceed NERC requirements. Ameren-IL recently conducted a NERC compliance audit that included over 300 simulations; the audit noted no violations.

2. Ameren-IL's sub-transmission planning standards and processes are comparable to those in use across the industry.

A planning criterion for this portion of the system is that any single event or outage will not cause a loss of load or customer interruptions. This design requirement forces redundancy in the system for events involving the looped system. Radial parts of the sub-transmission system feed the distribution system without this redundancy, and single events or outages will cause interruptions to customers. Ameren-IL's system planning for sub-transmission is the same as that used by most electric utilities in the United States, but represents a reduction in system redundancy compared to some past legacy practices.

[48] Response to Data Request #477.

3. Ameren-IL's sub-transmission planning standards are inconsistent across the operating companies. (Recommendation V-1)

Ameren-IP, Ameren-CIPS, and Ameren-CILCO all have standalone sub-transmission planning standards. Although Ameren-IL uses a common fault scenario in the system planning of these systems, the standards have many areas where differences exist. Examples of differences are the Ameren-CIPS equipment maintenance requirement and the Ameren-IP load power-factor requirement. Ameren-IL would benefit from a consistent set of planning standards.

4. Ameren-IL's 2008 transmission load forecasting processes are proper except for the use of a 50/50 weather-based design. (Recommendation V-2)

The use of a 50/50 forecast is not conservative. The industry trend for summer-peaking power systems is to design systems using a 90/10 weather basis.

5. Ameren-IL does not benchmark its transmission load forecast. (Recommendation V-3)

Benchmarking the transmission forecast is a good check for reasonableness and is good utility practice.

6. Ameren-IL's transmission load forecasts do not consider individual areas within the total system. (Recommendation V-4)

Ameren-IL now uses a system-wide load forecast for its transmission planning studies. Specific areas within the system are relatively independent from a transmission-planning point of view and the loads may peak at different times than the total system. Good utility practice requires the use of area peak loads for these studies.

7. Ameren-IL's distribution load forecasting processes are proper except for the use of a 100-year weather-based design temperature. (Recommendation V-5)

Distribution load forecasts use 100 years of weather data. Starting in 2008, the transmission load forecast appropriately used a rolling average 10 years of data to capture the change in climate observed in the service territory. Distribution planning should change its weather-based design criteria as well.

8. Short circuit, power flow, and transient stability models are of sufficient size and detail to produce reasonable and representative results.

The size and detail of Ameren's models are in line with industry acceptable practices. Ameren should continue the short circuit tie-line modeling of two buses away from Ameren ownership to allow for proper relay backup coordination.

9. Short circuit, power flow, and transient stability software programs are industry accepted.

Ameren uses industry-wide and accepted state-of-the-art software programs to perform its analyses. With the conversion of Ameren-IP's distribution analyses to the DEW in 2008, all operating companies will be consistent with their software.

10. The use of two short circuit models for Ameren-MO and Ameren-IL is inefficient. (Recommendation V-6)

Ameren starts the annual model cycle with a common short circuit model and both Ameren-MO and Ameren-IL make continuous updates to their copy of the model throughout the year. Ameren performs a data lock step annually. The Ameren short circuit conditions do not drastically change over the course of a year, and because the Mississippi River separates Ameren-IL and Ameren-MO, changes generally do not measurably affect each other's systems. However, the use of a single model would eliminate the need for annual lock step adjustments and allow both Ameren-IL and Ameren-MO to use up-to-date models throughout the year.

11. Ameren-IL has not systematically evaluated the total-loss-of-substation event. (Recommendation V-7)

Ameren-IL's planning with regard to a total loss of a substation is typical of other utilities. Ameren-IL knows in very general terms how it would cope with such an event. However, that general planning relies on load transfer ties that do not exist in many locations, portable equipment that may be in use or not readily available, spare equipment carried for reasons other than a loss of a substation, and on-the-spot troubleshooting and problem solving.

6. Recommendations

V-1 Develop consistent sub-transmission planning standards.

Ameren-IL should standardize its sub-transmission planning standards, including all the design basis assumptions such as power ratings and conductor temperatures mentioned in other sections of this report and an evaluation of the reduced legacy company standard. Ameren-IL should complete the development of common standards within one year of the date of this report.

In its comments on the draft report, Ameren-IL indicated that it is implementing this recommendation. It suggested that implementation be complete within two years of the date of this report.

V-2 Revise the transmission planning load forecast probability to 90/10 weather basis.

Ameren should plan its transmission system to a load forecast for which extreme weather has only a 10 percent chance of causing load to exceed the forecast. Ameren should make this revision immediately and apply it in its 2009 load forecast.

In its comments on the draft report, Ameren-IL said that this change was not necessary because of its conservative equipment ratings. Liberty does not agree.

V-3 Benchmark ("back-cast") the transmission-planning load forecast.

Ameren-IL should back-cast its transmission-planning load forecast to verify its validity for predicting future loads. Ameren-IL should adjust the model for any discrepancies and should repeat this process on a fixed schedule to be determined. Ameren-IL should begin this verification within three months of the date of this report.

V-4 Develop area load forecasts for transmission studies.

Ameren-IL should refine its exiting transmission load ratio process to include transmission-planning areas within the Ameren-IL system. Ameren should begin using this practice in its next load forecast.

V-5 Develop and use a 10-year weather-based design temperature for the distribution planning load forecast.

Using a 100-year weather database skews the weather based design temperature lower because of lower historical temperature data. Ameren-IL should develop a weather-based design temperature using 10 years of data and use that temperature in its distribution load forecasts. Ameren-IL should use this method in its next distribution load forecast.

In its comments on the draft report, Ameren-IL suggested only a study of the effect of using a 10-year temperature basis. Ameren-IL also stated that 100 years of weather data is more reasonable for a long term forecast. Liberty disagrees as the system is being planned to serve expected needs in the short term.

V-6 Centralize the short circuit model.

Ameren should centralize the short circuit model so that both Ameren-IL and Ameren-MO can make continuous updates to the same model. In this fashion, a current model is always available to both Ameren-IL and Ameren-MO and there is no need for an annual lock step. Ameren should initiate this change at the timing of the next annual update.

In its comments on the draft report, Ameren-IL indicated that this change is not necessary. Liberty disagrees because the process is inefficient. Ameren starts with two identical copies of the same model and both Ameren-IL and Ameren-MO update their copies continuously. This process requires the forces the annual lock step adjustment to occur.

V-7 Evaluate the transmission and distribution systems for a total-loss-of-substation event.

Ameren-IL should perform a systematic analysis of an event involving the catastrophic destruction of any substation, where restoration of the substation may take weeks. The objectives of the analysis should be to:

- Determine whether any particular substations may cause special problems such as extended outages or lengthy outages to critical customers.
- Determine whether any particular substations need additional protection or pre-event preparation.
- Determine whether the supply of mobile equipment and spare equipment is sufficient.
- Generate preliminary contingency plans.

Liberty does not mean that this evaluation requires 1,500 individual assessments and plans. Ameren-IL can group many similar substations and contingency plans for most single unit substations can be very general. Ameren-IL should complete an initial review of all substations within one year of the date of this report.

In its comments on the draft report, Ameren-IL indicated disagreement with this recommendation because the total loss of a substation is a rare event and developing contingency plans for the loss of a distribution substation has little or no value. Liberty disagrees. For example, a tornado or vehicle accident could destroy a distribution substation and having preliminary contingency plans developed at a high level could help to avoid extended customer outages.

E. Design

1. Transmission Line Design

a. Introduction

The transmission system is the portion of the electric delivery system that connects to electric generators and performs the first distribution of electric power. Transmission lines operate at high voltages so that they can move large amounts of power over long distances efficiently. Because of their importance to the electric delivery system, utilities design transmission lines to a high degree of reliability in a network fashion. Utilities construct transmission lines on right-of-ways to prevent interference by vegetation or vehicular traffic. Transmission lines are costly and physically large.

The table below shows the mileage of Ameren-IL's overhead transmission system by voltage level and company.[49] Ameren-IL does not have underground transmission lines.

Ameren-IL Transmission Lines (Miles)

Company	138,000 volts	161,000 volts	230,000 volts	345,000 volts	Company Totals
Ameren-IP	1,348	0	0	472	1,820
Ameren-CIPS	1,737	91	137	350	2,315
Ameren-CILCO	284	0	0	48	332
Totals by Voltage	3,369	91	137	870	4,467

[49] Response to Data Request #7.

The most important aspects of transmission line design are strength of materials, conformance to clearance and safety standards, and protection from lightning. The most common standard for strength of materials and clearance and safety standards is the National Electrical safety Code (NESC). Section F.2 of this chapter covers lightning protection of transmission lines and the associated grounding requirements. This section of the report addresses strength of materials and conformance to clearance and safety standards.

b. National Electrical Safety Code and Ameren Transmission Standards

Title 83 of the Illinois Administrative Code 305 requires Illinois utilities to construct their systems to the National Electrical Safety Code (NESC) C2-2002 edition. Utilities use the NESC manual in virtually every state in some form or fashion as a design guide. The 2002 edition was in effect in July 2006.[50]

The NESC is a safety code designed to protect both public and employee safety and to prevent electrical power equipment from damage. It is not a design document, but rather a performance standard that addresses issues such as safety clearances, operational safety, material strengths, and design loadings. The NESC sets forth minimum requirements and allows the facility owner to choose the design that meets those requirements. The NESC does not address reliability performance standards involving fusing, sectionalizing, and other control devices, leaving decisions on those matters to the facility owner with oversight from regulatory authorities. The Illinois Administrative Code addresses that oversight. Part 83 section 305.30 states "All electric supply and communication lines and equipment shall be designed, constructed and maintained to meet the requirements of this Part to enable service to be safe, adequate, and dependable. For all particulars not specified in this Part, construction and maintenance should be done in accordance with accepted engineering practices for the given local conditions."

The NESC addresses and defines the strength required for all materials used in the various grades of construction permitted by the code. The NESC sets forth three grades of construction, Grade B, Grade C, and Grade N. Grade B is the strongest grade and the NESC requires utilities to use it for railroad crossings, limited access highway crossings, and navigable waterway crossings. Grade C is the next strongest grade and the NESC allows its use on public right-of-ways. Grade C represents the majority of utility system construction. Grade N is the lowest strength grade, which utilities use primarily for communications cables and electric supply in rural areas.[51]

The NESC also addresses the loading requirements of the various grades of construction permitted by the code. It establishes different wind and ice loading areas throughout the country. The state of Illinois is in the NESC Heavy Loading district, requiring that utilities design facilities to horizontal 4 lb./ft.^{2} wind loading[52] impressed on facilities covered with ½ inch of radial ice at 0 degrees F. The NESC stipulates load factors (safety or overload factors) for each grade of construction. Generally, Grade B construction has higher load factors than Grade C

[50] The IEEE published an updated version of the NESC in 2007.
[51] Different grades of construction have different base loading and overload requirements.
[52] Equivalent to a 40 mph wind.

construction.[53] Ameren considers all of the NESC loading requirements of ice, wind, or combinations thereof in the design of its transmission lines.[54]

Many other factors prescribed by the NESC affect transmission line design. For example, the NESC specifies the minimum conductor spacing requirements at the structure and at mid-span. The transmission line designer must take of all these considerations into account in conjunction with the span length and conductor size. Because of the variance in wire size, span lengths, turning angles, and pole heights and class,[55] the utility must design each structure to meet NESC requirements.

Ameren does not have a consolidated set of transmission line standards. Ameren-IP and Ameren-CIPS developed their own standards prior to merging with Ameren. Ameren-IL uses those standards today to understand how those companies constructed transmission lines. Ameren-CILCO and Ameren-CIPS-UE never developed transmission line standards and would refer to specific drawings as reference documents.[56] Despite the lack of written transmission standards, all Ameren-IL legacy company practices met or slightly exceeded the applicable NESC Code requirements.[57] It is common for utilities to have no general standards for their transmission line design loads because they use loadings directly out of the NESC and because each line has unique design aspects.

Ameren-IL currently designs all transmission lines to NESC Heavy Load conditions and Grade B construction loading requirements.

c. Transmission Line Design Organization and Personnel Levels

The transmission-line design organization is part of the Transmission and Distribution Design group and as such, its Supervising Engineer reports to the Managing Supervisor – Line Design who reports to the manager of Transmission and Distribution Design. Nine engineers based in St. Louis perform transmission line designs for both Missouri and Illinois. Two civil/structural groups support the transmission line design engineers in addition to the substation design engineers. One of those groups is located in St. Louis, has eight engineers plus a Supervising Engineer, and is responsible for supporting Missouri projects and some of the Illinois projects. The second group is located in Decatur, has six engineers plus a Supervising Engineer, and is responsible for supporting the remainder of projects in Missouri and Illinois.[58]

The transmission line designers develop design criteria, perform tower spotting,[59] determine structure configurations for clearances, and provide the wires sizes and tensions. The civil group

[53] In the 2007 edition, the NESC also requires that structures that are 60 feet or more in height above the ground line be subject to design-strength wind loadings of 90 mph. On the Ameren-IL system, this requirement would apply to the taller structures used on the 69,000-volt and 34,500-volt systems.
[54] Response to Data Request #239.
[55] Pole class is a classification of pole strength. The lower the pole class number, the larger the pole circumference.
[56] Response to Data Request #238.
[57] Interview # 118, January 8, 2008.
[58] Response to Data Request #698. Prior to 2007, the Decatur group reported to the St. Louis supervising engineer.
[59] Tower spotting is the process of determining the transmission structure height and material requirements in relation to the terrain.

determines the loadings produced by the specified wire and tension, performs structural analysis, and foundation analysis if necessary. Personnel have full schedules and use consultants as required.[60] However, Liberty found that Ameren is completing its work with little outside resources and the workforce appears to be adequate.

The transmission line design personnel have little interface with the maintenance department, are not informed of maintenance issues such as leaning poles and broken cross arms, and have no input into the maintenance program regarding frequency or items for inspection.[61]

d. Design Process and Requirements

Ameren uses the Power Line System, Inc. software called PLS-CADD for tower spotting its new transmission lines. PLS-CADD is a state-of-the-art software package used by many utilities to design transmission lines. The software considers transmission line centerline and side profiles so that every phase meets NESC clearance requirements. The user can set "no build" zones in the profile to ensure that construction does not take place in certain locations, can specify minimum and maximum span lengths, and can manually insert locations for towers.[62]

After the program generates a line design in an iterative manner, a transmission design engineer reviews the line design to readjust pole locations to minimize the impact to customers. Ameren-IL places importance on placing towers in areas that do not interfere with the geometry of planting and the large machines used by farmers. Engineers then review the final design for cost, strength, and other factors.[63]

Ameren designs new lines to a maximum operating temperature of 120°C for ACSR (aluminum conductor, steel reinforced) and a maximum operating temperature of 200°C for ACSS (aluminum conductor, steel supported). Ameren uses an 8 percent over-voltage factor to calculate required NESC clearances in line designs.[64] Before energizing a new line, transmission line engineering personnel visually inspect the line for construction or clearance problems.[65] Many utilities allow operation of ACSR transmission lines at 140°C for short periods of time (*e.g.*, emergency rating for 15 minutes) to permit certain dispatcher switching to take place.[66] Because Ameren does not make a provision like this, it puts operating restrictions into its transmission line design that may require future and unneeded construction.

[60] Interview #118, January 8, 2008.
[61] Interview #118, January 8, 2008.
[62] Response to Data Request #237 and Interview #51, October 31, 2007.
[63] Response to Data Request #237 and Interview #51, October 31, 2007.
[64] NESC clearance requirements are voltage dependent. This figure represents the maximum operating voltage of the line above nominal voltage.
[65] Interview #51, October 31, 2007.
[66] For example, all New England utilities using ISO New England Planning Procedure #7 have a short-time, 15-minute rating with conductor temperature at 140 degrees C for the 345,000-volt system.

Ameren-IL currently designs its sub-transmission and transmission lines such that galloping of conductors will not cause an outage.[67] The legacy companies had elliptical separation design requirements for galloping conductors as the following table shows.[68]

Design Separation of Conductors during Elliptical Galloping Conditions

Company	34,500- and 69,000-volt Sub-Transmission	100,000 volt and Above Transmission
Ameren-IP	Not Touching Allowed Flashover Distance	Not Touching Allowed Flashover Distance
Ameren-CIPS	One Foot Separation (No flashover at these voltages)	One Foot Separation (Flashover allowed at these voltages)
Ameren-CILCO	No Written Guideline Not Touching – No Distance Specified	No Written Guideline Not Touching – No Distance Specified

Only Ameren-CIPS designed its sub-transmission lines to prevent outages from occurring during conductor galloping events. Ameren-IL could have galloping problems on its sub-transmission system and did not typically use anti-galloping dampers or spoilers in the initial design. Ameren-IL uses dampers and spoilers on its sub-transmission and transmission systems as a maintenance item only.[69]

Ameren adds additional clearance requirements to its line sag calculations to allow for variations in construction. Historically, Ameren-IP added three feet, Ameren-CIPS added one foot, and Ameren-CILCO added three feet to NESC required clearances regardless of the transmission line voltage for construction variations. Ameren-IL continues the practice of adding three feet to required clearance requirements.[70] Ameren-IL's practice in this regard represents common and acceptable industry practice.

Ameren uses a general guideline in the design of their transmission lines such that it installs storm structures[71] at 5- to 7-mile intervals. These structures reduce the possibility of cascading failures.[72] Although the terrain at many utilities prevents the ability to build long, straight transmission lines, Ameren's guideline in this regard is an acceptable industry practice.

Ameren sets its poles at the industry guideline of 10 percent plus two feet or 10 percent plus three feet depending on the pole class. Furthermore, Ameren has their poles branded[73] such that the pole brand is approximately 6 feet above the set depth for that pole.[74] This serves as a quick check for proper pole set depth. This is an acceptable industry practice, but Liberty notes that in

[67] Response to Data Request #237. Conductor galloping is a self-induced, low frequency, and large amplitude elliptical motion of conductors generally initiated by wind.
[68] Response to Data Request #381.
[69] Interview #118, January 8, 2008 and Ameren-IL's comments on the draft report, July 31, 2008.
[70] Response to Data Request #380.
[71] A storm structure is a structure that is self-supporting and that does not depend on opposing forces for support. These are also known as dead-end or strain structures.
[72] Response to Data Request #697.
[73] A pole brand indicates the pole class, height, manufacturer and date, species, and treatment.
[74] Response to Data Request #695.

2007 the NESC revised its loading requirements upwards for the taller poles. Even though the ICC has not adopted the 2007 NESC, Ameren-IL should analyze the changes to the NESC loading requirements and determine if the new loading requirements require changes to pole set depth guidelines for its new sub-transmission and transmission lines.

The quality assurance and quality control process with regard to transmission line design is informal. The project engineer typically performs his or her own quality assurance and quality control review.[75] This process is generally more formal at other utilities.

Ameren has no written policy on installing or rebuilding distribution lines under transmission lines. If the project is in-house, distribution engineering follows NESC clearance guidelines. They submit plans to transmission maintenance engineering for review against NESC requirements.[76] Liberty found that this process is problematic and Ameren-IL's process for under-building could result in insufficient clearances between transmission and distribution facilities and the inability to load transmission lines to their expected capabilities during contingency conditions. Even if the current in-house process is satisfactory, there remain the questions of foreign under-builds past and present and whether historic under-building provided for sufficient clearances.

Some older transmission lines had a design operating temperature of 49°C or 75°C. Ameren-CIPS reviewed lines constructed to this operating temperature in the mid-1980s to upgrade them up to the ability to operate at 100°C or establish line ratings based on limiting sags that met the 1984 NESC. However, the other two operating companies did not review older lines for this issue.[77]

Before the computer software that is in use today became available, utilities designed their transmission lines by manual tower spotting methods. They plotted a centerline profile of topography on a mile sheet[78] that had different vertical and horizontal scales. They may or may not have considered side profiles of the different phases. They made a sag template using the assumed ruling span,[79] conductor, operating temperature, and tension, and used that template to "spot" towers to maintain the NESC clearance with any allowance for construction deviations. The assumed ruling span could have been different from the actual ruling span for that section of line. This could have resulted in actual sags different from those assumed in the design resulting in possible NESC clearance violations when the line was at its design operating temperature.

[75] Interview #118, January 8, 2008.
[76] Response to Data Request #696.
[77] Interview #51, October 31, 2007.
[78] A mile sheet was the name given to the drawing because one mile of transmission-line profile data would fit on the drawing.
[79] A ruling span is the span that acts most like every span that exists between two fixed support points (dead ends) of a transmission line. Each section of a transmission line has a different ruling span and thus different sag characteristics.

2. Substation Design

a. Introduction

Substations are an important part of the electric delivery system. They perform many functions and are like nodes that connect the various parts of the system. At generating plants, substations connect the generator to the transmission system and increase the voltage to permit efficient carrying of power to customers over long distances. On the transmission system, substations can function as a switching station, connecting lines and allowing power to flow in the needed direction. The most common role of a substation is to reduce the transmission voltage to sub-transmission levels and then to levels that serve the distribution system close to customers.

An important aspect of substation design is conformance to clearance and safety standards, the most common of which is the National Electrical Safety Code (NESC). Other design considerations are the power ratings[80] and interrupting capability[81] of substation equipment, protection from lightning, equipment insulation levels, and grounding. Section F.2 of this chapter covers lightning and system protection. This section covers substation equipment and transformer ratings, substation grounding, and substation-equipment insulation levels.

b. National Electrical Safety Code

Title 83 of the Illinois Administrative Code 305 requires Illinois utilities to construct their systems to the National Electrical Safety Code (NESC) C2-2002 edition. Utilities use the NESC manual in virtually every state in some form or fashion as a design guide. The 2002 edition was in effect in July 2006.[82]

The NESC is a safety code designed to protect the safety of both the public and employees and to prevent electrical power equipment from damage. It is not a design document, but rather a performance standard that addresses issues such as safety clearances, operational safety, material strengths, and design loadings. The NESC sets forth minimum requirements and allows the facility owner to choose the design that meets those requirements. The NESC does not address reliability performance standards involving fusing, sectionalizing, and other control devices, leaving decisions on those matters to the facility owner with oversight from regulatory authorities. The Illinois Administrative Code addresses that oversight. Part 83 section 305.30 states "All electric supply and communication lines and equipment shall be designed, constructed and maintained to meet the requirements of this Part to enable service to be safe, adequate, and dependable. For all particulars not specified in this Part, construction and maintenance should be done in accordance with accepted engineering practices for the given local conditions."

Ameren-IL uses the NESC in the design of its substations to ensure personnel safety.

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[80] Power ratings are the amount of power that equipment can carry at its operating voltage without exceeding thermal capabilities. Power is current multiplied by voltage.
[81] Interrupting capability is a rating applied to equipment that must operate to interrupt the flow of power. A circuit breaker is an example of such equipment. The interrupting device must have the capability to interrupt the current flow and extinguish the resultant arc that develops.
[82] The IEEE published an updated version of the NESC in 2007.

c. Ratings of Substation Equipment[83]

Electrical equipment reaches its power rating when the power flowing through it generates an amount of heat that equals the ability of the equipment to dissipate that heat without damage. Simplistically, five factors determine the power rating of equipment. The first two are the amount of current flowing through the equipment and the voltage at which the equipment operates. The second two factors are the equipment operating temperature and the ambient temperature. The higher the allowed operating temperature, the more power can flow through the equipment. The ambient temperature is the thermal starting point for the power rating of the equipment. The higher the ambient temperature, the less power it will take to heat the equipment to its operating temperature. The last factor is time. Flowing power through equipment over time reduces the ability of the equipment to dissipate that heat. The equipment power rating reduces with a longer time the power flows. For example, equipment may have a power rating of "X" on a continuous basis, and "2X" for one hour.

Ameren rates all substation conductors and buses in accordance with Substation Design Standard No. 8G, "Design Guide for Outdoor Substation Conductor Current Ratings." This standard establishes both normal and emergency ratings for substation equipment with a 40°C (104°F) ambient temperature. Operating temperatures used in the calculation of these ratings are 80°C and are lower than operating temperatures for the lines entering and exiting the substation, thus ensuring conservatism and no power limitations within the substation.

Ameren-IL rates all substation equipment other than transformers at the maximum continuous rating with a 40°C ambient and a 90°C operating temperature. The operating temperature of substation equipment is lower than operating temperatures for the lines entering and exiting the station, thus ensuring conservatism and no power limitations within the substation.

Ameren-IL uses the nameplate interrupting capability of its circuit breakers to set current interrupting limits.

d. Ratings of Transmission Transformers

Ameren's specification for the purchase of transmission transformers is in accordance with Substation Design Standard No. 9.[84] Ameren provides the normal and emergency load cycles,[85] ambient temperature cycle,[86] and transformer temperature excursions that the transformer must meet.[87] Some of Ameren's temperature excursion values are lower than accepted ANSI standards

[83] Interview #175, June 3, 2008, and response to Data Request #781.
[84] A transmission transformer is one that connects two transmission voltages (345,000 volts, 161,000 volts, or 138,000 volts).
[85] These load cycles are the transformer loadings by hour that would be expected under normal and emergency operating conditions.
[86] The ambient temperature cycle is the hourly ambient temperature that the normal and emergency load cycles experience. The ambient temperature cycle is the hourly ambient temperature for the peak load day.
[87] Response to Data Request #244.

and are therefore more conservative.[88] The manufacturer must verify that the transformer meets the specified loading and temperature requirements by using ANSI-based rating calculations.[89]

The duty cycle placed on transmission transformers may not follow the daily load cycle of the system because of power transfers within and through the transmission system or differing generation patterns on the two transmission-voltage systems.[90] Even with that consideration, the Ameren rating practice of assuming a flat continuous load cycle for transmission transformers is conservative. By purchasing transformers that it cannot load to industry standards, Ameren must either bring each load cycle to the manufacturer for evaluation or lock itself into the flat load cycle design built into the transformer as its rating. This practice may require unneeded transmission construction to occur or restrict economic power flows to artificially low values. Liberty concluded that specifying transformers that cannot have alternative load cycle calculations performed in accordance with broadly used industry standards is not an acceptable practice.

Ameren indicates that they require that the loading capability of the transmission transformer ancillary equipment to be equal or greater than the transformer.[91] This requirement is included in their Standard 9 Supplemental Specification section 1.12. If Ameren did not have this requirement, they could be purchasing transformers that it believes has a certain capability, but in reality the transformer could fail at a lower level of operation due to under-sized or under-rated ancillary equipment.

When rating transmission transformers, Ameren only considers a normal loss of life.[92] Ameren calculates normal and 8-hour emergency ratings and sets both equal to the top nameplate rating of the transformer, which is a continuous rating. Manufacturers construct transformers to be able to operate at their top nameplate rating for 65,000 hours (referred to as the normal loss-of-life for the transformer). Operating the transformer below its top nameplate rating increases the life of the transformer just as operating above the top nameplate rating decreases the life of the transformer. Ameren's practice of rating these transformers at the top nameplate rating may result in the construction of transmission facilities to relieve transformer overloads when unused transformer capability actually exists. Liberty concluded that this practice is too conservative.

e. Ratings of Bulk and Distribution Transformers

Ameren's purchase specification for bulk and distribution transformers is in accordance with Substation Design Standard No. 8.[93] The ratings for these transformers are heat-run based and

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[88] ANSI is American National Standards Institute. An ANSI and industry standard is the IEEE Standard C57.91, IEEE Guide for Loading Mineral-Oil-Immersed Transformers.
[89] Response to Data Request #781.
[90] The load cycle on these transformers would be expected to be flatter when compared to the load cycle of the system.
[91] Transformer ancillary equipment is the equipment on the transformer other than the core and coils. Examples would be the bushings, current transformers, internal lead connections, and the tap changer.
[92] Normal loss of life refers to the expected aging of the transformer insulation during operation throughout its life. Utilities can develop a loss of life rating that would allow additional aging for rare emergency conditions.
[93] Bulk transformers are the transformers that step down the transmission voltage to the sub-transmission voltage. An example would be a 138,000/69,000-volt transformer. Distribution transformers are the transformers that step

use ANSI overload capability guides.[94] Ameren calculates three ratings for these transformers based on a 40°C ambient temperature. The normal rating uses a load cycle and allows only for normal loss of life. The long-time emergency rating is a 24-hour rating that allows for 0.5 percent loss-of-life per day over an assumed 5-day long-term event, or 2.5 percent loss of life per occurrence. The short-time emergency rating is a 24-hour rating that allows for 2.5 percent loss of life per occurrence.

Ameren has three options available for the specification of loading capability of bulk and distribution transformers. These generally follow legacy company practices. Ameren may specify ANSI standards and ANSI overload capabilities with some lower excursion temperatures allowed, a load profile rating as used in the transmission transformer specification (majority purchased with this option), or a 125 percent overload capability for 8 hours. Regardless of the specification option chosen, all transformers must be able to be loaded according to ANSI overload guides. In addition, the bulk and distribution transformer specification requires that the loading capability of all transformer ancillary equipment be equal or greater than that of the transformer.

Ameren's practices related to purchasing and rating its bulk and distribution transformers are slightly conservative and well within accepted industry practices.

f. Substation Grounding

Substation grounding is important to provide a low impedance path to ground for lightning strikes to the substation or to lines entering and exiting the substation, for protection of equipment, and for personnel safety during ground fault conditions. Liberty discusses the lightning protection and the protection of equipment aspects of grounding in Section F.2 of this chapter. In Chapter VI, Liberty reported that it found several substations without adequate grounding of substations and gates. This section deals solely with the adequacy of grounding for personnel safety.

During ground fault conditions, the ground potential rises and personnel who have their feet on the ground and touch substation equipment are subject to a difference of potential across their resistive bodies that will cause current to flow through their bodies.[95] If that current is large enough, death can result. Similarly, if personnel are walking in a substation during ground fault conditions, they are subject to a difference of potential across their legs that will cause current to flow through their bodies.[96] If that current is large enough, death can also result. Personnel protection from this condition comes from by an adequately designed grounding system that considers personnel location, magnitude of faults, ground potential rise, grounding grid spacing, and insulating materials between personnel and the earth.

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down the sub-transmission voltage to the distribution voltage. An example would be a 69,000/12,000-volt transformer.

[94] A heat run is a factory performed loading test that measures temperature response to transformer loading. These test results allow the equipment owner to simulate other loading conditions.

[95] This is called the touch potential.

[96] This is called the step potential.

The Ameren legacy companies and Ameren-IL all designed their substation grounding on IEEE Standard 80 "Guide for Safety in AC Substation Grounding" in some form. This standard has proved through experience to be an effective industry guide utilities have used for many years. Ameren-CILCO has no documentation of this design practice.[97] The table below shows the design substation-grid resistance for the various substation classes used by the legacy companies and Ameren-IL today.[98]

Design Resistance of Legacy and Ameren-IL Substation Grids by Substation Class (Ohms)

Substation Class	Ameren-IL	Ameren-IP	Ameren-CIPS	Ameren-CILCO
Transmission	0.5	1.0 or less	0.5	1.0 or less
Bulk	0.5	1.0 or less	0.5	1.0 to 5.0
Distribution	1.0	1.0 or less	1.0	1.0 to 5.0

Although the design-substation grid resistance may be different within a company for different substation classes, the grounding requirements were consistent.[99] However, grid resistance alone is not the determinate of a safe substation.

In the potential shock calculations, the utility must use a fault current to ground. It is this current that will determine the potential rise of the grounding grid. Factors that influence the fault current available at a substation are the proximity to facilities that can generate fault current and the number of lines and transformers entering and exiting the station.[100] The table below depicts what the legacy companies used for fault currents in their substation grid designs and what Ameren-IL uses today.[101]

Fault Currents Used for Grounding Grid Design (Thousands of Amps (kA))

Substation Class	Ameren-IL	Ameren-IP	Ameren-CIPS	Ameren-CILCO
Transmission	40kA or actual if greater	Actual[102]	40kA	Unknown
Bulk	40kA or actual if greater	40kA	40kA	Unknown
Distribution	Not Supplied	Low Voltage Bus Maximum	Low Voltage Bus Maximum	Unknown

The addition of many market generators increases available fault current because they are fault-current generators. Ameren-IL only reviews grounding adequacy within a substation if a new transformer or line terminal expands the area within that substation. This practice does not

[97] Response to Data Request #776.
[98] Response to Data Request #775.
[99] Interview #176, May 28, 2008.
[100] Increasing the number of lines and transformers entering the substation lowers the system impedance back to the generators of fault current thus increasing fault current at that station.
[101] Response to Data Request #778.
[102] Comments on draft Liberty report, July 31, 2008.

capture increased fault currents caused by system expansion outside of the substation.[103] Those new facilities may be in close proximity to the substation and may increase the available fault current above the original design values creating a safety condition. Due to market generator and associated line additions, many 345,000-volt utility systems are replacing 40kA ("kA" means thousands of amps.) breakers with 63kA breakers because of the increased fault duty.

IEEE Standard 80 uses an assumed earth resistivity for crushed rock. The crushed rock assumed is 2 to 3-inch of crushed rock to provide small points of contact of high resistance to the footwear of personnel. Ameren-IL and the legacy companies used a variety of substation-grading materials and it uses different resistances in the grounding grid calculations.[104] It is not clear that the substation grading material used matched the resistivity value used in the grounding-grid design calculations performed by Ameren.

Ameren-CIPS and Ameren-CILCO have grounding grid maps for most of the older stations. It was not the practice to put the calculation assumptions on these maps, and that information is now unknown.[105]

While each Ameren company had a requirement to tie the station grounding grid to the substation fence and gates, Liberty's inspections found that many of these ground connections no longer exist or are improperly connected. In addition, some substations have fences that sit on the property line.[106] In these cases, the required copper conductor away from and on the outside of the fence was never installed. The combination of no fence grounds or no outer fence conductor places both the public and employees at risk of shock during ground fault conditions.

All Ameren companies connected transmission line static wires to the substation grounding grid through the transmission line take off structures.[107] Most Ameren companies had a practice of installing a small grid wire mesh at manual switch locations for added personnel protection.[108]

Ameren-IL indicated that it bases any grounding grid designed today on IEEE Standard 80 and that it uses common assumptions regardless of legacy standards. Additionally, Ameren-IL has compared the resultant designs of the three legacy companies and found little difference.[109] However, as the table above shows, in some cases Ameren-IL would use actual available fault current values in the design allowing for no system growth.

Verification of grounding grid continuity and integrity varies among the operating companies. Ameren-IP checks continuity every two years, Ameren-CIPS checked ground grid integrity every five years up to 2000 but only verifies that transformer neutral current can flow today, and Ameren-CILCO had no standard ground grid test. Ameren-IL indicated that it is reviewing this issue.[110]

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[103] Response to Data Request #779.
[104] Interview #176, May 28, 2008.
[105] Interview #176, May 28, 2008.
[106] Interview #176 May 28, 2008.
[107] Interview #147, March 26, 2008.
[108] Response to Data Request #776.
[109] Interview #176, May 28, 2008.
[110] Response to Data Request #780.

Grounding grid design standards existed and the companies used them in the original design of substations. However, Ameren-IL has not maintained sufficient grounding design data, has some improperly grounded substation fences, and lacks updated grid analyses based on current system and available fault current conditions. Therefore, Ameren-IL cannot assure personnel safety during ground faults.

g. Equipment Insulation Levels

The insulation of substation equipment must sufficient such that voltage excursions caused by lightning or switching events do not damage the equipment. Ameren uses the following basic insulation levels (BIL)[111] when constructing its substations. ("kV" means thousands of volts.)

Bus Work
12kV bus – 110kV BIL
34.5kV bus – 200kV BIL
69kV bus – 350kV BIL
138kV bus – 650kV BIL
345kV bus – 1,300kV BIL

Transformers
345/138kV transformers have 1,050/550kV BIL windings
138/12kV transformers have 550/110kV BIL windings

These equipment insulation levels are in accordance with industry-accepted practices.

3. Distribution System Design

a. Introduction

The distribution system is the portion of the electric delivery system that connects to and supplies electricity to customers. The distribution system traverses virtually every street and alley to make customer connections. The distribution system is unlike electric generators that are few in number and are large, self-contained plants, and the transmission system that consists of fewer lines and has protection from harm by the use of right-of-ways. Cohabiting with trees, vehicles, and other utility services, the distribution system has exposure to many sources of potential harm, but still must provide reliable electric service to customers at a reasonable cost.

Utilities design high levels of reliability into the generation and transmission portions of the electric delivery system at significant cost. This involves a networked system that typically does not cause service interruptions when a problem occurs. They design reliability into the distribution system by balancing cost and the large number of facilities involved. Except in isolated cases such as urban areas, utilities do not network the distribution system and service interruptions will occur when there are outages. A reliable distribution system design will limit those outages and the number of customers affected when problems do occur.

[111] BIL is the measure of the dielectric strength of the system components.

b. Distribution Design Standards

1. National Electrical Safety Code Requirements, General

Title 83 of the Illinois Administrative Code 305 requires Illinois utilities to construct their systems to the National Electrical Safety Code (NESC) C2-2002 edition. Utilities use the NESC manual in virtually every state in some form or fashion as a design guide. The 2002 edition was in effect in July 2006.[112]

The NESC is a safety code design to protect both public and employee safety and to prevent electrical power equipment from damage. It is not a design document, but rather a performance standard that addresses issues such as safety clearances, operational safety, material strengths, and design loadings. The NESC sets forth minimum requirements and allows the facility owner to choose the design that meets those requirements. The NESC does not address reliability performance standards involving fusing, sectionalizing, and other control devices, leaving decisions on those matters to the facility owner with oversight from regulatory authorities. The Illinois Administrative Code addresses that oversight. Part 83 section 305.30 states "All electric supply and communication lines and equipment shall be designed, constructed and maintained to meet the requirements of this Part to enable service to be safe, adequate, and dependable. For all particulars not specified in this Part, construction and maintenance should be done in accordance with accepted engineering practices for the given local conditions."

The NESC addresses and defines the strength required for all materials used in the various grades of construction permitted by the code. The NESC sets forth three grades of construction, Grade B, Grade C, and Grade N. Grade B is the strongest grade and the NESC requires utilities to use it for railroad crossings, limited access highway crossings, and navigable waterway crossings. Grade C is the next strongest grade and the NESC allows its use on public right-of-ways. Grade C represents the majority of utility system construction. Grade N is the lowest strength grade, which utilities use primarily for communications cables and electric supply in rural areas.[113]

The NESC also addresses the loading requirements of the various grades of construction permitted by the code. It establishes different wind and ice loading areas throughout the country. The state of Illinois is in the NESC Heavy Loading district, requiring that utilities design facilities to horizontal 4 lb. /ft.^{2} wind loading[114] impressed on facilities covered with ½ inch of radial ice at 0 degrees F. The NESC stipulates load factors (safety or overload factors) for each grade of construction. Generally, Grade B construction has higher load factors than Grade C construction.[115]

Many other factors prescribed by the NESC affect distribution circuit design. For example, it specifies the minimum conductor spacing requirements at the pole and at mid-span. The circuit

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[112] The IEEE published an updated version of the NESC in 2007.
[113] Different grades of construction have different base loading and overload requirements.
[114] Equivalent to a 40 mph wind.
[115] In the 2007 edition, the NESC also requires that structures that are 60 feet or more in height above the ground line be subject to design-strength wind loadings of 90 mph. On the Ameren system, this requirement would apply to the taller structures used on the 69,000-volt and 34,500-volt systems.

designer must take of all these considerations into account in conjunction with the selected span length and conductor size. Because of the variance in wire size, span lengths, turning angles, pole heights and class,[116] and foreign attachments and equipment mounted on the pole, the utility must design each pole to meet NESC requirements.

2. Distribution Design Manuals, General

The electric utility industry typically has two types of design manuals. One is a distribution construction standards manual that covers matters such as available materials, preferred framing configurations, dimensions, sags, and other construction information. Engineers and system designers also need a distribution-engineering manual. It contains items such as how to perform pole class calculations, ruling span[117] calculations, and conductor sag calculations. It typically includes conductor data, ampacity ratings, protective coordination guidelines, sectionalizing guidelines, and other necessary engineering data. Evaluation of the usefulness of these manuals includes quality and completeness, coverage of topics, complete examples, and timeliness of updates.

3. Construction Standards Manuals, Ameren-IL

Ameren-IL plans for its distribution construction standards to be consistent in Illinois. It issued the Distribution Construction Standards Manual in 2005. Ameren-CIPS and Ameren-CILCO use this manual for field design, but Ameren-IP did not widely use it.[118] As of July 2006, Ameren-IP used the Ameren-IP Engineering Design Standards for distribution design and construction.[119]

Ameren-IL introduced new distribution design standards in early 2008; they will apply to all new distribution construction. This manual contains design information and configurations on poles, pole framing, conductor tensions and conductor sags, transformers, service connections, guying, lightning protection, grounding, fuse installation, switch installation, meter installations, underground construction, and other topics. The field designer makes decisions on required pole height and class based on the equipment to be on the pole, required conductor heights, wire size, span, and desired grade of construction. Alternatively, the field designer could select an available pole height and class and calculate the maximum spans allowed for a particular conductor. The manual requires that all construction should conform to the construction grades required by the NESC except for 34,500- and 69,000-volt construction, which requires a minimum class 1 pole size.[120]

The NESC construction grades used have varied among the legacy companies. For example:

- At the time of the 2006 storms, Ameren-CILCO, Ameren-CIPS, and Ameren-IP were designing to NESC Grade B construction except for some rural portions of circuits that

[116] Pole class is a classification of pole strength. The lower the pole class number, the larger the pole circumference.
[117] A ruling span is the assumed uniform span that most closely resembles all the various spans in a given section of line.
[118] Interview #105, October 29, 2007.
[119] Interview #146, March 27, 2008 and Response to Data Request #463.
[120] Response to Data Request #232.

were not main feeds. Ameren-CIPS-UE designed to NESC Grade C construction except where Grade B was required.[121]

- Some companies had been designing for NESC Grade B, but now design to Grade C and Grade B where required by the NESC.[122]
- Ameren-IP used NESC Grade B for all transmission and sub-transmission poles, and most distribution poles. It used Grade C construction for some rural distribution poles.[123]
- Ameren-CILCO used NESC Grade C construction and Grade B where required by the NESC prior to the merger in 2003. After the merger, they have used Grade B as the minimum.[124]
- Ameren-CIPS use construction standards per the Ameren Distribution Construction Standards Manual.[125]

Despite these variations, Liberty found that distribution construction design prior to the 2006 storms met or exceeded the NESC and Illinois Administrative Code 305.[126] Liberty also found that the new Ameren Distribution Construction Standards Manual, although less robust than some past practices, meets NESC requirements and Illinois Administrative Code 305.

4. Distribution Engineering Manuals, Ameren-IL

Ameren-IL does not have a common distribution-engineering manual. Rather, there is a set of engineering guidelines called the PS Guidelines. These guidelines cover engineering topics such as underground distribution design, overhead feeder circuit design, distribution-system protection coordination, reliability based prioritization, stray voltage trouble shooting, motor starting, and other engineering issues. The process of issuing these guidelines began in 2003 but Ameren-IL placed it on hold in the spring of 2006 due to lack of focus, strained resources, and some duplication of effort.[127]

Ameren-CIPS

Ameren-CIPS merged into the Ameren system in 1997. Prior to the merger, Ameren-CIPS used an engineering document titled "Electric Transmission and Distribution Department Engineering Manual."[128] The data in this manual was primarily 1980s vintage and major data areas such as pole class sizing were missing. It was in need of updating at the time of the merger.[129]

[121] Response to Data Request #290.
[122] Response to Data Request #232.
[123] Interview #103, November 30, 2007.
[124] Interview #105, December 14, 2007.
[125] Interview #104, December 7, 2007.
[126] Liberty found through field inspections that Ameren-IL used lower construction grades in some locations.
[127] Response to Data Request #345.
[128] Response to Data Request #231.
[129] Interview #104, December 7, 2007.

Ameren-CILCO

Ameren-CILCO merged into the Ameren system in 2003. Prior to the merger, Ameren-CILCO used an engineering manual called "Electrical Engineering Guide." The data in this manual was primarily mid-1980s vintage and was badly in need of updating at the time of the merger.[130]

Ameren-IP

Ameren-IP merged into the Ameren system in 2004. Prior to the merger, Ameren-IP used an engineering manual titled "Electrical Distribution Design and Data." This manual was comprehensive and was up to date at the time of the merger.[131]

Ameren-IP performs all of its distribution engineering designs at its centrally located Distribution Design Center in Belleville, IL. The Distribution Design Center uses the older Ameren-IP standards and Ameren-IP engineering manual as its design basis. For some items, the Distribution Design Center transitioned to using the standards in the new Ameren Distribution Construction Standards Manual. It is transitioning to the new Ameren standards as existing Ameren-IP material inventory is exhausted. The supervisor of the Distribution Design Center instructs Ameren-IP field personnel when to discontinue the use of a particular Ameren-IP standard and replace it with the new Ameren-IL standard.[132]

Summary

Ameren-IL does not have a common distribution standards manual in use among the operating companies. As the Ameren-IP Distribution Design Center transitions to the new Ameren Distribution Construction Standards, common construction standards will evolve. All three of the operating companies lack an acceptable distribution-engineering manual. The engineering manuals for Ameren-CIPS and Ameren-CILCO were incomplete at the time of their mergers and are out of date. The Ameren-IP engineering manual contains quality and complete engineering information but is now over five years old and needs updating.

c. Distribution Design Process

1. Ameren-CIPS[133]

Ameren-CIPS split the electrical design responsibilities for the divisions between two supervisors. The Division Supervisor-Engineering Electrical provides the technical electrical design responsibility for the division, has a staff of degreed electrical engineers, and a staff of engineering technicians to perform tasks such as surveying, mapping, and record keeping. The engineering electrical staff performs system planning, system improvement, protection coordination, designs for sub-transmission lines, and technical assistance for line extensions. The Supervising Engineer-Energy Services has the overall line extension responsibility for new customers in the division, has a staff of energy service specialists that function as the line-

[130] Response to Data Request #231.
[131] Response to Data Request #231.
[132] Interview #146, March 27, 2008.
[133] Interview #104, December 7, 2007, and Response to Data Request #657.

extension project manger and the customer contact. There is no formal training program and much of the training is on-the-job and depends on the experience of the degreed engineers. Ameren-CIPS uses subject matter experts from Ameren Services to conduct training on specific topics.

New Construction Design Process

The Customer Service System takes the customer request for service call at the Pawnee Call Center. The center directly routes requests for single-phase service of 200 amps or less to the construction service center if only service connections are required. It routes all other calls to the division's energy service specialists. The construction service center matches transformer load data from billing records to determine if the job requires pole or transformer work. If so, it routes those jobs to the energy service specialists.

The energy service specialist may also receive service requests directly from customers or developers. Energy service specialists generally have four-year degrees, but they may not be in engineering. They perform only jobs that they can design using templates prepared by division engineering, and will contact Ameren Services' subject matter experts or division engineering as required. Energy service specialists enter the jobs into the Distribution Operational Job Management (DOJM) system and perform customer contact and project management functions.

Energy service specialists use a personal computer-based system tool to design and upload their jobs into the work management system. Additional personal computer tools developed in-house include those for guy sizing, conductor galloping,[134] pole sizing, cable pulling tensions, and others.

System Improvement and Maintenance Engineering Process

Division engineering personnel perform system improvement work and are responsible for circuits from the distribution substation outward. They use the Load Analysis Program to perform annual feeder planning. They use the Distribution Engineering Workstation tool to perform circuit analysis for tasks such as power flow, motor starting, and protection coordination. Both tools use Ameren Distribution Construction Standards. To maintain protection coordination, division engineering has the authority to site necessary reclosers or fuses.

2. Ameren-CILCO[135]

The Supervising Engineer has design responsibility for the division. Distribution engineering personnel reports include both degreed engineers and energy application specialists. Engineers perform system planning, protection coordination, system improvement work, designs for sub-transmission lines and large projects, and design review for the smaller projects designed by the energy application specialists. Energy application specialists function as the customer contact,

[134] Conductor galloping is a self-induced, low frequency, and large amplitude elliptical motion of conductors initiated by wind.
[135] Interview #105, December 14, 2007.

project manager, coordinator of project needs for the customer, and work with the engineers as necessary on larger projects.

Ameren-CILCO does not have any formalized engineer-training program and relies on on-the-job training. Ameren-CILCO has used a shortened version of Union Electric's six-week Missouri classroom training program.

New Construction Design Process[136]

Customers either call the Peoria Call Center or contact the local energy application specialist. The energy application specialist will meet with the customer, obtain required information, design the job, perform cost estimates, and enter the job into the Distribution Operational Job Management system. Degreed engineers design the more complicated jobs such as underground residential design projects. They interface with the engineering group in Peoria as necessary. The Distribution Operational Job Management system generates a material list. Construction personnel order materials for smaller jobs while engineering personnel order material for the larger jobs.

Ameren-CILCO assigns engineering personnel with less than five years of experience to work under the supervision of a senior distribution engineer for all jobs. As the newer person demonstrates maturity in engineering design and judgment, they receive more responsibility. Senior distribution engineers review all work of junior personnel.

Designers use the Beyers system to generate maps of existing facilities and the Distribution Engineering Workstation as a design tool for jobs such as fault currents, power flows, and motor starting. They use the Ameren Distribution Construction Standards for sags and as a reference for pole loadings; however, designers still use an Ameren-CILCO in house spreadsheet for pole loadings. For the 69,000-volt and 34,500-volt systems, they use the Alcoa Sag 10 program to generate sag templates and check for galloping conductors. Ameren-CILCO uses an in-house spreadsheet to calculate wind loadings.[137]

System Improvement and Maintenance Engineering Process[138]

Degreed engineers use the Distribution Engineering Workstation to perform protective coordination studies.[139] Ameren-CILCO has not performed these periodic studies of late as the protection analysis needs of the tap fusing program has driven the protection coordination need.

Local engineers manage highway projects involving the 4,000-volt and 12,000-volt system and standard distribution-pole replacements. Engineers will contact the Peoria engineering group and Ameren subject matter experts as required. The supervising engineer approves all work orders.

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[136] Interview #105, December 14, 2007 and Response to Data Request #658.
[137] Response to Data Request #657.
[138] Interview #105, December 14, 2007 and response to Data Request #658.
[139] Protection coordination studies are periodically conducted on an entire circuit to ensure that the minimum number of customers is interrupted for a fault. If a fault occurred on a tap off the main line, the fuse on the tap would be expected to operate before the protection devices on the main line.

Peoria engineers design projects involving the 69,000-volt and 34,500-volt systems and keep records of those projects in Peoria.

3. Ameren-IP

The supervising engineer in the division has the overall line extension responsibility for the division. The primary engineering staff consists of field-engineering representatives who are also the customer contact and the field project manager. A small staff of degreed engineers performs system planning, system improvement, and protection coordination for the division and provides technical assistance to the field-engineering representatives. Degreed engineers have a mixture of experience and gain their training either by on-the-job experience or the classroom portion of the Distribution Design Center Engineer Representative training.

There is a centralized Distribution Design Center in Belleville that performs all project design work and most of the pole-replacement design work. The Distribution Design Center consists primarily of Engineering Representatives, enters the job into the Distribution Operational Job Management system, and provides the maps and work orders for construction. Almost all personnel are cross-trained in the six electric and gas design modules. Written examinations are required after the completion of each module. Ameren-IP has a full time trainer that administers this 7,200-hour program.

New Construction Design Process[140]

Customer Service Representatives receive calls at the Decatur Call Center for either gas or electric service. Six engineering representatives handle these requests if they are of standard design for single-phase service conductors and enter the information into the Distribution Operational Job Management system for construction. If the job requires poles, transformers, or other equipment, field-engineering representatives are the customer contact, prepare field notes, and define customer requirements. They forward these jobs and field notes to the Distribution Design Center.

The Distribution Design Center has a staff of 30 engineering representatives. It designs the jobs from field notes submitted, creates the construction of the job in Distribution Operation Job Management, and creates the bill of materials and cost of the job. The Design Center uses many in-house spreadsheet computer programs for matters such as voltage drop, cable pulling, and conductor galloping. The Design Center bases all of its programs on the Ameren-IP Engineering Design Standards. Liberty does not consider them as user-friendly compared to newer Windows-based software on the market.

A supervisor at the Distribution Design Center reviews each job before releasing it for construction. Each construction package references standards in the job packets and is sent to the field-engineering representative for review. The field-engineering representative acts as the project manager, customer contact, and coordinates other Ameren required functions such as tree trimming or real estate. The field-engineering representative is also responsible to approve job status changes until it is ready for construction and for returning the job to the Distribution

[140] Interviews #103, November 30, 2007 and #146, March 27, 2008.

Design Center when completed. The Distribution Design Center closes the job and updates the GIS database.

System Improvement and Maintenance Engineering Process[141]

The degreed engineers in the divisions who perform distribution planning are also responsible for system improvement projects. The engineers will work with the Decatur system planning group and field-engineering representatives as necessary. The engineers also are responsible for all division protection-coordination issues and use the Ameren-IP Engineering Design data manual to do so. Engineers consult with the system protection group for protection coordination with the substation breaker. Field-engineering representatives perform pole replacement jobs and place them in the Distribution Operation Job Management system in very limited circumstances. The Distribution Design Center performs all other pole replacement jobs to determine the proper poles and initiate pole transfer requests.[142]

d. Overall Organization

Ameren-IL has six distribution divisions (seven as of July 2006). Each division has both geographic and legacy-company boundaries.[143] In each of the three operating companies, there are procedural and process differences that create different divisional policies. Operating centers within the divisions maintain the separate companies. The three companies separate division engineering personnel and processes. Each division has a different mix of the three operating companies. As a result, each division's design organization is different. Each division has one to four supervising engineers. Each division may have other types of supervisors responsible for line extensions or design.[144] Each division has to develop its own internal design review and process resulting in complex reporting and technical review relationships.

The minimum engineering work backlogs and the quick design times suggest that staffing in the various divisions and centers is adequate.

4. Line Equipment Ratings

a. Introduction

All equipment in the electric delivery system has a finite capability to carry power. The power rating is the limit to which a piece of equipment can carry power. Current flowing through equipment generates heat, and more current generates more heat. The equipment either dissipates the heat or absorbs it, raising its temperature. When the equipment reaches a maximum operating temperature, it has reached its power rating.

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[141] Interviews #103, November 30, 2007 and #146, March 27, 2008.
[142] In 2007, the Illinois Joint Use Notification System was placed into service. This computerized system replaced various manual paper and telephone systems.
[143] Response to Data Request #288.
[144] Response to Data Request #603.

The ambient temperature is also a large factor in the determination of power ratings. The power rating for a piece of equipment is lower on a hot summer day than the power rating on a bitter cold winter day.

Time is also a factor in power ratings. Equipment can withstand a larger amount of current for a short period. A power rating for a piece of equipment is therefore "X" power for "Y" time. For example, a piece of equipment may have a power rating of "X" on a continuous basis and "2X" for one hour. The power industry uses three general power ratings—the normal or continuous rating, the short-time emergency rating, and the long-time emergency rating.

There are many types of equipment in use in the electric delivery system. For example, there are line switches, circuit breakers, transformers, splices, and conductors. Over the years, the industry has developed conservative standards for the construction of various equipment types and their power rating capability.

The power rating of a transmission line is equal to the lowest power rating of any piece of equipment on that line. The power rating varies according to ambient temperature, the amount of current on the line, and the duration of the current flow. The conductors of a power line will sag lower when more current passes through them. Utilities must maintain required safety clearances between the conductors and ground. In some cases, the utility may have to base the power rating for a line on maintaining those clearances and not the thermal capability of the power line.

Section V.E.2 above discusses power ratings of transformers and other substation equipment such as bus work, circuit breakers, line traps, and switches, and includes a discussion on the interrupting capability of circuit breakers. This section of the report discusses the power ratings of line equipment, which is the equipment that is in series with the power line (and not in the substation), including conductors, line switches, and line hardware.

b. Transmission Line Equipment Power Ratings

Ameren-IL develops three ratings for its transmission system. They are the normal or continuous rating, the long-time emergency rating of 8 hours duration, and the short-time emergency rating of 30 minutes. Ameren uses the long-time emergency rating for design purposes and only uses the short-time emergency rating in special operating circumstances.[145]

Ameren-IL sizes its line switches at nameplate rating and line hardware must have greater mechanical and current carrying capacity than that of the conductors. Ameren-IL uses no seasonal variation for the power rating of this equipment and rates it at a 40°C (104°F) ambient temperature. The table below shows the maximum operating temperatures that Ameren-IL permits for various transmission conductors.[146]

[145] Response to Data Request #62.
[146] Responses to Data Requests #62 and #369.

Maximum Operating Temperatures of Transmission Conductors

Conductor Type	Normal (Continuous) Rating Temperature (^oC)	Emergency (8-Hour) Rating Temperature (^oC)
Copper or Aluminum	90	100
Aluminum Conductor Steel Reinforced (ACSR)	90	120
Aluminum Conductor Steel Supported (ACSS)	160	200

Ameren-IL generates transmission-line rating tables that depict the limiting element in each transmission line and the transmission line rating including safety clearance limits.[147] These line ratings include both line equipment and substation equipment capabilities. As discussed in section V.E.2 of this report, Ameren-IL rates substation equipment at the manufacturer's nameplate rating. For the most part, Ameren-IL's transmission lines are conductor-limited.[148] The power ratings for line equipment in the legacy companies were similar. As each merger took place, Ameren-IL standardized line-equipment power ratings.[149]

c. Sub-Transmission and Distribution Line Equipment Power Ratings

For sub-transmission lines, Ameren-CIPS and Ameren-CILCO had identical power ratings for conductors. Each used 40°C as the summer ambient temperature and 10°C (50°F) as the winter ambient temperature. They limited all conductors to 90°C operating temperature for their normal power rating and 100°C for their emergency power rating, except for ACSR, which had an 110°C temperature for its emergency power rating. Ameren-IP used 40°C as the summer ambient temperature and 15.6^{o}C (60°F) as the winter ambient temperature. It limited all conductors except ACSR to 93°C operating temperature for its normal power rating and 125°C for its emergency power rating. Ameren-IP limited ACSR to 100°C operating temperature for its normal power rating and 130°C for its emergency power rating.[150] All legacy companies rated line equipment at the manufacturer's nameplate rating and required connectors to have greater capability than the conductors.[151]

Distribution line-equipment ratings were the same as for sub-transmission except that Ameren-IP limited all conductors to a 93°C operating temperature for both their normal power rating and emergency power ratings.[152]

[147] Response to Data Request #63.
[148] Interview #175, June 3, 2008.
[149] Interview #175, June 3, 2008.
[150] Responses to Data Requests #367 and #368.
[151] Responses to Data Requests #367 and #368.
[152] Responses to Data Requests #367 and #368.

d. Analysis

Ameren-IL plans its transmission system to 8-hour emergency ratings. Short-time emergency ratings are only available for short-lived operating conditions. Short-time emergency ratings are higher than long-time emergency ratings. Dispatchers using System Control and Data Acquisition (SCADA) can take corrective action to reduce load in a short period. If Ameren-IL had a short-time emergency rating, it could allow such operations, get more capacity from the transmission system, and possibly defer significant transmission construction.

The North American Electric Reliability Corporation (NERC) recognizes short-time emergency ratings in its reliability standards, and many companies use a 15-minute short-time emergency rating in their system design process based on a maximum operating temperature of 140°C. Ameren-IL's use of nameplate rating for virtually all of its equipment is conservative. This conservatism would allow Ameren-IL to develop short-time transmission emergency ratings without exceeding equipment capabilities. The main obstacle to implementation of higher short-time emergency ratings may be safety clearances. Historically, the companies designed transmission lines to much lower operating temperatures and the capability for increased loading even for short periods may not be available.

The majority of Ameren-IL's distribution system is radial in nature. Radial systems do not lend themselves to the use of short-time emergency ratings because there is no relief action that operators can take in a short period. A large portion of the sub-transmission system is radial. However, the portion that is networked could also benefit from the use of short-time emergency ratings.

Ameren uses many different maximum operating temperatures across the transmission, sub-transmission, and distribution systems. Aluminum begins to anneal at 93°C and this is why utilities generally use this temperature or a lower more conservative temperature for continuous ratings. Under infrequent emergency conditions, utilities can allow some conductor loss-of-life. Whatever maximum operating temperatures Ameren-IL chooses to use for a set of given conditions, those temperatures should be the same for the distribution, sub-transmission, and transmission systems across the three companies for the purpose of consistency in planning and construction.

5. Conclusions

1. Ameren's transmission design standards meet NESC requirements.

Ameren considers all loading scenarios and requirements of the NESC and constructs all its transmission line to construction Grade B or better.

2. The transmission-line design process is adequate, but quality assurance is informal. (Recommendation V-8)

Ameren uses state of the art computer models to design their transmission lines. In these models proper consideration is given to prevent outages due to galloping, inclusion of side profiles, construction variances changing clearances, NESC clearance and loading requirements, local requirements, and storm proofing of the transmission lines.

Ameren's transmission line design quality assurance and quality control process is informal and conducted by the project engineer.

3. The workforce is adequate for the current transmission-line design workload.

Current workload is accomplished by existing personnel with little outsource requirements.

4. Transmission design operating temperature is too low for ACSR conductor and perhaps other conductor types. (Recommendation V-9)

Ameren uses 120°C for the design operating temperature for ACSR conductor. Many utilities use 140°C to facilitate the use of short-time power ratings that allow for dispatcher action during contingencies. Ameren may be building limits into its transmission lines that will require future construction that may be unneeded.

5. Conductor galloping may occur on the sub-transmission and transmission systems, and historically the companies did not address it adequately. (Recommendations V-10 and V-11)

The legacy companies did not adequately design older sub-transmission and transmission lines to prevent outages due to conductor galloping. Conductor galloping is a recognized problem on the Ameren-IL sub-transmission system.

6. Sub-transmission and transmission pole set depth guidelines may be inadequate for new construction. (Recommendation V-12)

Ameren uses industry standard pole set depths for its poles that have a proven track record. The NESC increased loading requirements for line design calculations in 2007. These changes may require alterations in pole set depths for new construction because of increased moment loading especially on the taller sub-transmission equipment poles.

7. Older sub-transmission and transmission lines designed manually with a template may not meet NESC clearance requirements. (Recommendation V-13)

Older line designs that were done with a template were likely inaccurate and could permit NESC clearance violations.

8. Under-building on sub-transmission and transmission lines may cause outages during system contingency events. (Recommendation V-14)

Ameren has no written policy on installing or rebuilding distribution lines under sub-transmission or transmission lines. While Ameren states that it maintains NESC clearances during the design and review of the under-builds, questions remain regarding foreign under-builds and historic legacy company practices.

9. Substation design clearance standards are consistent with industry-accepted standards.

Ameren designs their substations in accordance with NESC requirements.

10. Ameren-IL's substation equipment (other than transformers) ratings are conservative.

Ameren-IL designs its substation equipment to remain below the operating temperature of the lines entering the station, at a maximum continuous rating, and at a 40°C ambient temperature. While this practice may seem overly conservative, it is often not costly to do so. It will allow Ameren-IL greater flexibility in developing aggressive ratings in its substations if line-operating temperatures increase in the future. Many utilities use line-operating temperatures that are higher than those Ameren uses.

11. The purchasing specification for and power ratings of Ameren's bulk and distribution transformers follow industry-accepted practices.

Ameren requires that all ancillary equipment of bulk and distribution transformers have load-carrying capability in excess of that of the transformer and that these transformers can be loaded in accordance with nationally accepted overload guides.

12. The purchasing specification for Ameren's transmission transformers is inadequate. (Recommendations V-15 and V-16)

Ameren should require that transmission transformers can be loaded in accordance with nationally accepted overload guides. While not being able to load transformers to industry accepted overload guides poses no risk to the transformers themselves, overly restrictive transfer limits or unneeded construction with negative economic consequences may result. This is not an acceptable industry practice.

13. Transmission transformer power ratings are too conservative. (Recommendation V-17)

Ameren rates its transmission transformers at the top nameplate continuous rating for both normal and emergency conditions. While transmission transformers have a differing load cycle than other transformers due to generation dispatch and transfer of power through the system, this practice may require unneeded transmission construction to occur or restrict economic power flows to artificially low values.

14. The interrupting capability rating of substation equipment is in accordance with industry-accepted practices.

Little additional interrupting capability above nameplate rating exists in substation equipment. Ameren, like most utilities, rates the interrupting capability of substation equipment at its nameplate rating.

15. Substation grounding practices are inadequate and may create unsafe conditions to the public and utility personnel during fault conditions. (Recommendations V-18 and V-19)

Former legacy substation grounding practices resulted in lost substation-grid design parameters, inadequate substation fence and gate grounding, and in inadequate procedures to review substation grounding adequacy as the power system grew. The inadequate grounding review procedure continues today and can result in unsafe conditions to the public and utility personnel during fault conditions.

16. The Ameren-IL companies used adequate distribution construction design.

Liberty found that distribution construction design prior to the 2006 storms met or exceeded the NESC and Illinois Administrative Code 305.

17. The Ameren-IL companies had different but adequate design review processes.

Liberty evaluated the assignment of design responsibilities and the design review processes used by the Ameren-IL companies and found them to be adequate and consistent with common utility practices.

18. The Ameren-IL companies used different construction standards. However, the construction standards are evolving into a single standard for application across the three operating companies and should result in acceptable and up-to-date engineering practices when complete. (Recommendation V-20)

Ameren-IP used different distribution-construction standards than those used by Ameren-CIPS and Ameren-CILCO. Ameren-IL introduced new distribution design standards in early 2008; they will apply to all new distribution construction. Ameren-IL will base all new distribution construction on these standards and that should result in common acceptable industry practices.

19. Ameren-IL does not have an acceptable and up-to-date engineering manual. (Recommendation V-21)

The engineering manuals for Ameren-CIPS and Ameren-CILCO were incomplete at the time of their mergers and remain out-of-date. The Ameren-IP engineering manual contains quality and complete engineering information but is now over five years old and needs updating. Ameren-IL issued a set of engineering guidelines called the PS Guidelines. These guidelines cover various engineering topics. The process of issuing these guidelines began in 2003 but Ameren-IL placed it on hold in the spring of 2006.

20. Ameren-IL would benefit from standardization and uniformity across the three operating companies in its distribution design processes. (Recommendation V-22)

The evolution of the distribution divisions with the three operating companies resulted in overlapping geographical boundaries and process differences within each division. Each division

developed complex reporting and technical review relationships in its design process. The Ameren-IP Distribution Design Center concept appears to offer a model for efficiency and standardization that Ameren-IL should consider for other parts of its territory. In addition, Ameren-IL should investigate upgrading some of the tools used by the Distribution Design Center to a Windows based environment.

21. Ameren's current level of distribution design personnel is adequate.

Ameren-IL's various design processes appear to produce engineering work in a reasonable time and minimum engineering work backlogs resulting in no delayed construction of new or modified facilities.

22. Ameren-IL inappropriately uses long-time emergency ratings for transmission and sub-transmission system design. (Recommendation V-23)

Short time power ratings are greater than long-time emergency power ratings. By using lower ratings, Ameren-IL may show the need for transmission construction long before it is actually required.

23. Ameren uses seasonal ratings for its transmission system.

Ameren develops summer, winter, and off-peak power ratings for the transmission system. The transmission system power flows are not just peak load sensitive. Significant power flow changes can take place on the Ameren transmission system due to generation dispatch on its system, generation dispatch outside of its system, weather in other areas of the country, or from different system energy economies. Seasonal power ratings bring additional capability to facilitate such transfers across the Ameren transmission system.

24. Ameren-IL uses different operating temperatures for the same type of conductor, and has other inconsistencies in power-equipment rating assumptions. (Recommendation V-24)

The long-time emergency operating temperature for the same ACSR conductor is 120°C for the transmission system, 110°C or 130°C for the sub-transmission system, and 93°C or 110°C for the distribution system. Whatever operating temperatures Ameren-IL decides to use for a conductor-type based on risk and loss-of-life, the temperature should be same across the system.

6. Recommendations

V-8 Formalize the transmission-line quality assurance and quality control process.

Ameren-IL should develop a more formal process to assure the quality of its transmission line projects. Ameren-IL should implement this change within one year of the date of this report.

V-9 Design new ACSR transmission and sub-transmission lines to a 140°C operating temperature. Determine higher design operating temperatures for other conductors used in transmission and sub-transmission line construction

Ameren-IL should design new ACSR transmission and sub-transmission lines with a 140°C operating temperature. Currently, Ameren designs its transmission system to long-time emergency ratings and uses short-time emergency ratings for short-term operations. Ameren should be building the ability to plan to short-term ratings to defer future construction. Ameren-IL should implement this recommendation for any new transmission and sub-transmission lines.

In conjunction with this change, Ameren-IL should determine higher operating temperatures for other conductor types for the same reasons. Ameren-IL should complete this review within six months of the date of this report.

In its comments on the draft report, Ameren-IL indicated that connector material specifications call for 115°C or 120°C and that specifying 140°C might cause suppliers to fail test requirements. Liberty believes that acceptable industry practice is to have the conductor, not connectors, be the limiting component in line design. All legacy companies incorporated this principal into their sub-transmission designs.

V-10 Analyze conductor galloping on existing sub-transmission and transmission lines.

For transmission lines, Ameren-IL should perform a data search for trips and try to determine if they are related to galloping. If galloping is determined to be a problem, Ameren-IL should develop a remediation program. Ameren-IL should complete this analysis within one year of the date of this report.

For sub-transmission lines, Ameren-IL should analyze the various existing sub-transmission configurations and determine which designs are subject to outages due to conductor galloping. Conductor galloping is dependent on the level of wind and its direction when compared to the longitudinal direction of the sub-transmission or transmission line. Ameren should study wind direction and velocity in its service territory in relation to its sub-transmission lines to determine what lines are prone to conductor galloping conditions. Ameren-IL should complete this analysis within one year of the date of this report.

V-11 Determine conductor galloping corrective measures.

Ameren should determine the most cost effective manner to prevent conductor galloping on the sub-transmission and transmission line configurations that are in areas prone to conductor galloping. Ameren should begin this determination immediately and complete its analysis within one year of the date of this report. Ameren-IL should complete all corrective measures resulting from these studies within four years of the date of this report.

V-12 Review pole loading requirements and required pole set depths.

Ameren-IL should analyze recent changes to the NESC loading requirements and determine if the new loading requirements require changes to pole set depth guidelines for its sub-

transmission and transmission lines. Ameren-IL should give special attention to sub-transmission equipment poles. Ameren-IL should complete this review and make any required changes to new construction practices within six months of the date of this report.

V-13 Check all sub-transmission and transmission lines for NESC clearance with new software.

If any sub-transmission or transmission line segment was not designed with the new iterative ruling span software and three feet of constriction variation clearance, Ameren should analyze that line segment to determine its maximum operating temperature (and power rating) while maintaining 2007 NESC clearances and three feet extra clearance for construction deviations. If Ameren-IL bases its calculations on actual field conditions, it may omit the construction deviation allowance. Liberty understands that the NESC requirement has not materially changed in the last 25 years in this regard. Ameren-IL should complete this analysis within one year of the date of this report. Ameren-IL should complete any resulting corrective measures within two years of the date of this report.

In its comments on the draft report, Ameren-IL said that is disagrees with this recommendation because NESC requirements are not retroactive. However, Liberty's experience is that the older templates were inaccurate and that good utility practice requires correction of known clearance violations of the standards that existed at the time of construction.

V-14 Identify and check clearances of all distribution and foreign under-builds of all sub-transmission and transmission line segments.

Ameren-IL should identify and profile all distribution and foreign under-builds of its sub-transmission and transmission line segments. Ameren-IL should ensure that it maintains NESC clearances while the sub-transmission or transmission line is at its maximum operating temperature, or in the alternative, restrict the sub-transmission or transmission line segment to a different maximum operating temperature that does maintain NESC clearances. The work performed in the above recommendation and the design records of newer properly design lines can be used. Ameren-IL should complete this review within one year of the date of this report and implement corrective measures within two years.

In comments on the draft report, Ameren-IL provided information different than that Liberty received during interviews, and argued that this recommendation was not necessary. Liberty will consider eliminating or changing this recommendation if Ameren-IL can demonstrate to Liberty in Phase 2 of this investigation that these clearance checks are unnecessary.

V-15 Revise the transmission transformer purchasing specification.

The specification should specify that the transformer and all ancillary equipment loading capabilities will be in accordance with IEEE Standard C57.91, IEEE Guide for Loading Mineral-Oil-Immersed Transformers. Ameren-IL should make any necessary revisions as soon as possible and before purchasing any transmission transformers.

V-16 Determine the overload capabilities of existing transmission transformers.

Ameren should obtain information from manufacturers regarding the ability to load these transformers in accordance with IEEE Standard C57.91. Ameren-IL should complete this effort within one year of the date of this report.

In its comments on the draft report, Ameren-IL states that these data should only be obtained if the transformer is identified as a constraint. Liberty disagrees because these data are required to develop the ratings recommended in this report.

V-17 Develop less conservative transmission transformer ratings.

After Ameren obtains information on transformer capabilities, it should develop new power ratings for these transformers. It should use these ratings in system operations to maximize the economic flow of power and in planning studies to prevent unneeded construction. Ameren should complete the implementation of this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL states that this recommendation involves increased risk. Liberty disagrees because the IEEE Standard C57.91 is considered conservative when compared to transformer designed overload capabilities.

V-18 Develop an on-going process for periodically reviewing and upgrading, where necessary, substation grounding adequacy.

Ameren-IL's Substation Engineering group should perform a review of the grounding adequacy of each substation on a 10-year cycle. In addition, it should review grounding at each substation for each of the following events:

- Expansion to the substation where fault duties change
- Expansion to a nearby substation substantially increases the ground fault current
- Addition of local generation that substantially changes the ground fault current
- Environmental activities that may have an effect on substation grounding.

Substation grounding should be either enhanced or upgraded to correct for any deficiencies in the substation grounding within one year after determination of a deficiency.

In addition, Ameren-IL's routine substation inspections should include and record:

- Gate grounding
- Fence grounding
- Equipment grounding
- Substation gravel
- Vegetation that may affect grounding

The Substation Maintenance Engineering group should review the results of substation inspections monthly and ensure that deficiencies are corrected within three months of discovery.

Substation Maintenance Engineering should forward any major grounding deficiency problems noted in the inspections to the proper substation engineer for analysis and action.

In its comments on the draft report, Ameren-IL proposed the actions listed above to address the substation grounding adequacy issue.

V-19 Revise substation grounding adequacy review process.

Ameren-IL should develop a procedure that allows for substation grounding design data retention for future use. Ameren should revise its substation grounding review process such that whenever it adds new equipment to the system, it can verify grounding for adequacy at both the equipment addition location and locations remote to the equipment location. Ameren-IL should verify grounding grid continuity and integrity at a specified interval. Ameren-IL should complete these process revisions within six months of the date of this report.

V-20 Implement the uniform distribution construction standards as planned for early 2008.

Ameren-IL introduced new distribution design standards in early 2008; they will apply to all new distribution construction. The implementation of this recommendation should be complete as of the date of this report.

V-21 Develop a common and up-to-date engineering manual for the entire Ameren-IL territory.

Ameren should immediately begin the process of updating engineering design tools for field personnel. This update would include common technology, current software packages, and a common engineering manual. Ameren-IL should issue the updated common engineering manual within two years of the date of this report.

V-22 Develop uniform distribution design processes.

The establishment of distribution divisions based on geography and not on company boundaries leads to the need to standardize distribution design practices and processes. In addition, the uniformity should capture the best practices of all three companies. Ameren-IL should verify the identified advantages of expanding the Distribution Design Center concept to all operating companies. Ameren-IL should investigate upgrading the tools used by the Distribution Design Center(s) to newer, more user-friendly programs.

Ameren-IL should complete its verification within six months of the date of this report and complete its standardization of distribution design processes within two years of the date of this report.

V-23 Develop short-time emergency ratings for the sub-transmission and transmission components.

The use of short-time emergency ratings in system planning studies in conjunction with SCADA can defer significant and costly construction. Ameren should determine what the maximum

operating temperature of conductors should be under short-time emergency conditions, develop short-time emergency ratings for the components of the transmission and sub-transmission systems, and use them in planning studies. Dispatchers should also use those ratings. In addition, Ameren should incorporate that new maximum operating temperature into new line and substation construction as appropriate. Ameren should begin the process within three months of the date of this report and complete full implementation within two years.

In its comments to the draft report, Ameren-IL states that the thermal time constant of most equipment is reached in 30 minutes and that there is little difference between the 8-hour and 30-minute ratings. Liberty disagrees in that Ameren-Il rates its equipment at continuous summer capability and equipment can carry more current than that for a shorter period of time. Ameren-IL designs its system to not to operate above nameplate ratings and will only do so for short term operational needs.

V-24 Make design basis assumptions the same in power ratings of the transmission, sub-transmission, and distribution systems.

Design basis assumptions should be the same for developing power ratings for the transmission, sub-transmission, and distributions systems. Ameren-IL should make all design basis assumptions for all system components consistent. Ameren-IL should implement this recommendation within six months of the date of this report.

In its comments on the draft report, Ameren-IL states that transformer-rating assumptions should not be the same for transmission and lower voltage systems due to the different modes of operation. Liberty disagrees. One may not use a short time emergency rating for a distribution transformer in a radial application, or the acceptable loss of life may be different because of replacement considerations, but the rating should be calculated in the same manner.

F. Protection

1. System Protection

a. Introduction

System protection is a general term for the detection and isolation of unwanted electrical conditions such as electrical overloads or short circuits. System protection uses high voltage devices such as circuit breakers and fuses to isolate the disturbance, and low voltage devices such as relays and sensing circuits, to detect fault conditions, quantify severity, and initiate the isolation signals.

System protection personnel design the overall scheme, select and integrate the proper devices, and specify the settings for these protective devices based on system simulations.[153] System protection designs must ensure the automatic and rapid removal of faults from the system, limit the extent of these protective operations to the minimum equipment necessary, and minimize the

[153] These simulations are short circuit studies for fault magnitudes and timing coordination studies.

operational disruption to the continuous operation of the electrical grid to prevent cascading outages and prevent significant damage to equipment.

To accomplish these objectives, the protection system generally clears faults "high speed" time,[154] *e.g.*, on the order of a three to five cycles (0.05 to 0.08 seconds) at the highest transmission voltage levels, and at lower speeds of around ten cycles (0.17 seconds) to a few seconds at distribution voltages. At these operational speeds, coordination is essential to accomplish the balance of system protection objectives.

Ultimately, the continuous steady state operation of the North American interconnected network depends upon the coordination and interoperability of system protection designs throughout the continent. Therefore, system protection personnel serve a vital role to ensure the security and dependability of interconnected electric systems. Standards of the North American Electric Reliability Corporation (NERC) and the Institute for the Electrical and Electronic Engineers (IEEE) provide applicable guidance to system-protection design engineers.

b. Protection Standards

1. General Description

Standards provide overall design guidance and general specifications for fault isolation scenarios. Two central considerations in system protection are the detection of disturbances and the timing coordination among the protective devices that must operate. Detection considerations ensure that system protection has the ability to sense low magnitude or distant fault conditions. This ability is "margin," which is simply a multiplying factor of minimum detection requirements. Coordination refers to the time domain differences of adjacent system protection schemes. Coordination considerations ensure that adjacent or backup protection schemes are time-sequenced properly to isolate equipment in a proper, controlled, and logical order. Protection engineers must expect design variations for individual facilities to accommodate unique configuration parameters such as equipment impedances, equipment ratings, connectivity, and soil resistivity. Design standards provide the general design principles for desired detection and coordination of system protection operations.

2. Ameren Transmission Standards

Ameren employs high-speed protection for transmission equipment. Because of the length of transmission lines and due to the meshed[155] network configurations, it frequently uses pilot schemes[156] to ensure high-speed coordination. Transmission protection designs also may include redundancy features to ensure operation for single protection component failures.

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[154] High speed also means that a fault anywhere in the zone of protection is detected by the equipment at that location.
[155] "Meshed" refers to the networked topology of interconnected lines, such that multiple electrical sources exist on both ends of the circuit.
[156] Facilities that communicate status and detection information from one end of the transmission line to the other end.

Ameren-IL generally accomplishes distribution system protection through electromechanical over-current detection relays.[157] Because of the primarily radial configuration of distribution circuits,[158] Ameren-IL provides system protection to the entire circuit from autonomous protection at the substation circuit source. Subordinate circuit protection facilities such as tap fusing or reclosers coordinate with the circuit's main protection at the substation to minimize local faults and to maximize service continuity for the majority of the customers served. Distribution protection also includes redundancy, but not to the extent found in transmission designs.

Three main documents contain Ameren's system protection standards: Substation Design Standard No. 15G, Design Guide for Transmission and Bulk[159] Substation Relay and Control, Substation Design Standard No. 14G, Design Guide for Distribution Substation and Feeder Protection, and EDD PS-50 Distribution Feeder Protection.[160] Standard 15G applies to protection of facilities with voltages at and above 34,500 volts. Standard 14G applies to protection of facilities with voltages of 4,000 volts through 12,470 volts. EDD PS-50 applies to distribution facilities, primarily circuits, outside of the substation and including fuses, reclosers, and other feeder protective equipment. In summary, these standards define the design principles and general design guidance for the protection of facilities from Ameren's highest transmission voltage, 345,000 volts, to the end customers served from 4,000-volt distribution circuits.

Liberty found that Ameren has adequate and complete system protection standards. Ameren should consider clarifications for readability in Standard 14G, such that the applicability of designs is clearly associated with indoor switchgear designs or outdoor bus designs (essentially urban or rural design). While the content is accurate, the presentation is confusing due to the depiction of both construction classes on common figures.

Liberty reviewed Ameren's current system protection standards.[161] They document the variability of diverse urban and rural service territories across Illinois. The applicable Ameren standards in 2006 were similar in content to present standards.[162] Legacy companies maintained individual, but similar, system protection standards prior to Ameren's acquisition of each. Ameren instituted common protection standards as they acquired legacy companies beginning in 2004.[163]

Ameren's current standards require digital microprocessor relays for new construction relaying; however, electromechanical relays comprise the majority of the installed system-protection relay equipment. Digital relays afford the integration of protection across discrete protection zones and afford other advanced abilities beyond their electromechanical predecessors. Personnel can query digital relays for retained information after an operation through communication ports, allowing insight to fault scenario sensing quantities, timing characteristics, and overall functionality.

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[157] The magnitude of the fault current electromechanically determines the time of operation of the relay.
[158] "Radial" refers to the topology in which the circuit has only a single source at its origin, and is not tied to another circuit.
[159] "Bulk" at Ameren refers to 69,000-volt and 34,500-volt systems and is referred to as sub-transmission.
[160] Responses to Data Requests #719 and #720.
[161] Responses to Data Requests #712 through #720.
[162] Interviews #163 through #168, May 1, 2008.
[163] Interviews #163 through #168, May 1, 2008.

All Ameren system protection schemes regardless of type employ redundancy in the overall design. The intent of redundancy is to provide two main functional considerations: security and dependability.[164] Liberty found the levels of redundancy consistent with NERC transmission planning standards and consistent with industry practices.[165] The levels of redundancy generally increased with increasing facility voltage levels. Examples of such redundancy included independent relays, sensing elements, control elements, and tripping devices.[166]

Liberty found Ameren standards addressed minimum and total clearing times, to ensure that the system clears faults prior to incurring long-term damage to major equipment from sustained through-fault current. Liberty also found that Ameren standards addressed sufficient coordination between remote and electrically adjacent protection schemes.[167]

Ameren protection standards were consistent with NERC and IEEE guidelines for high-speed protection of transmission and bulk facilities. Transmission protection standards provided for complete coverage of networked transmission and bulk lines from either end terminal at "high speed." The usage of pilot relaying schemes was consistent with industry standards where applicable.[168]

System protection standards accounted for primary fault clearing contingencies, *i.e.*, the unexpected failure of a single element such as a breaker failure, using time-delayed breaker failure schemes. Additional contingency considerations were built-in to protection schemes to protect against switching into a fault after planned outages and initial energizing of transformers. Ameren protection standards contained appropriate measures for unique permanent configuration characteristics such as three-terminal lines and parallel line mutual inductance.[169]

Ameren transmission standards addressed automatic reclosing of facilities to minimize service interruptions and system fragmentation.[170] System protection personnel determine reclosing settings and include features for remote source isolation logic, minimum clearing time to preclude fault re-flash (for transient faults), and for safe and sequential reconnection of isolated facilities to the grid. They determine reclosing philosophy and timing by voltage class and configuration of facilities.[171]

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[164] Security means immunity to failure of a single element. Dependability means assurance that protection systems will operate to isolate faults.
[165] NERC Transmission System Protection standards, found within NERC planning standards.
[166] Interviews #163 through #168; May 1, 2008.
[167] Responses to Data Requests #719 and #720.
[168] Responses to Data Requests #719 and #720.
[169] Responses to Data Requests #719 and #720.
[170] Automatic reclosing is the reconnection (after a suitable time delay) of electrical facilities after faults have been safely isolated from the system.
[171] Response to Data Request #715.

3. Ameren Distribution Standards

The predominate configuration of distribution circuits is a single power source at the origin of the circuit, at the substation, protected by a circuit recloser[172] or circuit breaker. Ameren protection standards address the detection challenges of long rural circuits. Ameren standards include coordination considerations with substation elements, as well as downstream circuit sections, circuit taps, and distribution load-transformer protection devices.[173]

Legacy company practices were similar with respect to urban and rural distribution substation-protection designs. Ameren-CIPS used about 7 percent indoor switchgear construction designs, Ameren-CILCO used about 15 percent indoor switchgear construction designs, while Ameren-IP used about 4 percent indoor switchgear construction designs. This reflects the urban and rural service areas. All legacy companies have a mixture of enclosed switchgear and outdoor exposed bus substations with appropriate protection schemes.[174]

The legacy company distribution-switchgear designs used single battery designs with single-phase electromechanical relays. New switchgear designs use microprocessor relays. Rural installations use self-powered electronic reclosers, breakers with self-powered relays, or hydraulic oil reclosers in legacy rural outdoor designs and in new rural installations without an enclosed control building.[175]

Distribution circuit-protection standard EDD-PS50 provides guidance for the coordination of circuit protection with substation facilities and coordination of circuit subordinate facilities such as circuit taps and capacitors.[176] The standard provides guidance for the coordination of the types of protective equipment used in breaker-to-fuse, recloser-to-fuse, and fuse-to-fuse scenarios.[177] The standard also addresses ensuring complete circuit detection and adequacy of margins between devices.

The Ameren standards address automatic reclosing of distribution circuits to minimize customer service interruptions. Reclosing settings are determined by system protection and include features for minimum clearing time to preclude fault re-flash (for transient faults), and for safe and sequential reconnection of isolated facilities to the grid. Ameren protection standards also address overload conditions via transformer overload sensing and planned load reduction and system under-frequency load shedding.[178]

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[172] A recloser is a fault interrupting device (like a circuit breaker) with self-contained system protection functionality.
[173] Interviews #163 through #168, May 1, 2008.
[174] Comments on draft Liberty report, July 31, 2008.
[175] Interviews #163 through #168, May 1, 2008.
[176] Response to Data Request #720.
[177] Response to Data Request #720.
[178] Responses to Data Requests #719 and #720.

c. Processes

1. General Description

System Protection personnel are responsible for protection of all equipment from the 345,000-volt system down to the distribution circuit origin at the distribution substations. Feeder protection is the responsibility of the division organizations. The divisions are responsible for designing and maintaining protection in accordance with EDD PS-50, which in turn provides protection guidelines in coordination with system protection Standard 14G.[179]

Several key processes accomplish system protection. Expansion and modification of the Ameren-IL system relies on capital expenditures through specific projects. Maintenance and protection of existing assets rely on cyclic processes and reviews funded by operating and maintenance expenditures. The system protection organization is engaged in these ongoing processes and routinely interacts with other Ameren organizations to preserve system protection through system growth and over the lifetime of assets. Liberty found that Ameren-IL has adequate processes for the construction and modification of facilities to ensure safe and reliable system protection operations.

2. System Expansion

Most system expansion or system reinforcement projects are completely within Ameren-IL's system borders and originate from Ameren's planning organization as a project notification diagram (PN). Some PNs represent preliminary options for expansion that require general technical requirements and cost estimates from system protection to evaluate the best alternative.

Ameren requires new customers and/or facilities to the Ameren system to meet system protection standard facility requirements. Ameren requires generation facilities to meet additional requirements for generator protection during transient fault conditions and for steady state synchronization to the grid. Protection requirements escalate with generator size and interconnection voltage class to accommodate escalating levels of system protection complexity. Interconnections to neighboring utilities may require a composite system protection approach to interconnecting lines to bridge differences in standards between Ameren and the interconnected system. System protection coordinates all interconnections to its system, which may include an exchange of modeling data and relay settings with interconnecting parties.[180]

Upon receipt from Ameren's system planning department, system protection personnel provide an initial review of the project and add an initial cost estimate for system protection requirements of the project. When planning selects a final alternative based on the balance of requirements from other organizations, the project returns to system protection for a detailed preparation of costs, required equipment, and preparation of project schematics as part of system protection's design activity of the assigned system-protection project engineer. The project engineer is responsible to interface with the rest of the project team as the facility is constructed and put into service.

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[179] Interviews #163 through #168, May 1, 2008.
[180] Response to Data Request #718.

Ameren protection engineers use ASPEN® software to perform short circuit analyses for coordination studies.[181] System Protection maintains an electrical system model within ASPEN® to conduct accurate system studies and simulations. The model has two representations to provide the appropriate level of detail for each of the two system protection sub-groups (by voltage level) that are located in separate offices in St. Louis and Decatur. Ameren aligns the representations annually to maintain consistency between the groups. While the models are electrically the same, there is some tailoring of each visual representation to meet the needs of each group as required by their respective area of responsibility.

As Ameren-IL adds new protection facilities to its system, the protection project engineer is responsible to issue relay settings for each protective relay to the relay testing organization. The System Relay Department enters the relay information into the PowerBase® system database for protective devices. The completed settings and any minor corrections go to the protection project engineer at the completion of project for record keeping and accounting purposes.[182]

System planning and system protection coordinate annually to assess capacity load-growth studies and load flow analyses as the system expands or experiences modifications due to customer connection and load curve changes. System protection provides an annual review of relay load limits to coincide with system planning's annual planning cycle. This interface assures that the relay settings and relay rating characteristics are not limiting or encroached on by load growth on Ameren facilities at projected peak loads. Ameren maintains a relay load-limit database for that purpose.[183] Engineers review instances where a relay limits the load carrying capability of primary equipment for potential settings changes or relay replacement if necessary. They also review load encroachment scenarios where a relay's protective fault setting is susceptible to an unwanted operation under load conditions.

Distribution-circuit protection guidelines are contained within design standard EDD-PS50. Distribution-system modeling tools are contained within the Distribution Electrical Workstation (DEW), an EPRI distribution fault-study modeling tool.[184]

System protection uses the input of field personnel and event based data to identify protection upgrades for obsolete and poorly performing relays. In these cases, system protection upgrades occur with other system expansions or as standalone capital projects. System protection has upgraded about 20 relay terminals annually.[185]

3. System Preservation

System protection reviews the performance of system component operations, including all automatic operations due to either fault responses or false trips. The operations dispatch personnel transmit summary information about system events to Ameren internal stakeholders

[181] Interviews #163 through #168, May 1, 2008.
[182] Interviews #163 through #168, May 1, 2008.
[183] Response to Data Request #718.
[184] Interviews #163 through #168, May 1, 2008.
[185] Interviews #163 through #168, May 1, 2008.

for review. They use this information, along with data recorded by oscillographs[186] relay operations data or remotely accessible data in appropriately equipped stations, to determine whether system protection facilities have operated properly. System protection personnel store transmission-event tracking and assessment information in an Access database designed for outage submittal to NERC and SERC (The regional reliability organization). They investigate incorrect operations for corrective action and for the identification of actions to preclude recurrence. These actions may include protection-setting revisions and extend to similar protection applications across the system. Liberty found the review of transmission system operations adequate.

The System Relay Department maintains a master inventory of settings and is converting from a paper system to an electronic database (PowerBase®) format. They expect completion of this conversion by 2010.

Ameren performed comprehensive system coordination studies at the higher voltage levels as it acquired the legacy companies. Comprehensive transmission and sub-transmission systems coordination studies are time consuming and resource intensive, and so Ameren studies additional system sub-sections as conditions necessitate.[187] While Ameren has completed transmission and sub-transmission coordination studies with the acquisition of each legacy company and continues to perform area studies with growth, no established review period for comprehensive system transmission and sub-transmission coordination studies exists. Currently, System Protection has a ten-year goal of comprehensive transmission and sub-transmission systems coordination studies, but lacks a formal requirement.[188]

Ground resistance assumptions of the legacy companies used in the setting of relays were different prior to the mergers. Initial review of Ameren-IP at the time of its merger indicated that protection coordination problems existed between the legacy companies.[189] Ameren-IP has not conducted comprehensive ground coordination studies. However, it performs area studies with system growth.[190] Latent ground coordination issues may exist due to dissimilar legacy company ground-resistivity assumptions that result in an approximate eight percent difference in zero sequence impedances.[191]

4. Peer Review

Effective peer and supervisory level review in system protection processes is an important aspect of efficient and consistent protection-system equipment operation. These reviews enable Ameren to adhere to industry best practices, regulatory requirements, and to provide safe, reliable, and cost-effective energy delivery systems for their customers.

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[186] An oscillograph is a high speed event recording device for the pictorial examination of protection quantities through time.
[187] Interviews #163 through #168, May 1, 2008.
[188] Interviews #163 through #168, May 1, 2008.
[189] Interviews #163 through #168, May 1, 2008.
[190] Interviews #163 through #168, May 1, 2008.
[191] Response to Data Request #790.

Liberty found that Ameren capital expenditure processes contained sufficient levels of peer and supervisory review. For system expansion projects, Liberty found sufficient levels of peer and supervisory level review in the initial system protection PN review and in the final design requirements of approved projects. System protection engineers are to adhere to Ameren standards and guidelines and to point out exceptions to the system protection-supervising engineer. The supervising engineer is responsible for the approval of the overall scheme and its consistency to standards.[192]

In large capital projects, sufficient budgetary review was present by peer and supervisory review as directed by the enterprise budgeting process. In small capital projects, such as relay replacement projects that do not require significant construction resources, the system-protection engineer functions as the project engineer and assumes the responsibilities for overall project budget accountability.[193]

In system preservation processes, such as the review of protection discrepancies discovered during planned maintenance or during system operations, Liberty found sufficient levels of peer and supervisory review of system operations assessments through the wide distribution of event logs, operations investigative reports, and corrective action reports.

In the review and distribution of system protection standards, Liberty found sufficient levels of peer review, through Ameren's participation within NERC, its regional counterpart, the Southeast Electric Reliability Corporation (SERC), IEEE, and other industry technical committees. Sufficient peer review of Ameren standards was evident in the standard's approval process, as Ameren's interdepartmental review includes system planning, design organizations, operations, relay testing, and construction.[194]

d. Design Controls

1. General Description

Design control is an important aspect of efficient design/build processes. Design control ensures that installed facilities meet the general design requirements within Ameren protection standards and the specific requirements specified by the protection design engineer. This is "design functionality." Design control precludes the omission of designed functionality due to the expediency of the construction schedule or site contingencies. Liberty found that Ameren's system protection processes had adequate design controls to assure that construction and maintenance processes did not bypass or alter intended system protection functionality.

2. Ameren Design Control Practices

In capital projects, adequate design controls preserve system protection's functionality. Construction and testing personnel cannot change protection functionality without the system-protection project engineer's approval unless specified by system protection setting orders.

[192] Response to Data Request #718.
[193] Interviews #163 through #168, May 1, 2008.
[194] Interviews #163 through #168, May 1, 2008.

Within Ameren design disciplines, design controls preclude the engineering project engineer from changing system protection functionality without the system-protection project engineer's approval.

In maintenance processes (both preventive and repair), protection's functionality was preserved by adequate design controls. Relay field personnel and operations personnel cannot bypass system protection functionality without approval of system protection.

e. Equipment and Material Review and Testing Controls

1. General Description

Equipment and material review provides a first-line of design control to assure that system protection components meet applicable design standards and have not suffered damage in transit or temporary storage. Component testing and commissioning testing provides design control of functional integrity during the construction process. Periodic testing provides for continued functional integrity testing to combat reliability defects and aging conditions such as latent defects, equipment infant mortality, electrical drift, and mechanical wear.

2. Ameren Material Review & Testing Controls

All sensing, relay, and control components in Ameren's protection systems undergo commissioning or acceptance tests. Relay testing personnel (or contract testing services) perform functional testing. They test new relays and components to the Ameren system prior to incorporation into the system. New installations undergo startup tests and in-service protection tests as an overall check of functionality. System protection reviews the initial in-service startup sequence prior to execution by on-site relaying personnel.[195]

Engineers monitor the continued performance of relays through review of system protection operations during actual system events. They remove from the system-protection construction standards relays that exhibit poor reliability, excessive component failure, or supply chain difficulty with replacement part procurement.[196]

Ameren had tried to diversify their dependence upon a single microprocessor relay vendor, but has standardized to relays from a single manufacturer due to poor quality with other microprocessor relay vendors.[197] Engineers identify and replace obsolete and poorly performing relays through annual programs based on system performance tracking.

[195] Interviews #163 through #168, May 1, 2008.
[196] Interviews #163 through #168, May 1, 2008.
[197] Interviews #163 through #168, May 1, 2008.

f. Feedback from Construction and Operations

1. General Description

Engineering disciplines like system protection require functioning feedback loops from construction and operations personnel in order to adjust designs and standards for actual field conditions, constructability, and maintainability. Good utility practices encourage the exchange of this information through well-designed processes, which result in safe and reliable energy delivery systems.

2. Ameren's Construction and Operational Feedback Practices

For capital projects, Liberty found adequate feedback to system protection from construction and operating organizations. Construction and relay personnel provide feedback to system protection about the adequacy of design, materials, in-service checks, and overall constructability.

In maintenance and operations, Liberty also found adequate feedback to system protection from construction and operating organizations. Operations and relay personnel provide feedback to system protection about the maintainability of protection equipment, the reliability of protection designs, and overall operability of protection schemes and practices. System protection reviews all transmission system events and sub-transmission events suspected of misoperation for proper system protection functionality. They retain transmission equipment operations in an Access database designed for outage submittals to NERC and SERC.[198] System protection retains its own database for the assessment of transmission protection operations.

The placement of initial protective settings on new equipment and revision of protective settings on existing equipment initiated by system protection studies, provide additional opportunities for feedback from field personnel to system protection.

Several legacy-company systems retain records of sub-transmission equipment operations in various systems such as Major Outage Report (MOR) for Ameren-CIPS, Resume for Ameren-CILCO, and Service Interruption Report (SIR) for Ameren-IP. Ameren-IL has not completed, and has on hold, consolidation to a common system; however, Ameren-IL recognizes this as a deficiency that it needs to correct.[199] The companies record but do not review and analyze sub-transmission protection operations. Because of the significant number of customers served by the sub-transmission system, Liberty found this review of sub-transmission operations inadequate. Ameren-IL should implement a process similar to that currently in place for transmission system operations.

[198] Response to Data Request #718.
[199] Interview #163, May 1, 2008.

g. Workforce Adequacy

1. General Description

The provision of an adequate workforce is necessary to ensure timely and efficient system design, undue delays toward system reinforcement and improvement projects, and resolution of maintenance issues. The retention and development of adequate experience and the size of the workforce to handle the workload are necessary considerations.

2. Ameren's System Protection Workforce Adequacy

The size of the workforce has been constant over the merger/acquisition of legacy companies as each respective legacy company group merged into the central organization. The centralization of the organization is appropriate for this specialized work expertise. Presently there are five personnel in the St. Louis protection group and ten personnel in the Decatur protection group that have responsibility for the protection of Illinois facilities.[200] Liberty found that the system protection workforce has been adequate throughout the legacy company acquisitions and through present staffing. The senior personnel demonstrated technical expertise and managerial competence.

a. Organization

The organization of a workforce is critical to the accomplishment of its mission. The division of responsibilities with adequate supervision is important to the proficiency of the group. The location of work centers and centralization of key disciplines leverages the efficiency of key organizational interactions. In general, Liberty found Ameren-IL's system protection organization had well defined responsibilities, an experienced staff, an adequate workforce, adequate training and development practices, and appears adequately prepared for the future needs of the Ameren organization.

Energy Delivery Technical Services (EDTS) – System protection has responsibility for Ameren's system protection responsibility and is split by voltage levels, into two main groups that share a common manager.[201] A supervising engineer supervises each group. The St. Louis protection group has five engineers in a sub-group responsible for Illinois transmission protection requirements. The Decatur protection group has ten engineers, with two located in Peoria responsible for Illinois sub-transmission protection requirements.

System protection in St. Louis provides transmission operations support for both the Ameren-IL and Ameren-MO transmission systems.[202] System protection in Decatur provides support for the Ameren-IL sub-transmission system. Due to the nature of the differences between higher and lower voltage systems, the responsibility by voltage class creates expertise in bulk energy transfer and load-serving functionality, respectively.

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[200] Response to Data Request #732.
[201] Response to Data Request #732.
[202] Response to Data Request #723.

Transmission capital projects go to the same protection group office as the overall project engineering office in order to keep the various design disciplines within a single office/location.[203] Sub-transmission capital projects are the responsibility of the Decatur system protection group. The responsibilities for the legacy companies have not changed since 2006 except for the transmission support, which the St. Louis protection group now performs centrally.

EDTS has responsibility for distribution substation protection and coordination including setting relays on distribution feeder breakers or the selection of distribution feeder reclosers.[204] Distribution operations support and project support is provided by the Decatur system protection group. Division engineers provide 12,000-volt and 4,000-volt line protection at various locations throughout Illinois. This includes approximately 32 engineers located in six divisions. The Decatur protection group assists the divisions as necessary.[205]

System protection personnel and division personnel mutually agree on settings for new feeder installations. The Division is responsible for the overall protection of the feeder and its downstream facilities. If changes occur, it is the division's responsibility to notify system protection.[206] Division engineering can consult with EDTS on protection/coordination issues throughout the feeder. As general guidance, the division consults EDTS for installation of protective devices larger than 100 amps, for 12,000-volt feeders longer than five miles long without a protective device, and 4,000-volt feeders longer than 2 miles without a protective device.[207] They also consult EDTS for customer installations with other complex protection requirements.

Liberty found that this interface, *i.e.*, the coordination of division personnel and system protection, was inconsistent with respect to the protection of distribution substation transformers in accordance with system protection standards and industry standards designed to protect distribution substation transformers from adjacent faults.[208] Liberty found that the new processes require a coordination check when there are changes to line-device settings, however past legacy practices for the interface of division design personnel and system protection personnel allowed a lack of design control related to the coordination of protection between the distribution circuit protection and substation transformer protection. The inconsistency also suggests a lack of division design personnel training with regard to transformer protection standards.

b. Training

Workforce training is necessary to develop and retain skilled employees and managers. In technical disciplines such as system protection, the recruitment and mentoring of personnel is vital to the success of the organization.

[203] Response to Data Request #731.
[204] Response to Data Request #720.
[205] Response to Data Request #732.
[206] Response to Data Request #720.
[207] Response to Data Request #720.
[208] Response to Data Request #788.

New system protection personnel are largely degreed electrical engineers with a power curriculum.[209] Ameren-IL practices adequate training/mentoring oversight to develop system protection expertise and match responsibility with experience levels by assignment. Experience in other engineering and support groups helps develop well rounded personnel. Consulting engineer titles designate senior technical personnel development.

c. Adequacy for the Future

The ability to meet ongoing and future needs, both in quality and quantity of personnel needed for the workload, is a measure of the health of any organization. The retention of qualified personnel and the ability to develop the skills needed for future challenges are prerequisites for future adequacy and competency.

Liberty found that the protection groups appear prepared for the future protection needs of Ameren. The St. Louis and Decatur groups have both experienced personnel and some junior personnel developing skills for succession.[210] The group hired an additional full time engineer since 2006.[211] The quality and quantity of system protection personnel from outside and within the company appear well positioned for the future. Personnel work experience within the company exhibits leveraging of cross training.

h. New Programs

New system protection programs since the storms of 2006 offer an opportunity to improve the safety and reliability of Ameren's energy delivery systems or to improve the efficiency of Ameren processes.

Ameren-IL began installing manual-sectionalizing schemes using SCADA with installed fault indicators and automatic-sectionalizing schemes of the sub-transmission circuits in Ameren-CIPS in 2004.[212] Ameren-IL expanded this program in the other companies to also include auto-transfer schemes where two sources to a distribution substation existed as well as auto-sectionalizer schemes and manually controlled SCADA switches. About 100 sub-transmission circuits have automated and manual SCADA schemes installed.[213] While this practice is not completely new since the 2006 storms, it is ongoing and its potential expansion into distribution voltage levels appears to have significant reliability improvement potential. Auto-sectionalizing or auto-transferring of distribution circuits has not been undertaken to date, but Ameren-IL's plan is to consider distribution circuit automation after the sub-transmission circuit program estimated 2009 completion.

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[209] Interviews #163 through #168, May 1, 2008.
[210] Response to Data Request #731.
[211] Interviews #163 through #168, May 1, 2008.
[212] Auto-sectionalizing is the installation of automatic switches on circuits to permit the connection of un-faulted sections of circuits to alternate sources post fault, thereby minimizing the disruption duration to affected customers.
[213] Interviews #163 through #168, May 1, 2008.

2. Lightning and Surge Protection

a. General

Lightning can cause faults in electrical power circuits by making a connection between two or three differing phase conductors or, more commonly, between one phase conductor connecting to ground. This arc (or fault) will continue until a circuit breaker protecting the line opens. A "flashover" is a fault caused by a lightning strike.

Design aspects of the electric delivery system can limit the outages caused by lightning. Lightning rods or masts intercept lightning and terminate the electric charge into the earth where the charge is dissipated. Shield wires installed above power lines serve this same purpose. Lightning arrestors, (or surge arrestors), are devices connected between an electrical conductor in a power system and the earth. They provide a direct path to the ground in series with a non-conductor, over which lightning jumps. Its purpose is to limit the rise in voltage when lightning strikes a power line or switching takes place. Arrestors use various techniques including voltage-activated solid-state switches to allow the high voltage of a lightning strike to go safely to ground.

The utility needs to have proper placement of lightning arrestors and should replace failed and obsolete arrestors with modern, more reliable designs. In addition, line and substation grounding must be appropriate to provide for reliable lightning arrestor performance.

Weather was the most significant cause of outages on the Ameren-IL system.[214] Lightning caused some portion of these weather-related outages. It is therefore important that Ameren-IL have proper design standards in place to minimize lightning-related interruptions to customers and to protect expensive utility equipment from these and other voltage surges.

b. Transmission and Sub-Transmission System Lightning and Surge Protection

Ameren Services was responsible for all new transmission and sub-transmission line designs in Illinois and Missouri, including the application of lightning arrestors. As Ameren acquired each of the Illinois companies, the Transmission Line Design group in St. Louis took over this responsibility.[215]

Ameren provided lightning protection for transmission and sub-transmission lines only through the installation of grounded shield wires and does not use lightning arrestors for lightning protection at each structure.[216, 217] Ameren also provided lightning protection using arrestors installed at line terminals in substations, which Liberty discusses below.[218]

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[214] Response to Data Requests #269 and #610.
[215] Interview #147, March 26, 2008.
[216] Interviews #163, #164, #166, and #167, May 1, 2008.
[217] These overhead-grounded wires are also known as static wires.
[218] Ameren does allow protection of 69,000-volt and 34,500-volt lines with lightning arrestors in its new line design per Interview #179A, June 3, 2008.

Ameren's current transmission and sub-transmission shield-wire design standards were in place in July 2006 and it has made no changes to them since that time.[219] Ameren installs shield wires to provide a maximum 30-degree shield angle[220] to the phase conductors, limits the shield wire sag to no more than 75 percent of the phase conductor sag at mid-span, and maintains an average 10-ohm tower footing resistance[221] at each tower.[222] It ties the shield wires to the substation grounding grids at the end of the line through the substation line take-off structures.[223]

The grounding system for the shield wire requires a low resistance ground connection (tower footing resistance) to earth for good performance. The Ameren-IP legacy standard was to use a ground rod at each pole for the initial ground; Ameren-CIPS used a butt wrap plate[224] for the initial ground. The current Ameren-IL standard for the initial ground is to use a butt wrap plate. If the average measured resistance is above 10 ohms, it adds additional ground rods to reach the 10-ohm value at each structure.[225]

Ameren Services' goal is to design its transmission and sub-transmission lines for less than one flashover per 100 miles of line per year.[226] Ameren design criterion accepts 1 to 2 flashovers per 100 miles of line per year as an attempt to control costs if it cannot achieve the 10-ohm tower footing resistance.[227] Liberty found that Ameren's transmission and sub-transmission lightning design standards are adequate and in line with industry practices.

Ameren Services uses software obtained about 1990 from the Electric Power Research Institute (EPRI) to calculate expected flashover rates.[228] The program, MULTIFLASH, uses structure layout, phase conductor and shield wire physical locations at the structure and at mid-span, Isokeraunic level,[229] number of insulators in the insulator string, length of line, and the ground resistance as input parameters. The program couples lightning stroke densities and lightning stroke magnitude to determine the expected flashover rates. Liberty's review of sample calculations indicated that Ameren does not consider the surge impedance of the shield wire down lead in its calculations.[230]

The lightning data used by the program for number of storm days, lightning intensity, and lightning density are taken from the 1970's EPRI "Red Book on Transmission Design." EPRI

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[219] Interview #147, March 26, 2008.
[220] The shield angle is the angle measured from the vertical plane of shield-wire support base outward towards the phase conductor.
[221] Tower footing resistance is the resistance to ground at a transmission line tower and is the grounding system for the shield wire.
[222] Response to Data Request #239.
[223] Interview #147, March 26, 2008.
[224] A metal plate installed on the bottom of the pole buried in the ground with a ground lead to the surface prior to the pole being set.
[225] Interview #147, March 26, 2008.
[226] Liberty notes that this value is generally accepted industry wide as acceptable lightning performance.
[227] Interview #147, March 26, 2008 and response to Data Request #239.
[228] Flashovers can occur as a shielding failure where the shield wire does not protect the line resulting in a direct strike and a back flashover failure where the ground voltage rises above the insulation value of the structure and insulators and flashes over to the phase conductor.
[229] Number of expected thunderstorm days per year.
[230] Response to Data Request #763.

has just published a new version of their Red Book on transmission design in 2008. The number of thunderstorm days has increased from 53 to the mid 60s for the Illinois area. This factor alone would increase calculated trip out rates by 25 percent.[231] Liberty's experience with these types of programs is that older software may under predict flashover rates because it does not analyze the total typical lightning stroke and may not contain complete lightning density data.

The National Lightning Detection Network provided the FALLS lightning data. This network went through an upgrade from 2001 to 2003 to increase both flash detection and stroke detection. It achieved significant improvement in the data.[232]

To determine expected lightning performance of the existing 138,000-volt system, Ameren Services modeled a typical Ameren-IP 138,000-volt H-frame transmission tower of 65-foot height, 37-degree shield angle,[233] 550-foot spans, 8 insulator bells in the insulator string, an Isokeraunic level of 53, and varied the tower footing resistance from 10 ohms to 30[234] ohms and structure height to 80 feet. For the 65-foot structures, Ameren found that there were no shielding failures and that back flashover failures accounted for less than a 1.0 failure rate per 100 miles per year at 10 ohms tower footing resistance and a 1.2 failure rate per 100 miles per year at 20 ohms tower footing resistance. For 80-foot structures and a 10-ohm tower footing resistance, Ameren found that while the failure rate remained less than 1.0 per 100 miles per year, both shielding failures and back flashovers occurred. Ameren noted that it expected better results on the Ameren-CIPS and Ameren-CILCO systems because those systems used nine insulator bells in the insulator string. The current Ameren standard calls for the use of nine insulator bells.[235]

Due to the agricultural interest in minimizing the footprint of transmission towers, the Illinois Department of Agriculture requires that new transmission lines be single-pole structures.[236] Liberty requested that Ameren perform failure rate calculations for typical and taller single-pole, single-circuit and single-pole double-circuit 138,000-volt transmission lines as a comparison analysis to the one described above. The table below depicts the results of that analysis.

[231] Interview #179, May 29, 2008.
[232] Response to Data Request #766.
[233] Ameren's past practice for transmission and sub-transmission line shield-wire angle was 40 degrees or less per response to Data Request #35E.
[234] Ameren corrected this value to 20 ohms in its responses to Data Requests #768 and #769.
[235] Interview #147, March 28, 2008 and response to Data Request #768.
[236] Interview #147, March 26, 2008, and the response to Data Request #798.

Expected Trip Out Rates for Older Typical Height and Taller Single-Pole, Single-Circuit and Double-Circuit 138,000 volt Transmission Lines[237]

# Circuits	Pole Height (Feet)	Tower Footing Resistance (Ohms)	Failure Rate (Flashovers per 100 Miles per Year)
1	75	5	0.80
1	75	10	2.10
1	75	20	6.70
2	75	5	1.24
2	75	10	2.35
2	75	20	8.36
1	85	5	1.43
1	85	10	3.10
1	85	20	8.50
2	85	5	2.12
2	85	10	4.19
2	85	20	10.68

From these results, Liberty concluded that existing and new H-frame wood 138,000-volt transmission lines should perform in accordance with industry practices, provided that Ameren continues to obtain a 10-ohm tower footing resistance wherever possible. Liberty also concluded that Ameren's older design of single-pole, single- and double-circuit 138,000-volt transmission lines has inadequate lightning performance characteristics as designed. Lower tower-footing resistance, better shielding, tower redesign, or a combination of all three would be required to bring lightning performance in line with industry standards.

Liberty did not review other sub-transmission or transmission line configurations.[238] Liberty notes that the steel H-frame 345,000-volt line design and other tower configurations are taller than those reviewed and may exhibit poor lightning performance. Ameren has not analyzed its current two lightning protection options for the 69,000-volt and 34,500-volt systems for expected lightning performance[239].

c. Substation Lightning and Surge Protection

Lightning protection in a substation consists of two main design elements. First, the shield wires on the incoming transmission and sub-transmission lines provide partial protection for the substation by shielding the incoming lines. Shield wires may also extend across the substation to provide lightning protection. The shield wires tie to the low-resistance substation grounding grid, which typically has less resistance than the 10-ohm tower footing resistance of the incoming line.

[237] Response to Data Request #653.
[238] Supplied in response to Data Request #769. That response also indicated that the new single-pole design produces no flashovers using the older software.
[239] Interview 179A, June 3, 2008.

The lower resistance results in better performance of the shield wires near the substation and better lightning protection. Lightning masts[240] also tied to the low resistance substation grounding grid can augment lightning protection. The second design element is the application of lightning arrestors that spark over to ground when they experience predetermined voltages.[241] By operating at a preset voltage and coordinated with the dielectric strength of equipment,[242] lightning arrestors limit the voltage impressed on equipment by lightning or switching surges[243] to levels that will not damage the equipment.

Since 2006, Ameren Services' Substation Design Group has used the Electro Geometric Model using the rolling sphere method as described in IEEE (Institute of Electrical and Electronic Engineers) standard 998-1996 (R2002) – "IEEE Guide for Direct Lightning Stroke Shielding of Substations" for lightning protection of transmission, bulk, and distribution substations. This method allows the use of both shield wires and lightning masts to provide a zone of protection for the substation equipment and bus work based on the lightning stroke magnitude and the BIL of the equipment and bus work that needs protection.[244] Ameren used a commercially available program, WinIGS, to perform these calculations to provide a graphical display of required shielding in new substations and uses an Isokeraunic level of 100 thunderstorm days for conservatism[245]. A module of this program is the substation ground-grid program, which includes the shield wire and lightning mast placement data.[246]

Ameren's Substation Design Standard 10G is the Design Guide for the Application of Metal Oxide Surge Arrestors.[247] This standard prescribes the design for the application of lightning arrestors within Ameren substations. Substation Design Standard 10G uses protective margins and discharge voltages based on the methods described in IEEE Standard C62.22, the IEEE Guide for the Application of Metal-Oxide Surge Arrestors for Alternating Current Systems, and requires a protective margin[248] of 20 percent for breakers, cables, switches, and voltage transformers, and a 50 percent protective margin for power transformers.

Ameren applies lightning arrestors at incoming line terminals within a substation, on both the high side and low side of transformers, and other locations where distance studies dictate that arrestors should be installed for proper protection.[249] Two relay groups[250] perform insulation coordination analysis, determine the ultimate placement of arrestors, and determine whether to use intermediate or station-class arrestors.[251] Prior to the storms of 2006, both Ameren-CIPS and

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[240] A lightning mast is simply a pole that is much taller than the substation that attracts lightning thus shielding it.
[241] The voltage that the lightning arrestor sparks over is dependent on its voltage rating.
[242] Also referred to as the Basic Insulation Level (BIL) of the equipment, which varies by voltage level.
[243] Every time a line is switched in or out, traveling waves are created that are higher than the voltage of the circuit switched. These waves are called switching surges and can damage equipment. The two pronged protection provided by arrestors is why arrestors are also commonly referred to as surge arrestors.
[244] Response to Data Request #596.
[245] Response to Data Request #770.
[246] Interviews #148 and #149, March 26, 2008.
[247] Response to Data Request #655.
[248] The percent by which the system-equipment insulation strength exceeds the maximum surge voltage allowed by the surge arrestors.
[249] Interviews #163, #164, #166, and #167, May 1, 2008.
[250] One for Missouri projects and one for Illinois projects.
[251] Interviews #148 and #149, March 26, 2008.

Ameren-CILCO used heavy-duty lightning arrestors and Ameren-IP used standard duty lightning arrestors. Since 2006, all Ameren companies use the heavy-duty lightning arrestors[252]. Liberty found that Ameren's substation lightning design standards are adequate and in line with industry practices.

With regard to substations designed prior to the current standards, Ameren believes that lightning is primarily a problem with very small stations because the shield wires of the lines and lightning masts protects the large stations. Where Ameren determines lightning to be a problem, it may improve grounding, add arrestors, or relocate arrestors.[253] This is a reactive approach because lightning must damage equipment or be problematic prior to action by Ameren. While substation outages due to lightning would be expected to be much less probable because of the smaller footprint and lower resistance to ground of the grounding grid compared to a transmission line, good utility practice is that all substations are adequately protected from lightning.

Switching surges occur during the normal operation of the power system and during conditions when protective devices automatically clear faulted elements. Good utility practice requires that arrestor placement not only protect equipment from lightning induced voltage surges but also protect equipment against so-called switching surges. Utilities generally perform switching surge studies when they place new equipment in service to ensure that arrestor placement is adequate for foreseen switching conditions. The analysis of the system includes the case when all elements are in service and under contingency conditions.[254] Ameren-IL sizes and installs surge arresters to protect equipment from switching surges per Ameren TDD Substation Design Guide 10G and IEEE Std. C62.22. Ameren-IL completed a transient switching study for the Sioux-Roxford-5 line, which was the last Ameren 345kV built in Illinois. This study showed no adverse consequences resulting from transient switching over-voltage. Ameren has not experienced EHV switching caused failures.[255]

d. Distribution Lightning and Surge Protection

Ameren-IL provides lightning protection on the distribution system mainly through the application of lightning arrestors to limit voltage surges to both customers and equipment. The current Ameren-IL practice is to install lightning arrestors at the following locations.[256]

- All equipment poles – locations with transformers, reclosers, regulators, capacitor banks, or primary metering equipment.
- Transition poles to or from an underground configuration.
- At the ends of feeder-open points.
- On line sections without equipment at a minimum spacing of four per mile of line as required by the National Electrical Safety Code.

[252] Response to Data Request #765.
[253] Response to Data Request #35E.
[254] Liberty notes that for voltages of 161 kV and below, standard placement of arrestors at line and transformer terminals is generally adequate for this protection.
[255] Interviews #163, #164, #166, and #167, May 1, 2008, and comments on draft Liberty report, July 31, 2008.
[256] Response to Data Requests #35E and #232.

Generally the four NESC lightning arrestors per mile requirement applies to rural areas where there is little utility equipment installed. In urban areas, where the quantity of utility equipment installed is high, the number of lightning arrestors is also high thus meeting the per mile requirement.

Ameren has taken measures to maximize the performance of lightning arrestors by placing them as close as possible to the equipment they are intended to protect and by using tank mounted arrestors on new pole-mounted recloser and transformer installations.[257] Liberty finds that current distribution system lightning protection design is adequate and in line with industry practices.

3. Animal Protection

Contact with power lines by animals is a major cause of interruptions to electric service. Good design standards can help to minimize these events. On Ameren-IL's system, service interruptions caused by animals averaged 11.5 percent of all non-weather related customer outage minutes from 2005 through 2007.[258]

a. Transmission and Sub-Transmission Systems

Ameren-IL has over 4,880 miles of transmission lines.[259] Animal-caused outages to the transmission system and the sub-transmission system have not historically been a problem due to the size of the facilities and the resultant large physical spacing, making contact unlikely for smaller animals.[260] Larger animals such as raptors are of concern for transmission and sub-transmission lines animal protection. Ameren reported no raptor deaths involving transmission or sub-transmission lines in the last three years.[261] Ameren's experience is in line with the experience of other utilities.

b. Substations

Animals caused many outages at substations. From 2005 through 2007, animal-caused outages in substations accounted for 5.4 percent of total customer minutes interrupted. Squirrels accounted for 48 percent of substation animal outages followed by raccoons at 27 percent and birds at 15 percent.[262]

Ameren Design Standard 30G, Design Guide for Distribution Substation Animal Protection, provides the design standards for substation animal protection.[263] This standard has been in effect since 2003; Ameren-IL has applied it to all new substation construction and retrofits since that time. It is similar to Ameren-IP legacy designs. Standard 30G aims the protection against

[257] Response to Data Request #232.
[258] Responses to Data Requests #269 and #610.
[259] Response to Data Request #57.
[260] Response to Data Request #35E.
[261] Response to Data Request #598.
[262] Responses to Data Requests #269 and #610.
[263] Response to Data Request #520.

intrusion of animals like raccoons and squirrels. Standard 30G calls for the following on all equipment rated 15,000 volts and below (including power transformers):[264]

- Wildlife guards on bushings
- Insulated tubing or tape for 24 inches on the bushing leads above the bushing
- Wildlife protector disks installed near the grounded end of the insulator on secondary bus work and disconnects

It calls for a review to identify and insulate clearances that may result in animal contact.

Liberty found that these design standards for substation animal protection were adequate and in line with industry practices.

The Ameren-IL companies built many of their substations before these standards came into effect. Animal protection measures for these substations are retrofit jobs. In addition to the products described above, Ameren-IL has installed a TransGard electric fence at some substations, primarily to protect against raccoons. The fence is three foot high and uses DC circuitry to discourage breaching the fence with a correctional shock. The cost to install a single TransGard fence is approximately $25,000. Ameren-IL also employs critter line guards as animal protection. This guard is circular and placed on feeder exit lines to prevent squirrels from entering the substation by running along the feeder circuits and entering the equipment area.[265]

The table below shows the number of animal protection products that Ameren-IL installed from 2005 through 2007 in retrofit applications. Ameren has steadily increased the amount of retrofit animal protection installations.[266]

Number of Wildlife Protection Products Installed in Retrofits

Product	2005	2006	2007
16-Inch Wildlife Disk[267]	505	932	3,300
Critter Line Guards[268]	180	358	860
TransGard Electric Fence[269]	9	4	16

Ameren-IL's installation of animal protection retrofit projects has generally been reactive to problem locations; it has not initiated any system-wide retrofit projects. Refer to Chapter VI of this report, and in particular to the section on system conditions in which Liberty recommends improvement in animal protections at distribution substations.

c. Distribution System

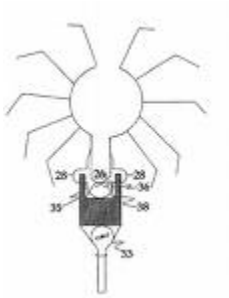
Wildlife protection is very important on the distribution system for improving circuit reliability. Distribution lines are often located in residential and rural areas where animal activity is high. The lower spacing between energized equipment rated 69,000 volts and lower, and the large

[264] Interviews #148 and #149, March 26, 2008.
[265] Interviews #148 and #149, March 26, 2008.
[266] Interviews #148 and #149, March 26, 2008.
[267] Response to Data Request #600.
[268] Response to Data Request #601.
[269] Response to Data Request #602.

number of pieces of equipment at these lower voltages, makes the distribution circuit vulnerable to animal-caused outages. From 2005 through 2007, animal-caused outages on distribution circuits accounted for about 19 percent of non-weather outage events and 4 percent of customer interruption minutes.[270]

Birds, squirrels, snakes, raccoons, and other types of animals that can climb poles commonly cause outages on the distribution system. Because distribution equipment tanks connect to ground, the equipment's high voltage bushings are particularly susceptible to animal-related outages.[271] Common animal protection against such outages is the installation of wildlife protectors to each energized bushing. Prior to the 1980s, wildlife protectors were available, but their use was limited due to difficulty in installation and poor performance. In the 1980s, the industry developed a wildlife protector that consisted of a plastic clamshell device wrapped around the equipment bushing. In the early 1990s, the industry developed an electrostatic wildlife protector that is easy to install on equipment bushings. The photographs below show each of these devices; they still represent the state of the art in distribution-system wildlife protection.

Clamshell Wildlife Protector



Electrostatic Wildlife Protector

Ameren's distribution standards require and specify complete animal protection for new construction. New pole-top transformers come with a clamshell wildlife protector attached to the equipment bushing. New capacitor banks have covered wiring and wildlife protectors on the bushings. Lightning arrestors have wildlife protector caps and the standards require all 15,000-volt equipment bushings covered with wildlife protectors.[272]

These standards provide for complete wildlife protector installation for new units and new construction. However, many distribution circuits have been in service before the advent of modern wildlife protectors or prior to adoption for use by Ameren-IL. These circuits will not

[270] Responses to Data Requests #1 through #3 and #269.
[271] A bushing is an electrical component that insulates a high voltage conductor passing through a metal enclosure.
[272] Response to Data Request #232.

have all of the wildlife protectors installed unless a wildlife-protector retrofit program has specifically taken place on the circuit in question. Historically, retrofit programs were determined as necessary on a local basis and retrofit programs varied across the divisions and operating centers. Chapter VI of this report addresses Liberty's findings in this regard.

Some animals such as raptors require special protection consideration. In 2005, there was one raptor death (Ameren-CIPS), two in 2006 (Ameren-CIPS), and none in 2007. Ameren reported these incidents to the United States Fish and Wildlife Service (USFWS) to assess the site location in a collaborative manner with USFWS, and come to agreement as to the need and design for the reconfiguration of the equipment at the site. As of July 2006, Ameren did not have a written raptor plan in place. By December 2007, Ameren drafted a Raptor Protection Plan and sent a copy to USFWS for comment. USFWS objected to some parts of the draft plan. Ameren revised its draft Raptor Protection Plan, sent it to USFWS in February 2008, and is currently waiting for a response.[273]

Liberty found that Ameren-IL's distribution system animal protection design standards were adequate.

4. Conclusions

1. Ameren-IL has adequate protection standards. One area needs clarification. (Recommendation V-25)

Liberty found the protection standards to be adequate. One diagram in Standard 14G shows the switchgear substation-protection scheme in urban areas and the outdoor bus protection scheme in rural areas. Ameren should revise the standard for clarification.

2. Ameren-IL should make some improvements in system protection studies. (Recommendations V-26, V-27, and V-28)

Ameren-IL lacks a defined period of comprehensive review of transmission and sub-transmission coordination studies. Ameren completed transmission and sub-transmission coordination studies at the time of each merger and continues to review area coordination as the systems change, but lacks a defined period of review.

Ameren should use the same ground resistivity in the calculation of system impedances and relay settings in all legacy companies. Ameren-IP used 30 ohm-meters and the remainder of the legacy companies used 100 ohm-meters for ground resistivity assumptions when calculating zero-sequence line impedances resulting in an approximate 8 percent difference in results. Ameren should perform a ground coordination study on the legacy companies whose assumed ground resistivity changes.

[273] Response to Data Request #598.

3. Ameren-IL has acceptable processes for the construction and modification of facilities to ensure safe and reliable system protection operations.

Ameren-IL construction processes include appropriate levels of system-protection design review to ensure the consistent application of Ameren-IL system protection standards for the construction of new facilities and modifications to existing facilities.

4. Ameren-IL has adequate processes for the review of transmission system operations. However, it needs to complete the collection of sub-transmission event operations. (Recommendation V-29)

Ameren-IL has established and effective processes for the review of system protection performance in response to transmission system operations. Ameren-IL should replicate and extend these practices to include the review of sub-transmission operations because of the significant number of distribution customers ultimately served from sub-transmission facility sources. Ameren-IL recognized the need to complete the equipment event database, but placed the process on hold.

5. The Ameren-IL system protection organization has well defined responsibilities, an experienced team, an adequate workforce, adequate training and development practices, and appears adequately prepared for the future needs of the organization.

6. The Ameren-IL design interface of division distribution-design personnel with system protection is not adequate. (Recommendations V-30 and V-31)

Ameren is aware of inadequacies in the protection of some 12,000-volt and 4,000-volt distribution substation transformers where the transformer damage curve requirements for adjacent faults were not met prior to the mergers with Ameren due to lack of training and knowledge. Engineers only look for these inadequacies when they change line-device settings. Ameren should check the damage curves for all distribution substation transformers for compliance.

Ameren-IL should review the coordination of division personnel training requirements. Training related to the comprehensive application of current and ongoing distribution-system protection design principles is required to protect system equipment from premature failure.

7. The installation of auto-sectionalizing and auto-transfer devices in the distribution system may result in reliability improvements. (Recommendation V-32)

Ameren plans to consider distribution circuit auto-sectionalizing along with auto-transfers and manually SCADA controlled switches after the sub-transmission circuit program's estimated completion in 2009.

8. Ameren's current design standards for lightning protection of transmission and sub-transmission lines, distribution system, and substations were adequate and in line with industry practices.

The design standards that Ameren applied to new electric delivery system installations as of July 2006 (and current) should provide adequate lightning protection and were consistent with electric utility practices.

9. Ameren's lightning protection design of older 138,000-volt, single-pole transmission construction was inadequate and not consistent with industry practices. (Recommendation V-33)

Liberty found that the lightning failure rates of Ameren's older, 138,000-volt, single-pole construction were above industry-accepted levels, even if it achieved a 10-ohm tower footing resistance standard.

10. Existing and new H-frame, wood 138,000-volt transmission lines should perform in accordance with industry practices provided that Ameren continues to obtain a 10-ohm tower footing resistance wherever possible.

Liberty found that 138,000-volt H-frame wood transmission line designs were at industry-accepted levels using the older software and lightning data if Ameren-IL obtains a 10-ohm tower footing resistance.

11. Ameren's lightning protection for older and smaller substations may not be adequate. (Recommendation V-34)

Ameren's approach to bring older and smaller substations up to current standards was reactive and not in line with industry practices. Ameren did not know the extent to which lightning affects reliability or equipment damage in substations designed to older standards. Ameren took action only after there were apparent lightning problems at a substation.

12. Ameren has performed switching surge analyses of its transmission system but not for off-normal conditions. (Recommendation V-35)

Ameren-IL should include off-normal conditions in its switching surge analyses of its transmission system.

13. Ameren's software to determine the lightning performance of transmission lines is outdated and relies on outdated data. (Recommendations V-36 and V-37)

The thunderstorm day data, lightning density data, and lightning intensity data is outdated. Newer and more complete data is available that suggests that predicted trip out rates are significantly higher than predicted.

14. Ameren-IL's animal protection design standards for new construction were adequate and in line with industry practices.

Liberty found that Ameren-IL's transmission, substation, and distribution design standards for animal protection were adequate and in line with industry practices. Ameren-IL's installation of animal protection on existing substations was reactive in nature. Retrofit of animal protection on older distribution system components varied across the Ameren-IL service territory. Chapter VI of this report covers these topics.

5. Recommendations

V-25 Separate the switchgear substation-protection scheme in urban areas and the outdoor bus protection scheme in rural areas into two distinct diagrams.

Ameren-IL would improve present Standard 14G with a clear distinction in these protection configurations. Ameren should start this endeavor within six months of the date of this report and complete the revision within one year.

V-26 Establish a defined period for system-wide review of transmission and sub-transmission coordination.

Ameren-IL has not undertaken a system wide review of transmission and sub-transmission protection coordination since the merger of the respective legacy companies. System protection has a goal of ten years for comprehensive transmission and sub-transmission systems coordination studies, but lacks a formal requirement. Ameren should set a schedule for system wide review of transmission and sub-transmission protection coordination within six months of the date of this report and complete its reviews within that defined period.

V-27 Use the same ground resistivity in the calculation of system impedances and relay settings in all legacy companies.

Ameren-IP used 30 ohm-meters and the remainder of the legacy companies used 100 ohm-meters for ground resistivity assumptions when calculating zero-sequence line impedances. This resulted in an approximate 8 percent difference in results. Ameren should immediately determine the more appropriate value of earth resistivity and recalculate relay settings on those impedances within five years of the date of this report.

V-28 Perform a ground coordination study on the legacy companies whose assumed ground resistivity changes.

Depending on the results of the investigation recommended above, Ameren-IL should conduct a ground coordination study on any legacy company whose assumed resistivity is different from that historically used as latent coordination issues may exist. Ameren-IL should complete the analysis within five years of the date of this report.

V-29 Complete the sub-transmission-equipment event database.

The completion of equipment event databases would facilitate the efficient review of system events for system protection correctness from the highest transmission voltages to the substation distribution circuit main breaker (or recloser). Ameren should begin this process immediately and complete the database within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

V-30 Meet all distribution substation transformer damage curves for downstream coordination.

The legacy companies placed a priority on coordination with downstream devices over coordination with the distribution-substation transformer damage curve. Ameren should complete a thorough coordination review including checking the damage curves for all distribution substation transformers for compliance. Ameren-IL should complete this effort including issuing changes within five years of the date of this report.

V-31 Review the coordination of division personnel training requirements.

Training related to the comprehensive application of current and ongoing distribution-system protection design principles is required to protect system equipment from premature failure. Ameren-IL should begin this process immediately and should complete this effort within one year of the date of this report.

V-32 Perform a cost-benefit study of expanding auto-sectionalizing into the distribution system.

Ameren-IL should develop a plan for a prioritized distribution-system auto-sectionalizing and auto-transferring program after the completion of the sub-transmission program in 2009. Ameren-IL should perform a cost-benefit study of that plan beginning in December 2009 and complete it within one year of that start date.

In its comments on the daft report, Ameren-IL accepted this recommendation.

V-33 Improve lightning protection performance of older 138,000-volt, single-pole structures.

Ameren-IL should immediately investigate its design of older 138,000-volt, single-pole structures so that lightning performance is in line with industry practices. Ameren should determine the most cost effective way to bring the lightning performance of existing older single pole 138,000-volt structures in line with industry practice by lowering tower footing resistance, providing better shielding, redesigning towers, or a combination of all three. Ameren-IL should complete its analyses within six months of the date of this report and fieldwork within three years.

V-34 Analyze overall lightning protection for older substations. (Also, see Recommendation VI-26)

In Chapter VI of this report, Liberty recommends the improvement of lightning protection at distribution substations. In conjunction with the implementation of that recommendation, Ameren-IL should perform an analysis for older substations to verify that lightning performance is at industry-acceptable levels if Ameren-IL has not specifically analyzed those substations. Those analyses should begin immediately and completed within three years of the date of this report.

V-35 Perform switching surge studies for the 230,000-volt and 345,000-volt transmission system for off-normal conditions.

Ameren should perform switching surge studies to ensure that arrestor placement is adequate under contingency conditions more severe than design requirements, and under black start conditions. Switching surge analyses are required to ensure that line switching, especially under off-normal system configurations, will not damage equipment with over voltages. Those analyses should begin immediately and be completed within one year.

V-36 Obtain updated lightning software and data for transmission lightning performance analysis.

Ameren should obtain the recently published lightning data and software from EPRI or an equivalent vendor. Ameren should obtain these data and software as soon as possible and before it performs any additional lightning analyses.

V-37 Verify lightning performance characteristics of all existing and legacy transmission and sub-transmission configurations.

Some older transmission configurations did not conform to industry standards using outdated lightning data. Current transmission configurations perform to industry standards using the older data and software. Newer data suggests that lightning performance will be worse than currently projected. In addition, Ameren should specifically model the surge impedance of the static ground down lead in subsequent analyses. Ameren should verify that the lightning performance of current and legacy transmission and sub-transmission configurations is adequate and correct problems discovered if economic and practical to do so. Ameren should complete its analyses within six months of the date of this report and correct problems discovered within two years.

G. Construction

1. Introduction

Construction activity is a significant portion of every utility's workload and underlying costs. Construction processes must be robust and repeatable because of the frequency of new customer construction requests, system modifications required for public improvements, system capacity reinforcement, and reliability improvements. Construction of new facilities represents a long-term utility investment, thus installations must be reliable, maintainable, safe, and operable for decades of service.

The construction process is often the first point of contact for new customers; therefore, the efficiency of the construction process and the proficiency of construction personnel often determine initial customer satisfaction.

2. Standards

Standards provide uniformity and enable efficiency in the construction management process. Ameren-IL employs two main types of standards to accomplish this. Design standards specify the design functionality to meet criteria of applicable codes, industry standards, and corporate policies. Design standards provide the designer the appropriate guidelines for design calculations, principles, and margins to comply with the required functionality. Construction standards specify the major equipment, unit assemblies, component, and raw material specifications to ensure compliance with design standards, and compliance with industry and manufacturing standards. Construction standards also afford uniformity of raw materials, efficient construction procurement, and field configuration details for repeatable constructability.

Good utility practices include the use of both types of standards. Design standards provide general functionality requirements and are useful to designers. Both designers and construction personnel use construction standards. Design standards generally will undergo less change over time, while construction standards tend to expand as new materials, technologies, and methods become available to enable additional construction equipment options and materials. The combined usage of both standards allows the uniformity of designs over time and across diverse geographical service areas. Cost efficiency comes from bulk ordering of raw material and uniform manufacturing requirements, minimization of custom designs, and construction personnel familiarity with the erection and installation of standard equipment configurations.

a. Design Standards

Ameren divided its design standards into distribution, substation, and transmission categories. It also organized them by engineering disciplines such as civil, electrical, and system protection. Construction projects use the applicable standards necessitated by the facility type and design disciplines. Sections V.E and V.F of this chapter discuss distribution and system-protection design standards.

b. Construction Standards

Ameren also organized construction standards by facility and discipline categories. Design departments assemble and transmit the construction standards needed for a project as a document package to the construction organizations.

For large substation projects, Ameren-IL issues a job specific construction standard that is a compilation of construction standards for the major components and equipment within the civil, electrical, and system-protection disciplines of the project. Additional generic contractor requirements are also included within this specification, where applicable, to address work rules, personnel drug and substance usage dismissal policies, and other contract requirements. Liberty reviewed a sample of distribution, substation, and transmission projects of the legacy companies

and found that the project construction standards issued were adequate to ensure safe and reliable energy delivery systems.[274]

3. Processes

Robust construction processes are required to ensure that the functionality designed on paper comes to fruition in the field. Best practices construction management maintains control of project scope, schedule, and budget, which enables quality, timeliness, cost effective construction, and dependable facility service. This section describes Liberty's findings with Ameren construction management with respect to these practices.

a. General Description

Design/build processes require several attributes to ensure safe and reliable end-results. Features such as effective peer review, design control, equipment and material reviews, and construction testing requirements provide a set of checks and balances throughout the entire design/build process. Liberty reviewed a sample of Ameren-IL's distribution, substation, and transmission projects and found that these features of Ameren's construction processes were generally adequate to ensure safe and reliable energy delivery systems. However, Liberty identified some improvement opportunities as described below.

b. General Features

1. Effective Peer Review

Effective peer and supervisory level review of system construction standards, project designs, installed assets, and operating functionality is an important feature for efficient and consistent processes. These reviews enable Ameren-IL to adhere to industry best practices, regulatory requirements, and to provide safe, reliable, and cost effective energy delivery systems for their customers. Peer and supervisory reviews ensure that qualified personnel have reviewed technical design requirements to preclude omission or inadvertent inaccuracy, which construction personnel might miss. However, experienced construction and testing personnel provide an additional informal layer of peer review by their knowledge of good construction practices from similar projects.

In addition, peer reviews serve to provide checks and balances for cost control of the overall construction process. Peer review of project costs is beneficial at the project-selection, preliminary-cost phase and throughout the balance of key phases of a project.

Liberty found that Ameren processes provided adequate levels of technical peer review to ensure safe and reliable energy delivery systems.[275] For example:

- design and construction standards are routed to internal stakeholders for review and approval[276]

[274] Responses to Data Requests #546, #684, and #685, and Interviews #151 through #155, April 2-3, 2008.
[275] Interviews #151 through #155, April 2-3, 2008.
[276] Responses to Data Requests #684 and #685.

- project drawing reviews are performed by peer draftsmen or by the responsible project engineer[277]
- wiring diagrams are reviewed by relay testing personnel[278]
- site document reviews are conducted by site construction personnel[279]
- all design functionality changes are reviewed and approved by the design project manager[280]
- reconciliation of wiring and project drawings reviewed by draftsmen prior to final corporate drawing transmittal.[281]

In the area of reviews for cost control, Ameren-IL has several practices such as:

- automatic senior management review of all projects in excess of $1,000,000[282] (or in excess of $100,000 for emergency replacement approvals)[283]
- monthly cost control project reports updating by the project engineer[284]
- work order extension/reduction authorizations for cost variances of +/-10 percent cost variances or for standing work order (SWO)[285] changes in excess of $50,000.[286]

However, Liberty also found that Ameren-IL bases the project selection process on conceptual project cost estimates for budgetary review and selection. While Ameren recognizes the usage of these estimates is for preliminary review,[287] it uses these estimates for the final project selection.[288] If there are initially several options, the estimates have less accuracy, 25 to 30 percent, until Ameren-IL selects the alternative.[289] In some cases, competing alternatives that will satisfy the system requirements are not so close in cost that the lack of estimate accuracy will result in improper alternative selection. Although Ameren-IL ultimately prepares a detailed cost estimate for approved projects, it makes the project selection based on the rough estimate. In cases where there are satisfactory alternatives that have costs in the same order of magnitude, more detailed cost estimates are appropriate.

In addition, Liberty found that final cost controls were lacking in certain respects. Ameren-IL only required final cost control reviews if costs were to exceed $250,000 or 10 percent of overall costs, whichever was greater, or $500,000 or more regardless of percentage.[290] This policy

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[277] Response to Data Request #687.
[278] Interviews #151 through #155, April 2-3, 2008.
[279] Response to Data Request #687.
[280] Response to Data Request #687 and Interviews #151 through #155, and #161, April 2-3, 29, 2008.
[281] Response to Data Request #687 and Interviews #151 through #155, and #161, April 2-3, 29, 2008.
[282] Interview #152; April 2, 2008.
[283] Interview #151; April 3, 2008.
[284] Interview #151; April 3, 2008.
[285] A standing work order is comprised of multiple projects each less than $100,000. Response to Data Request #690.
[286] Response to Data Request #687.
[287] In its response to Data Request #694, Ameren states that this inaccuracy will not result in inaccurate project selection providing all projects are estimated with consistent assumptions. Liberty disagrees.
[288] Response to Data Request #694.
[289] Interview #151 and #152, April 2-3, 2008.
[290] Response to Data Request #705.

results in a lack of cost reviews for the majority of projects. The identification of excess material costs is the responsibility of administrative clerical personnel during project closeout.[291] The overall process lacks adequate independent cost controls for the majority volume of projects, which tend to be the smaller projects. Thus, Ameren-IL may never identify chronic overestimation in either material or labor.

In Liberty's review of seven sample projects, only one project was over budget.[292] While this is general evidence of cost control, it may also suggest a built-in cost plus factor within the process, given the labor estimation process, which would preclude most projects from variance reviews above budget. Liberty found that since the construction departments are responsible for identifying cost control overruns at the conclusion of the project, potential latent issues have little opportunity for independent disclosure of the estimation process.[293]

2. Design Controls

Design control is an important feature of efficient design/build processes. Design control ensures that the installed facilities meet all the general design requirements, the Ameren design standards, and the project design engineer's job specific design requirements. Design control precludes the omission of designed functionality or safety features that service-date time pressures could cause.

Construction and testing personnel cannot change designed functionality without the project engineer's approval. Within Ameren design disciplines, design controls preclude the engineering project engineer from changing system protection functionality without the system-protection project engineer's approval. In addition, the electrical engineer cannot change the structural engineering functionality without the civil engineer's approval. Liberty found that Ameren-IL's construction processes had adequate design controls to assure that the construction process did not bypass or omit intended functionality.[294]

3. Equipment and Material Review and Testing Controls

Equipment and material reviews provide a first line of design control to assure that construction raw materials, components, and major equipment meet applicable design standards and have not suffered inadvertent substitution, damage in transit, or degradation in temporary storage. Component testing and commissioning testing provides design control of functional integrity during the construction process.

New installations undergo startup tests and in-service protection tests as an overall check of functionality, proper phasing, polarity, primary/secondary ratios, and restraint characteristics,[295]

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[291] Interview #154, April 2, 2008.
[292] Liberty requested projects constructed in 2005-2007 with total cost in excess of $100,000. Approximately 200 projects were constructed of this scope and in this period. Response to Data Request #546.
[293] Interview #154, April 2, 2008.
[294] Interviews #151 through #155, April 2-3, 2008.
[295] For example, harmonic restraint characteristics for transformer protection to preclude false tripping.

as necessary. Operating and engineering personnel review the startup sequence for first-time equipment energizing prior to execution by on-site relaying personnel.[296]

c. Construction Process

The overall construction process has identifiable sub-processes. The beginning and end of the construction process is often marked by the release of key documents, financial authorizations, final drawing incorporation, or by project accounting closure actions. The entire process requires the interaction of several organizations at various phases of the process. Liberty reviewed a sample of projects from various disciplines and across the all legacy-company organizations to assess the consistency and repeatability of the process to ensure construction of safe, reliable, and cost effective energy delivery systems.[297]

1. Project Selection and Budgeting

Project selection and budgeting are the earliest stages of the construction process.[298] Groups within Ameren can identify construction projects to solve system problems or external groups such as customers or public agencies can identify the need for construction projects.[299] For example, System Planning may initiate significant reinforcements or expansions by issuing a Project Notification (PN) document, also referred to as a job description (JD), that it routes to internal Ameren stakeholders for review and requested "budget grade" estimates.[300] Engineering departments prepare an initial budget estimate, which should be within 20 percent of the constructed cost.[301] The overall estimate received by system planning is a composite total of the individual discipline estimates. System planning may request initial estimates for several alternatives as part of its review of alternatives for ultimate selection.

Externally driven requests for construction from customer requests and public improvements generally do not result in the system planning alternative selection process, because the alternative selection is subject to the approval of the customer or by the governmental agency. For example, the Illinois Department of Transportation may request the relocation of facilities for public improvement. However, Ameren-IL generally follows the process with respect to the design departments' submittal of a budget level estimate. At times, this too can be iterative as the customer or the public agency evaluates multiple alternatives. Each project normally has a required service date, which the sponsor provides with the request.[302]

Ameren-IL's current Central Review Committee (CRC) and checkbook process for transmission and substation projects allows for adjustments in spending due to unexpected projects such as a failed transformer or other major substation equipment. In one case, however, the process lacked

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[296] Interviews #151 through #155, April 2-3, 2008.
[297] These projects were a sample of transmission, bulk substation, distribution substation, and distribution projects completed from 2005-2007 with final costs that exceeded $100,000 from the three legacy companies. Response to Data Requests #616 through #620, #684, and #685.
[298] Response to Data Request #687.
[299] Response to Data Request #687.
[300] Interview #152, April 2, 2008.
[301] Response to Data Request #694.
[302] Sponsor in this case refers to the initiating party, e.g., planning, operations, etc.

adequate pre-established contingency funding for one large transformer emergency replacement.[303] As a result, Ameren-IL charged to a maintenance budget some of the removal cost to transfer equipment from one Ameren-IL location to another.

After the selection of alternatives, the CRC must approve the corporate budget using the Integrated Spending Prioritization (ISP) tool.[304] Senior management is involved in the approval of all construction requests over $100,000. Executive approval is required for projects in excess of $1,000,000. The budgeting process is iterative and the ISP tool evaluates multiple parameters for ultimate approval.[305] When the budgeting process is completed, Ameren-IL routes an authorized project to internal stakeholder managers, and assigns a work order number within the corporate budget system (CBS) to the project.[306]

2. Detailed Engineering and Procurement of Resources

After project authorization, engineering departments begin the detailed engineering work in each of the respective disciplines as necessary. The design supervisor assigns a project engineer to secure an initial authorization of $50,000 to capture early design work and begin the detailed design work, *e.g.*, surveying, permitting, drafting, and engineering.[307] Engineering may select construction standards, standard sub-assemblies, and may create detailed engineering drawings for the integrated assembly of the facilities, site preparations, and overall layout. In addition, the project engineer develops a schedule that includes significant milestone dates in the construction process. Part of the scheduling activity is the coordination of outage requests with applicable operations groups.

The project engineer assembles a labor estimate for each phase of the project using project-estimating tools.[308] Several internal stakeholders review this estimate via a "labor clearance" form.[309] Ameren's internal labor management entities, Transmission, Division Operations (for distribution work), and Substation maintenance department review the estimates and milestone service dates. The internal construction forces review the package first and decide whether their construction personnel resources can accomplish the work according to the schedule while meeting their own internal maintenance and operating schedule obligations. Construction Services reviews all projects not committed to by internal construction forces for the selection and committal of appropriate outside contractors according to contractor skill levels, resource availability, and cost. Construction services serves as the contractor administrator.

Near the completion of the detailed-design work phase, the project engineer obtains a work order extension,[310] which permits the procurement of resources and long lead time equipment.[311] The

[303] Interview #151, April 3, 2008.
[304] Response to Data Request #293.
[305] Response to Data Request #293.
[306] Response to Data Request #687.
[307] Response to Data Request #687.
[308] Interview #151, April 3, 2008.
[309] Response to Data Request #687.
[310] Ameren-UE material ordering is unique. Response to Data Request #687.
[311] Response to Data Request #687.

project engineer typically schedules material delivery for one month in advance of site construction.

When the drafting organizations complete design drawings and all of the material has a delivery schedule, Ameren-IL transmits a construction-release document package to the construction and testing organizations one month in advance of the scheduled site construction start.[312] Status changes accompany the construction release date in work management systems such as P3E, DOJM, and EMPRV.[313]

3. Construction Phase

The construction phase has several identifiable sub-segments. Site construction often depends on fair weather to preclude work stoppage. The project engineer may convene an initial project meeting prior to site construction. This meeting allows design and construction personnel to meet at the construction site and review the document package, confirm schedules, and review the rules of engagement.[314]

a. Site Prep & Civil Construction

Most system-reinforcement construction projects have a pre-summer completion date. Therefore, site preparation and civil construction often begins in the previous fall to ensure completion of excavation and structural foundations early and to preclude delays due to wet spring conditions. Contractors typically do this work. The project engineer, with assistance from civil engineering, resolves construction contingencies such as poor soil conditions or buried obstacles.

b. Electrical Construction

Electrical construction includes the erection, placement, assembly, interconnection, and wiring of electrical equipment. Either internal or contract labor perform the electrical construction. Construction Services, responsible for contract labor administration, periodically visits the contractor crews at the construction site for coordination with Ameren-IL in-house activity, but these crews supply their own direct supervision. The project engineer arranges for system outages in advance to permit connection to or modification of system facilities. Transmission outages require longer lead times for regional system operations coordination with the Midwest Independent System Operator.

All legacy companies provide their own supervision of internal electrical construction crews. The required in-service date often dictates labor hours and overtime. This date is either customer-driven or prior to June 1 for most system reinforcement work. The project engineer has the responsibility for the project budget. Construction management, either internal or externally contracted, is responsible for labor hours to complete the work to schedule. The project engineer

[312] Response to Data Request #687.
[313] Response to Data Request #687 and Interview #155, April 3, 2008. DOJM, EMPRV, P3E are work scheduling tools.
[314] "Rules of engagement" include designated storage areas for contractors, site reporting rules, grievances, and other work rules to govern the construction personnel activity.

is on-site occasionally as-requested, but site construction is the responsibility of the construction department.[315]

The project engineer files quarterly cost control reports.[316] The project engineer also holds monthly schedule meetings with internal stakeholders to manage the work and the scheduling.[317] The project engineer coordinates changes to the physical, electrical, or functional drawings and specifications for approval. Construction drawings are temporarily marked-up with the approved changes for final drawing incorporation at project closeout.

c. Testing & Commissioning

Testing activity includes the pre-service testing of major equipment, system protection facilities, control system tests, and in-service testing verifications. Relay testing personnel typically do much of this work. Testing may be concurrent with the electrical construction phase of the project. The initial equipment "livening"[318] sequence for new construction has the pre-approval of operations, system protection, and the project engineer prior to its initiation.[319] The in-service tests are the final tests conducted to verify proper connection and functionality of installed facilities.

The project engineer approves changes to construction drawings. Generally functionality does not change, however minor wiring changes may be part of the temporarily marked up construction drawings for final document incorporation at project closeout. Drafting personnel incorporate changes on electronic drawings.

d. Closeout and Reconciliation

Closeout and reconciliation of a project includes the removal of temporary construction equipment, return of unused stock material, reconciliation of "marked up" drawings, filing of permanent documentation, enterprise system entries, e.g., electronic drawings, energy management systems, SCADA,[320] GIS[321] mapping, and plant accounting record keeping. The project budget remains open for three months to permit all of the material and document reconciliations.[322] Clerical personnel perform this work. After work order closure, people cannot charge costs to the project. Occasionally, Ameren-IL holds post-project meetings to glean lessons-learned; however, this is customary only on the largest and most complex projects.[323]

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[315] Response to Data Request #687.
[316] Response to Data Request #687.
[317] Interview #151, April 3, 2008.
[318] Livening is an industry term meaning energization of equipment.
[319] Response to Data Request #687 and Interviews #151 through #155, and #161, April 2-3, 29, 2008.
[320] SCADA, Supervisory Control and Data Acquisition is the electronic control and monitoring of facility status and electrical parameters.
[321] GIS, Geographical Information System is a database/mapping system of facilities.
[322] Interview #161, April 29, 2008.
[323] Interview #161, April 29, 2008.

4. Construction Process Deficiency Summary

Liberty found that the construction process has insufficient flags for possible cost overruns. Such overruns may only be visible to clerical personnel. The process relies too heavily on low-level self-policing. The thresholds for budgetary review triggers are too high to identify systemic over-estimation and labor or material excess.

Liberty found that the overall process in 2006 lacked an adequate independent QA/QC function, although a new QA/QC program began in late 2007. The project engineer is not responsible for construction quality and site visits are only on an as-needed basis.[324] Construction quality by Ameren-IL construction crews is the responsibility of first line supervisors and crew leaders. This assessment is not independent. Ameren's contract-labor management site visits are also on an as-needed basis. While Construction Services independently rates the overall performance of contractors for specific projects,[325] this does not include a documented field inspection of final construction quality.

4. Workforce Adequacy

The provision of an adequate workforce is necessary to ensure timely and efficient system design, undue delays of system reinforcement and improvement projects, and resolution of maintenance issues. The retention and development of adequate experience and the size of the workforce to handle the workload are necessary considerations. Liberty found that overall the Ameren-IL design and construction workforce was adequate to accomplish construction projects without undue delay. Liberty found only one project within its sample of projects reviewed that had a delayed schedule. The delay was due to the extended usage of Ameren crews for mutual assistance due to hurricane relief.[326]

The percentage of substation construction work completed by contract labor in Ameren-IP was high. Each legacy company relies on varying levels of contractor labor. In 2006, contract labor for substation projects comprised 29 percent of Ameren-CILCO's work, 58 percent of Ameren-CIPS's work, and 66 percent of Ameren-IP's work.[327] The percentage of major transmission and substation construction projects assigned to outside labor sources was Ameren-CILCO 14 percent, Ameren-CIPS 23 percent, and Ameren-IP 63 percent.[328] It is unknown whether this unbalanced allocation of work to outside resources is due to attrition of Ameren-IP forces, disparate levels of construction activity, or maintenance and operations workload for Ameren-IP compared to the other companies. Ameren-IL should determine whether this work allocation implies an insufficient workforce at Ameren-IP.

The summary of distribution design/construction work for the three legacy companies for 2007 indicates that Ameren-IP service territory continued to contribute a significant majority of the Ameren-IL construction workload. Ameren-IP had 63 percent of the major distribution

[324] Interviews #151 through #155, April 2-3, 2008.
[325] Interview #161, April 29, 2008.
[326] Response to Data Request #620.
[327] Response to Data Request #706.
[328] Response to Data Request #546B.

construction projects (greater than $100,000) and 58 percent of the new permanent service installations.[329] Ameren-CILCO also relied heavily on contract labor in 2007, *i.e.*, 56 percent, for distribution construction.

5. Organization

The organization of a workforce is critical to the accomplishment of its mission. The division of responsibilities with adequate supervision is important to the proficiency of the group. The location of work centers and centralization of disciplines leverages the efficiency of key organizational interactions.

Transmission and distribution design is centralized within the Energy Delivery Technical Services (EDTS) organization, which reports to a single Vice President for Missouri & Illinois.[330] The Manager of T&D Design reports to the EDTS Vice President to manage the organization and its managing supervisors. This organization includes system protection, transmission design, substation design, and drafting. The main offices are located in St. Louis, MO and Decatur, IL. Other key personnel in the organization have work locations in Mattoon and Springfield, IL.[331] The organization size and structure has remained largely unchanged since 2006. Some reorganization within the group occurred in 2007 to better align disciplines resources and Illinois construction workloads.[332] The number of direct reports for supervisors and managers appears reasonable.

The Managing Supervisor Line Design supervises the transmission organization.[333] There are three design groups that report to this manager, each supervised by a supervising engineer. The electrical discipline is located in St. Louis, MO and the civil discipline has offices in St. Louis, MO and Decatur, IL.

The Managing Supervisor Substation Design supervises the substation organization.[334] There are four design groups that report to this manager, each supervised by a supervising engineer. The Bulk & Distribution Substation Design groups are in St. Louis with responsibility for Missouri and Illinois and in Decatur with responsibility for Illinois only. The Distribution & Customer Substation Design group is in St. Louis with a Missouri scope only. The Transmission Substation Design group is in St. Louis with responsibility for Missouri and Illinois.

The drafting responsibility is under the Chief Draftsman who reports to the Manager T&D Design. The Chief Draftsman has five direct reports and three main sub-groups aligned by location and work assignment with the corresponding design groups. The organization and number of direct reports appears reasonable to Liberty.

[329] Response to Data Request #702.
[330] Responses to Data Requests #691 and #698.
[331] Responses to Data Requests #691 and #698.
[332] Responses to Data Requests #691 and #698.
[333] Response to Data Request #698.
[334] Response to Data Request #691.

Distribution Design is the most decentralized design organization within Ameren. The Ameren-IL service territory has six operating divisions[335] split between two managers. The distribution design organizations are located in several offices throughout the state, which permits local familiarity, and close proximity to the population centers. The southern divisions utilize a mix of centralized design (The Distribution Design Center in Belleville, IL) and local office personnel to accomplish distribution construction work. The northern divisions have more of the design and drafting personnel located in the local offices. [336]

Liberty found adequate organization of construction work groups including appropriate levels of centralization and specialization by discipline. Liberty found that additional distribution design centralization, as found with the Belleville Distribution Design Center, offered additional opportunities for Ameren-IL wide consideration given the efficiency and centralization of expertise demonstrated.

6. Training

Workforce training is necessary to develop and retain skilled employees and managers. In technical disciplines such as system protection, the recruitment and mentoring of personnel is vital to the success of the organization.

Liberty found that Ameren-IL developed designers through a series of in-house courses and a progression of promotions. Degreed engineers have mentoring under the guidance of senior engineers.[337] Substation construction personnel have a three-year apprentice program with a screening test. Construction foreman require at least three years construction mechanic experience with additional supervisory training and management classes. Seniority determines construction crew leaders.[338] Liberty found the training of design/build personnel adequate to develop and retain skilled employees and managers.

7. New Programs

Ameren-IL established a Quality Assurance program as of May 2007 to ensure several objectives. This program may address the lack of quality control elements in the construction process. This initiative includes the appointment of two field auditors who were to begin their work in December 2007.[339] One of the objectives of the program is to ensure field compliance with the National Electric Safety Code and existing Ameren construction standards. It is too early to determine whether this initiative will be effective. However, it is a step in the right direction to address the lack of quality assurance for 2006 construction processes.

[335] There were seven divisions at the time of the 2006 storms.
[336] Response to Data Requests #699 through #701.
[337] Interview #161, April 29, 2008.
[338] Interview #161, April 29, 2008.
[339] Response to Data Request #299.

8. Conclusions

1. Technical and financial peer review is adequate for construction projects.

Ameren-IL processes provided adequate levels of technical peer review to ensure the construction of safe and reliable energy delivery systems. Ameren-IL processes provided several adequate financial peer reviews such as senior management review of major projects, monthly construction cost reviews, and cost change authorizations for significant variances.

2. Ameren construction work group's organizational features are adequate and effective.

The sub-division of disciplines within the organization affords close support for effective and efficient construction management. The organization has remained largely unchanged in the past few years.

3. Ameren construction design controls are adequate.

Ameren-IL construction processes have adequate design controls to assure that there was no omission of intended functionality.

4. Initial budget estimates may be inadequate for proper project selection when satisfactory alternatives have costs of the same order of magnitude. (Recommendation V-38)

Ameren-IL's project-selection estimate process uses a low accuracy estimate of 25 to 30 percent for budgetary review and selection. This may not be appropriate in all cases.

5. Ameren-IL lacks sufficient independent final project cost review. (Recommendation V-39)

Ameren-IL final project cost reviews lack adequate independent oversight for the majority of major projects. The impetus for disclosure of systemic labor and material over-estimation rests upon in-house clerical personnel.

6. Ameren-IL lacks general contingency funding for large unexpected projects. (Recommendation V-40)

Ameren-IL budgets contingency funds to replenish spare circuit breaker and transformer inventories as they are deployed to replace failed units. Ameren has in place a CRC and checkbook process for transmission and substation projects that allows for adjustments in spending due to unexpected projects. Ameren-IL should improve this process so that it does not place operating and maintenance funds at risk when such contingency funding needs arise.

7. Ameren's construction process lacked a Quality Assurance function. (Recommendation V-41)

Ameren-IL's overall construction process lacked a Quality Assurance function in 2006. Although Ameren-IL established a Quality Assurance program in late 2007 and this is a positive step to address this deficiency, it is too early to determine whether this organization will be effective in its objectives.

9. Recommendations

V-38 Conduct initial selection and budget estimates with finer grade cost estimates when satisfactory alternatives have costs of the same order of magnitude.

Current estimation accuracies of 25 to 30 percent may result in improper alternative selection when comparing projects alternative projects that meet system requirements. Ameren should begin this effort immediately and complete the budgeting estimate process changes for implementation within one year of the date of this report.

In its comments on the draft report, Ameren-IL states that for planning and selection purposes the industry practice is to use a 30 percent estimate. Liberty disagrees and also notes that Ameren-IL uses its 30 percent estimate for budgetary purposes.

V-39 Change final project variance review triggers and process to provide effective and independent cost review.

Ameren-IL should adjust review triggers to better identify proper thresholds for meaningful and independent cost reviews. Ameren-IL should base final project cost reviews on revised thresholds by personnel of authority and independence to preclude conflicts of interest. Results of cost reviews should go to appropriate stakeholders for corrective action. Ameren should complete the review and process modifications within six months of the date of this report.

V-40 Improve the process for contingency funding of large unexpected projects.

Ameren-IL budgets contingency funds to replenish spare circuit breaker and transformer inventories as it deploys them to replace failed units. Ameren has in place a CRC and checkbook process for transmission and substation projects that allows for adjustments in spending due to unexpected projects. Ameren should review alternatives for funding and budgeting in the most cost effective and compliant accounting method. Ameren should complete the review within three months of the date of this report.

V-41 Implement the new Quality Assurance program for construction projects.

Ameren-IL indicated that it has already met this recommendation. Liberty documents the recommendation for follow-up during the verification phase of this investigation. (Also, see Recommendation I-1 in Chapter I of this report.)

H. The Effects of Planning, Design, Construction, and Protection on the 2006 Storms

This section addresses the question of whether Ameren-IL's system planning criteria, design, construction practices, or system protection practices contributed to the negative effects of the 2006 storms. It also addresses the question of whether the environmental conditions such as wind and ice exceeded the design basis of Ameren-IL's electric delivery systems during the 2006 storms.

1. Planning

For the purposes of system planning, Ameren-IL's electric delivery system contains three parts. The distribution system is the portion that operates at 15,000 volts and below. The sub-transmission system is the portion that operates at 34,500 and 69,000 volts; Ameren considers the sub-transmission system part of the distribution system. Liberty separates sub-transmission facilities here because the Ameren-IL companies' approach to planning differs from that done for the lower voltage distribution facilities. The transmission system is the portion that operates at 138,000, 161,000, and 345,000 volts.

A planning criterion for most of the distribution system is that any fault or system event that causes an outage will in turn cause a loss of load and customer interruptions. This is the same planning criterion used by most electric utilities. It would be very expensive and impractical to plan the distribution system such that a single event would not cause customer interruptions. Where there is redundancy in the distribution system, it is generally in downtown urban areas with high electric load density or in locations where individual customers elect to pay for it. Most of the interruptions that occurred during the 2006 storms resulted from events (such as trees falling on poles or lines) on the distribution system. Even if the Ameren-IL companies planned their distribution systems so that single events would not cause interruptions, the result during the 2006 storms would have been much more system damage and a large number of customer interruptions with outages on both of the redundant electric supplies. The other alternative for the distribution system is to have more of it placed underground. The distribution system can be underground in the form of a network installation or as a direct buried cable system. By placing the distribution system underground, it is much less susceptible to damage and the resultant customer outages like those that occurred during the storms of 2006.

However, there are drawbacks to underground electric distribution systems. Those drawbacks are high cost and increased outage time if a failure occurs. To reduce outage time associated with underground distribution systems, some systems contain redundancy, which adds to the costs. In places like New York City and downtown Chicago, utilities design portions of the electric distribution system in a network. In this arrangement, there are multiple electric supplies such that a single event will not cause customer interruptions. Ameren-IL has three small underground networks in its system located in Champaign, Peoria, and Decatur. Expansion of these networks or the establishment of new networks is not economically practical unless there is a large concentration of load. Such is not the case for the majority of the Ameren-IL system.

The other popular underground system is the use of direct buried cable, which is in customer yards and neighborhoods. It requires excavation for installation and replacement. Moreover, the

normal life expectancy of direct buried cable life is shorter than other methods of electric distribution. Again, this method is not economically practical for much of the Ameren-IL system.

Liberty concluded that Ameren-IL's distribution system planning radial design significantly contributed to the negative effects of the 2006 storms. The storms caused outages in the distribution system and the outages resulted in service interruptions to customers. However, alternatives to Ameren-IL's distribution system planning would be impractical, extremely costly, and may not have materially reduced the number of customer interruptions. Based on its review of the 2006 storms, Liberty does not recommend any changes to Ameren-IL's distribution system planning criteria.

The layout of the sub-transmission portion of the electric delivery system is either looped or radial. The looped portion allows for the supply of electricity from more than one source. A planning criterion for this portion of the system is that any single event or outage will not cause a loss of load or customer interruptions. This design requirement forces redundancy in the system and provides alternative paths to serve customers during storm events. Radial parts of the sub-transmission system feed the distribution system without this redundancy. Single events or outages in these parts of the system will cause interruptions to customers. Ameren-IL's system planning for sub-transmission is the same as that used by most electric utilities in the United States.

The tables below show that in both the July and November/December 2006 storm events, Ameren-IL quickly restored service to customers interrupted due to sub-transmission system outages. The data also imply that the sub-transmission system was quickly available to pick up lower distribution voltage customers. The ability to restore service quickly after a major storm event was attributable in part to sub-transmission system planning (*i.e.*, the looped design).

Sub-Transmission System Outages
Customer Restoration Pace During the July 2006 Storms[340]

Day and Time	Customers Interrupted that Day	Customers Restored that Day	Percent Customers Restored that Day	Net Customers Remaining Out
7/19/06 12 a.m.	52,810	24,222	46	28,588
7/20/06 12 a.m.	6,201	9,634	28	25,155
7/21/06 12 a.m.	16,097	29,340	71	11,912
7/22/06 12 mid	68	11,980	100	0

[340] Response to Data Request #432.

Sub-Transmission System Outages
Customer Restoration Pace During the November 2006 Storm[341]

Day and Time	Customers Interrupted that Day	Customers Restored that Day	Percent Customers Restored that Day	Net Customers Remaining Out
11/30/06 12 a.m.	69,883	25,927	37	43,956
12/1/06 12 a.m.	50,833	88,698	94	6,091
12/2/06 12 a.m.	752	6,101	89	742
12/3/06 12 a.m.	1473	2,214	100	1

Liberty concluded that Ameren-IL's sub-transmission system-planning design significantly mitigated the effects of the 2006 storms. Analysis of the 2006 storms does not suggest any changes to Ameren-IL's basic sub-transmission system planning that would make it less susceptible to storm damage and the resultant interruptions.

Ameren-IL's planning criteria for the transmission system is similar to, but more stringent than that used for the sub-transmission system. That is, non-radial portions of the system require two or more overlapping outages before there are customer interruptions. During the July 2006 storm, there were eight sustained transmission system outages, but none of them resulted in Ameren-IL retail customer interruptions and only three resulted in wholesale customer interruptions.[342] During the November/December 2006 storm, there were eleven sustained transmission system outages, five of which resulted in Ameren-IL retail customer interruptions. Three of those outages also resulted in wholesale customer interruptions and two others interrupted wholesale customers only.[343] Five of the outages related to failed shield wires[344] and accounted for four of the load interruption events. These shield wire failures likely indicate a weakness in that equipment rather than the design of the transmission system itself. Refer to the section below on design for an additional discussion of shield wire failures.

The tables below show that in both the July and November/December storm events, the transmission system quickly picked up the customers it served, the sub-transmission system it served, and was ready to pick up lower distribution voltage customers. The ability to pick up customers quickly after a major storm event is in part attributable to system planning (*i.e.*, the looped design) of the transmission system.

[341] Response to Data Request #473.
[342] Response to Data Request #139.
[343] Responses to Data Requests #139 and #582.
[344] A shield wire is a wire that is above the current carrying conductors and grounded to protect the current carrying conductors from lightning strikes.

July 19-23, 2006, Transmission-Caused Customer Outages and Duration

Retail Customers		Wholesale Customers	
Number	Duration (Hours)	Number[345]	(Hours)
None	N/A	2 1 1	2.7 Unknown[346] 0.7

November 30 – December 1, 2006, Transmission-Caused Outages and Duration

Retail Customers		Wholesale Customers	
Number	Duration (Hours)	Number[347]	Duration (Hours)
2,285 1,009 1,652 1,377 917 729 1,587 596 Unknown	50.8 37.1 0.7 0.8 0.3 0.3 28.6 Unknown[348] Unknown[349]	1 1 4 2 1 7	Unknown[350] 20.9 0.3 28.6 8.1 Unknown[351]

Liberty concluded that Ameren-IL's transmission system planning design significantly mitigated the effects of the 2006 storms. Analysis of the 2006 storms does not suggest any changes to Ameren-IL's transmission-system planning criteria that would make it less susceptible to storm damage and the resultant interruptions.

2. Design

a. The National Electrical Safety Code

Utilities design electric delivery systems to standards that provide structural integrity under specified conditions. The National Electrical Safety Code (NESC) is the most widely used standard. The NESC specifies moderately high environmental conditions (*e.g.*, wind and ice) and requires different overload factors for different grades of construction. Grades B and C are the most common.[352] The general good performance of systems constructed to the NESC is due in large part to these large overload factors. The IEEE[353] updates the NESC from time to time.[354]

[345] Ameren does not know the true number of customers served by a wholesale delivery point and counts a wholesale delivery point as one customer.
[346] Customer has alternate electric supply feed.
[347] Ameren does not know the true number of customers served by a wholesale delivery point and counts a wholesale delivery point as one customer.
[348] These customers were already out of service for other reasons.
[349] These customers were already out of service for other reasons.
[350] This customer was not an Ameren wholesale customer.
[351] These customers were already out of service for other reasons.
[352] Grade B construction has larger overload factors used in its design than Grade C and is therefore stronger.
[353] The IEEE (Institute of Electrical & Electronic Engineers) publishes the NESC (National Electrical Safety Code).

The Ameren-IL companies constructed their electric delivery systems to standards that were identical to or consistent with the NESC.[355] At the time of the 2006 storms, the applicable standard was the 2002 version of the code. The companies constructed many distribution circuits and transmission lines in compliance with prior NESC versions, and thus may not have fully complied with the 2002 code. The NESC does not require updating or rebuilding systems to new requirements. However, this is not a significant issue in the case of structural integrity because the code's design parameters have not materially changed for many years.[356]

The 2002 NESC base loading design parameters for the Ameren-IL area are:[357]

- Wind: 4 psf[358] (Approximately 40 mph wind)
- Ice: 0.5" radial ice
- Overload Factors (Grade B)
  - Transverse Wind: 4.0
  - Vertical: 2.20
  - Wire Tensions: 2.0
- Overload Factors (Grade C)
  - Transverse Wind: 2.00
  - Vertical: 2.20
  - Wire Tensions: 1.33
- High Wind (for structures taller than 60 feet)
  - Transverse Wind: 80 mph (Prior to NESC 2002 Code)
  - Transverse Wind: 90 mph (NESC 2002 Code and later)

Using the above parameters, the table below shows the design and expected horizontal loads for a typical distribution structure.[359]

Design and Expected Wind Horizontal Loading in Pounds per Foot

Grade B - Heavy Load Design	Grade C – Heavy Load Design	High Wind (80 mph)	High Wind (90 mph)
2.48	1.24	1.56	2.00

This table shows that typical Grade B construction can withstand 80 mph and 90 mph winds[360] with a significant margin. However, winds of 80 mph and 90 mph exceed the loading capability of Grade C construction.

The next table shows the amount of ice required to exceed the Grade B and Grade C construction requirements for the same typical distribution structure.

[354] For example, the 2007 version of the NESC added a concurrent wind and ice-loading requirement to the long established standalone wind and ice loading requirements.
[355] Interviews #118 and #119, December 20, 2007, and responses to Data Requests #238, #290, #291, and #463.
[356] Liberty's review of past NESC codes.
[357] NESC Table 253-2.
[358] Pounds per square foot.
[359] NESC Heavy Load area and 477-kcmil conductor, where kcmil is means a thousand circular mils or about 1/32-inch of cross sectional cable area.
[360] Assumed to be 90 degrees for design purposes.

Inches of Radial Ice[361] and Wind to Exceed Grade B and Grade C NESC Design Loadings

	Grade B	Grade C
30 mph Horizontal Wind	2.50	1.375
40 mph Horizontal Wind	1.25	0.800

The horizontal forces constructed into a typical[362] transmission structure are 2.81 pounds per foot of wire under Heavy Load[363] wind and ice design conditions and 1.96 pounds per foot of wire with 80 mph wind and no ice.

The Ameren-IL companies used a variety of legacy-company, Ameren corporate, and project-specific design standards.[364] The Ameren distribution standards allow Grade C construction for urban areas, Grade B for railroad, highway, and waterway crossings, and a Grade N for rural applications if there are no communication conductors on the pole. Historically Ameren-IP used Grade B for urban areas and Grade C for rural areas. By July 2006, Ameren-IP used Grade B construction for nearly all construction. Prior to the merger in 2003, Ameren-CILCO used Grade C construction except where the NESC required Grade B. Since the merger in 2003, Ameren-CILCO used Grade B construction as a minimum. Ameren-CIPS and Ameren-CIPS-UE used the Ameren standards since 1997.

b. July 2006 Storms

The July 2006 storms were wind events. According to reports from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), on July 19, 2006, trained spotters saw two tornados, and there was one report of a 90 mph wind. There were three other reports of winds of approximately 70 mph July 19, 2006.[365] The National Weather Service also reported that there were "widespread damaging winds estimated around 90 mph."[366] There were five tornados reported on July 21, 2006, four were class F0 (40-72 mph) and one was a class F1 (72-112 mph).

Wind gust observations contained in the NWS metered observation data included 19 observations on July 19, 2006, in which the highest two Illinois observations were 55 mph gusts in Alton, IL.[367] The data also included twelve observations on July 21, 2006, with the highest observation of 48 mph in Belleville, IL.[368]

As demonstrated above,[369] 90 mph winds produce loadings within the design capabilities of transmission and distribution facilities constructed to NESC Grade B. Winds of 80 mph or less can exceed Grade C loading. Liberty concluded that it is likely that electric delivery system facilities constructed in accordance with NESC 2002 Grade B standards did not fail due to the

[361] Vertical icicles would be twice the values shown.
[362] 795-kcmil conductor.
[363] The Ameren-IL service territory is in the geographic area defined by the NESC as "Heavy Load" area.
[364] Interviews #103, #104, and #105, #118, and the responses to Data Requests #232 and #238.
[365] http://www.crh.noaa.gov/ilx/?n=2006-jul19
[366] http://www.spc.noaa.gov/archive/.
[367] http://www.spc.noaa.gov/archive/.
[368] http://www.spc.noaa.gov/archive/.
[369] For the wire type used in the illustration.

July 2006 winds alone.[370] Because the NESC Code has not significantly changed for the past 25-30 years, it is also likely that transmission, sub-transmission, and distribution facilities designed for Grade B according to past NESC Codes did not fail from the wind alone. Liberty also concluded that facilities designed according to NESC Grade C standards could have had some failures during the July 2006 storms depending on their location relative to locations of the very high winds and the direction of the wind on the facilities.[371]

c. November/December 2006 Storm

The November/December 2006 storm was both a wind and ice event. The amount of ice accumulated is critical to performing forensic analysis calculations in comparison to the NESC design basis. Other than the gross system damage observed during this storm, it is difficult to determine whether icing severity alone contributed directly to structural damages on specific distribution facilities. Liberty noted in Chapter II of this report that Ameren-IL failed to capture sufficient photographic failure evidence for forensic damage assessment purposes.

In reviewing the wind data from the National Weather Service, the weather station at the Lawrenceville, Illinois airport recorded a peak wind speed of 58 mph on December 1, 2006. The Champaign, Illinois airport recorded a peak wind speed of 44 mph on December 1, 2006. The remaining peak wind speeds for the Illinois did not exceed 40 mph.[372] As shown above, the winds experienced during the November/December storm were less than the design basis of either Grade B or Grade C construction.

Liberty reviewed the limited available photographs in comparison with applicable NESC standards. As an example, the picture shown below[373] shows up to 2 inches of ice suspended from the wires near the pole (icicles). However, the total amount of ice on the wires longitudinally between the poles in the wire span is unknown. Liberty believes that less ice formed on the electric conductors because conductors are generally warmer than structures or trees due to the resistive heating of the wires while in service. Liberty believes that actual icing may have exceeded the 0.5” radial design by only slight amounts in limited locations.

[370] Of course, the wind could cause a tree to fall and the tree could cause an electric system structure to fail.
[371] The NESC design loadings assume all winds are at 90 degrees to the conductor.
[372] NOAA National Weather Service website.
[373] Response to Data Request #475.

This type of ice formation was consistent with the near-freezing temperatures and low wind speeds reported[374] and with the ice patterns described for these weather conditions in an industry reference guide.[375] Liberty concluded that the total icing accumulation on the wires in the November/December 2006 storm may have exceeded the amount of ice assumed in the design basis (*i.e.*, 0.5" radial ice), however not significantly. Wind speeds also were generally below 40 mph, the NESC design basis for Heavy Load conditions. A 40 mph wind with a 1.25" radial ice accumulation (or 2.5" icicles in the vertical) would exceed the NESC Grade B construction design basis. A 40 mph wind with a 0.8" radial ice accumulation (or 1.6" icicles in the vertical) would exceed the Grade C design basis. With the overload factors, the wind and icing loading should not have exceeded either the Grade B or Grade C construction design-loading basis.

Because transmission and distribution facilities were of a similar design basis, because the storm wind and ice loadings were generally below the design basis during the November/December storm, and because there was only one transmission failure and many distribution failures, Liberty concluded that the distribution failures were not attributable to design inadequacy. Therefore, distribution (including sub-transmission) structural failures were attributable to other differences between distribution and transmission facilities such as nearby trees or the condition of the facilities.

d. Storm Damage Reports

Liberty reviewed storm damage reports for the two transmission structures that failed during the July 2006 storms.[376] One structure was a pole that Ameren-IL had recently tested at 97 percent of its required strength. Ameren believes it is likely that a tornado caused its complete destruction. The other structure was a two-pole H-frame for which an April 2004 inspection identified the

[374] NWS weather station data: http://cdo.ncdc.noaa.gov/qclcd/qclcdhrlyobs.htm.
[375] Electrical Transmission in a New Era (ASCE).
[376] Response to Data Request #176.

poles as needing replacement. The storm broke both poles at the ground-line because they were in a state of decay. Liberty concluded that the design caused neither of the failures.

Ameren-IL reported broken shield wires in the 2006 storms.[377]

- Two of the lines with shield wire failures used a particular type of wire (3#7 Copperweld) installed in 1949.
- Two of the lines with shield wire failures used 5/16″ extra high strength steel (EHS) wires, one installed in 1950, and the other in 1953.
- There was one failure of another particular type of wire (7#9 Copperweld) installed in 1938.

The broken shield wires were small in diameter. They would sag between the energized conductors with 1.25" of radial ice and the transmission structures 600' apart. Under these conditions, a 20 mph wind could blow the shield wire into the energized conductors and fail the shield wire. Liberty's analysis of the 5/16" EHS and Copperweld shield wires found that at a 600' span, it would take a minimum 2.0" of radial ice to break the shield wires. The age of the shield wires could be a failure factor as all of them were in excess of 55 years old. In addition, Ameren-IL determined that Copperweld shield wires struck by lightning are subject to subsequent breakage. Liberty concluded that the most likely cause of the shield wire failures was not ice from the November/December 2006 storm.

3. Construction

Utilities construct the electric delivery system in parts over the years when required to serve new load or reinforce parts of the system. As a result, parts of the system can be decades old and constructed to different standards that exist today. There is no practical method to evaluate whether years ago construction crews followed the existing construction specifications. To evaluate the possible effects of construction practices on the impact of the 2006 storms, Liberty analyzed the available information about storm damage, outage causes, and observed system configurations to infer conclusions. As reported in the design section above, Liberty concluded that the 2006 storms generally did not produce environmental conditions that exceeded the system design bases. Therefore, assuming a correct design and no other contributing factors (such as poor maintenance or vegetation interference), good construction practices would have resulted in few equipment failures.

a. Transmission System

During the July 2006 storms, there were eight sustained[378] transmission outages, three of which interrupted wholesale customers and none of which interrupted retail customers.[379] Ameren-IL attributed two of the outages to either bad poles or a failed structure. It attributed two outages to shield wire problems,[380] labeled one as "unknown," and found no cause for another. An apparent

[377] Responses to Data Requests #139 and #571.
[378] Defined as transmission line lockouts in Data Request #609.
[379] Response to Data Request #139.
[380] One outage is not confirmed as a shield wire problem but is suspected as such.

switching misoperation at a substation caused one sustained transmission outage and a failed switch due to lightning caused the other. Because of the small effect on customers and the known outage causes, Liberty found that construction practices did not influence the effects of the July 2006 storms.

During the November/December 2006 storm, there were eleven sustained transmission outages. Three interrupted retail and wholesale customers, two interrupted retail customers only, and two interrupted wholesale customers only.[381] Five of the outages related to shield wire[382] failures. Of the remaining six transmission outages, one outage was the result of the failure of shield wire hardware, two had unknown causes, another involved an equipment misoperation at a substation, and the last was a result of structure damage.

Because the storm's conditions did not exceed the design basis, mechanical equipment failures should not have occurred unless the constructor did not follow good practices or something else caused the failure. The age of the failed shield wires was 55 to 70 years. In addition, Ameren recognized that some shield wires break after lightning strikes them.[383] There was only one instance recorded as equipment failure unrelated to the failed shield wires. Again, because of the small effect on customers and the known outage causes, Liberty found that transmission construction practices likely did not influence the effects of the November/December 2006 storms.

Liberty's observations during an aerial inspection of the transmission system reinforced this conclusion.[384] During that inspection, Liberty found that the Ameren-IL transmission system was in reasonable repair and condition for its age. New poles, new cross arms, replaced insulators, new cross braces, and pole reinforcement at the ground line were evident. There was no visible evidence of poor construction practices.

b. Sub-Transmission System

The sub-transmission system sustained more outages during the 2006 storms than the transmission system. One would expect this to be the case because Ameren-IL's sub-transmission system contains about 2,000 more miles of line than the transmission system.[385] More importantly, many sub-transmission lines are not on rights-of-way, but rather on city streets in close proximity to vegetation. In addition, those lines that are on rights-of-way have much less side clearance to vegetation than transmission lines.[386] Therefore, in addition to damage from wind and ice, which might indicate construction issues, the closer proximity of vegetation could inflict more damage on the sub-transmission system than would be the case for the transmission system.

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[381] Response to Data Request #139.
[382] A shield wire is a wire that is above the current carrying conductors that is grounded to protect the current carrying conductors from lightning strikes.
[383] Response to Data Request #553.
[384] Interview #67, November 28-29, 2007.
[385] Response to Data Request #7.
[386] Response to Data Request #45.

Liberty's approach to determine whether sub-transmission construction issues contributed to the effects of the storm was to estimate the number of cases in which trees may have caused sub-transmission outages. If an insignificant number of outages were tree related, then construction issues could come into play. However, Liberty found that vegetation might have caused about 60 percent of the 48 sub-transmission outages during the July storm, and 54 percent of the 68 sub-transmission outages in the November/December 2006 storm. Liberty's observations during the sub-transmission vegetation inspection also identified no construction issues. However, Liberty observed the smaller clearances to vegetation compared to the clearances on the transmission system. Liberty concluded that vegetation, not construction was the major contributor to sub-transmission outages during the storms.

c. Distribution System

Most of the system damage and resultant outages during the 2006 storms was on the distribution system. The distribution system is more susceptible to damage from vegetation than other parts of the system. In addition, some of Ameren-IL's distribution system is in a "back lot" configuration,[387] which is more difficult to reach with personnel, supplies, and equipment. This can result in more potential vegetation problems and longer outage durations. As reported in Chapter VI of this report, Liberty observed that some back lot tree trimming was not in accordance with Ameren-IL's vegetation standards.[388] Liberty identified no reason to suspect that construction issues had a material effect on the results of the 2006 storms.

Liberty analyzed data from the Outage Analysis System to help determine whether other aspects of distribution system construction contributed to the severity of the 2006 storms. As discussed in Chapter II of this report, Liberty found that there were many more outages related to service drops compared to the number of outages related to primary and secondary lines.[389] Liberty concluded that this result was largely because Ameren-IL's vegetation management practices for the distribution system focuses on circuit primaries and secondaries located along the streets or in rights-of-way in the rear of customer's property. Ameren typically does not perform vegetation trimming along service drop lines.[390] The July 2006 and November/December 2006 storms were wind and wind/ice events that brought down trees and branches that fell on service drops and caused more service interruptions than what occurred on primary and secondary lines because of the vegetation management practices.

Service drops typically do not have the same strength as other parts of the distribution system. The wires and connections in service drops simply cannot withstand the same forces (from, for example, wind and ice) as primary and secondary lines. The point of delivery[391] is generally at

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[387] A back-lot distribution construction configuration is one where the distribution primary and secondary wires are in the back yards of customer's property.
[388] Interview #109, December 17-21, 2007, and January 7-11, 2008.
[389] Primary lines are the conductors that are on the top of the pole on the street or in the back yard and operate at the higher distribution voltages. A transformer reduces the voltage level of the primary line to a level that can be directly used by the customer. This voltage level is the secondary voltage. Secondary lines attach to the poles for a short distance along the street and are connected to individual service drops that bring the secondary voltage level to the customer. In rural areas, service drops connect directly to the transformers.
[390] Response to Data Requests #251 and #522.
[391] The point of delivery is where the utility connects to the customer's property.

the weatherhead[392] for overhead service. The customer is responsible to ensure that the drop has adequate clearance, the connection is adequate for wind and ice loadings, and it meets the company's standards and the National Electrical Safety Code.[393] Customers generally use private contractors to perform this work and local government personnel inspect it. Ameren estimates that the time required to complete a service drop reconnection is 30 to 45 minutes once an employee arrives at the work location in non-storm conditions.[394] Liberty believes that repair time could approach an hour during storm conditions. There were 1,987 service drop repairs required in the July 2006 storms and 7,495 service drop repairs required in the November/December 2006 storm.[395] Based on a one-hour repair time, a one hour travel time, and an 8-hour day, service drop repairs alone required approximately 500 crew-days and 1,900 crew-days respectively for the two storm events.[396] Liberty concluded that the construction of service drops likely contributed to the storm's effects. However, Ameren-IL's design and construction in this regard is typical of electric utilities across the country.

4. Protection

Protection on an electric delivery system provides the capability to isolate faulted or failed equipment from the remainder of the system and thus limiting the effects of the fault or failure. Proper operation of protective devices (*e.g.*, fuses, relays operating circuit breakers, and remotely controlled switches) help limit the effects of storms. Therefore, Liberty's evaluation focused on failures of protective devices to operate properly (called misoperations) and the lack of protective devices in the Ameren-IL system.

On the transmission and sub-transmission systems,[397] Ameren-IL uses circuit breakers that open when monitoring relay systems sense faulted equipment. The circuit breakers isolate faulted, radial portions from the rest of the system. On the distribution system,[398] Ameren-IL also uses circuit breakers at substations to isolate faulted parts (feeders) of the system. However, isolation of a feeder can cause many customers to lose power. To limit the number of customers interrupted, the distribution system has fuses and other devices downstream of the circuit breaker that should limit the effect of a fault.[399]

SCADA[400] permits operators to gather data and change system configuration to limit the effects of outages. All three Ameren-IL companies have SCADA installed in the transmission and sub-transmission substations. Ameren-IP and Ameren-CIPS have very little SCADA in the

[392] The weatherhead is where the service drop attaches to the customer's building for overhead service.
[393] Response to Data Request #523.
[394] Response to Data Request #524.
[395] Response to Data Request #275.
[396] Customer outage times could be longer because attaching the service drop to the customer's building does not necessarily restore service if repairs are required to customer-owned equipment.
[397] The transmission system operates at 345,000 volts, 161,000 volts, or 138,000 volts. Sub-transmission parts of the system operate at 69,000 volts or 34,500 volts.
[398] The distribution system operates at 15,000 volts and below.
[399] A distribution circuit is comparable to a tree. The trunk represents the tie to the substation. The trunk splits into large and then smaller branches. Fuses with varying opening times are coordinated to limit problems to smaller branches.
[400] Supervisory Control and Data Acquisition.

distribution system. Ameren-CILCO has SCADA installed on 60 percent of its distribution feeders. Ameren-CIPS-UE (Alton and East St. Louis) has a significant amount of distribution system SCADA.[401]

a. Transmission System

Ameren-IL experienced two transmission misoperations on its 138,000-volt system during the July 2006 storms and four misoperations during the November/December 2006 storm. These were all momentary operations.[402] Ameren-IL also experienced three 138,000-volt problems in which SCADA was inoperative or misoperated during the November/December 2006 storm and none during the July 2006 storms. None of the SCADA problems caused circuits to trip and one was temporary in nature.[403] Liberty concluded that, based on the lack of customer impact in the form of outage or restoration problems, the transmission system protective devices and systems did not contribute to the effects of the 2006 storms and did not impede restoration.

b. Sub-Transmission System

Ameren-IL experienced no sub-transmission protection misoperations during the 2006 storms.[404] Ameren-IL experienced one 69,000-volt problem in which SCADA was inoperative or misoperated during the July 2006 storm and three 34,500-volt SCADA problems during the November/December 2006 storm.[405] Ameren-IL corrected the single SCADA problem in July four days later. One of the winter 2006 SCADA problems occurred when operators thought a remote terminal unit was out of service, and the other two events occurred on the same circuit. Liberty concluded that, based on the lack of customer impact in the form of outage or restoration problems, the sub-transmission system protective devices and systems did not materially contribute to the effects of the 2006 storms and did not significantly impede restoration.

c. Distribution System

Distribution system branches (taps) that are not fused require other upstream devices to operate to isolate faults on that branch. Problems such as a tree falling on the lines of a tap that is not fused can cause more customer interruptions than if the same event happened on a fused tap.

Ameren-IL estimated that there were 74,695 fused taps and 12,537 unfused taps (14 percent of total) on its system prior to the 2006 storms. The exact number for each division was not available.[406] In the July 2006 storms, Divisions V and VI were the hardest hit and accounted for about 79 percent of the customer interruptions.[407] For the purposes of a simplistic analysis, Liberty assumed the number of unfused taps was proportional to the number of customers served by each division. In addition, Liberty subtracted the sub-transmission and single outage orders from the total "lights-out" orders to determine that there were about 2,200 distribution outages in

[401] Response to Data Request #40.
[402] Response to Data Request #566.
[403] Response to Data Request #567.
[404] Response to Data Request #566.
[405] Response to Data Request #567.
[406] Response to Data Request #555.
[407] Response to Data Request #265.

those two divisions that could be fuse-related. Using approximations for the average number of customers on a single tap, Liberty estimated that over 8,000 customers could have experienced service interruptions because a tap in another branch did not have a fuse.[408] While this approximation is very rough, Liberty concluded that unfused taps had an influence on the effects of the July 2006 storms.

In the November/December 2006 storms, Divisions III, V, and VI were the hardest hit. Liberty determined that there were approximately 4,000 distribution outages in those divisions that could be fuse-related. A similar analysis resulted in Liberty's estimate that over 15,000 customers in those three divisions could have experienced service interruptions because a neighboring distribution branch did not have a fuse. Liberty concluded that unfused taps also had an influence on the effects of the November/December 2006 storm.

SCADA[409] use is limited on the Ameren-IL distribution system. SCADA allows operators to gather data and operate the system remotely without the requirement to send personal to remote sites and thus facilitating daily operations or restoration efforts. The magnitude of damage that took place on the distribution system in the two 2006 storms was very large. The damage required many field personnel regardless of the degree to which Ameren-IL had SCADA installed. More complete distribution automation would have aided outage reporting and identification. However, having additional remote control in the distribution system during these two significant storms would not have limited the damage, would not have been a significant help in restoration, and could have raised safety concerns with remote operation of equipment with so many people in the field.

5. Conclusions

1. Ameren-IL's system planning criteria for the transmission and sub-transmission systems mitigated some of the negative effects of the 2006 storms.

Ameren-IL's planning criteria for portions of the transmission and sub-transmission systems includes a looped design in which more than one power source can supply electricity to the loads served by those systems. This aspect of system planning helped to reduce the number and duration of service interruptions during the 2006 storms.

2. Ameren-IL's system planning criteria for the distribution system had a major negative effect on the impact of the 2006 storms. However, alternative planning criteria are not practical.

Except in limited applications, the distribution system does contain redundant power supplies. That is, a fault or an outage on the distribution system will cause customer service interruptions. The 2006 storms caused many distribution system outages and resulting interruptions. However, Ameren-IL's distribution system planning criteria were the same as most other utilities in the United States. Alternatives arrangements such as providing redundant supplies are impractical

[408] Responses to Data Requests #265, #266, #555, and #556.
[409] Supervisory Control and Data Acquisition.

and very expensive (*e.g.*, underground networks) or would have caused more storm damage and not significantly fewer interruptions (*e.g.*, redundant overhead supplies).

3. The environmental conditions in the July 2006 storms may have exceeded the design basis for parts of the electric delivery system.

The Ameren-IL companies designed the electric delivery system to withstand the loads specified in the National Electrical Safety Code (NESC). The peak winds in the July 2006 storms could have exceeded the NESC design basis for parts of Ameren-IL's electric delivery system. The design-grade loading that Ameren-IL used for most of its systems was greater than the loads created by the winds in the July 2006 storms.

4. The environmental conditions in the November/December 2006 storm did not exceed the design basis of the electric delivery system.

The wind and ice conditions present during the November/December storm did not create structural loadings greater than that used in the design of Ameren-IL's electric delivery system.

5. Construction practices did not contribute to the effects of the 2006 storms except for the construction of service drop lines.

Liberty found no indications that Ameren-IL's construction practices contributed to the bad effects of the 2006 storms. There were many outages on service drop lines, which carry the electric power from Ameren-IL's facilities to the customer's premises. Customers (or their contractors) may not have designed and constructed the service drop lines to appropriate standards. However, service drop lines often are in close proximity to trees, and vegetation caused many of these interruptions.

6. Ameren-IL's system protection for the transmission and sub-transmission systems did not contribute to the effects of the 2006 storms.

Ameren-IL's system protection on the transmission and sub-transmission systems (*e.g.*, circuit breakers that isolate faulted sections of the system) in terms of either the failure to operate or improper operations did not materially contribute to the effects of the 2006 storms.

7. Taps in the distribution system that did not contain fuses contributed to the negative effects of the 2006 storms.

Problems that occurred on distribution system taps or branches that did not have installed fuses likely caused more customer interruptions than would have been the case if there were installed fuses.

6. Recommendations

Liberty has no recommendations in this section of the report. Liberty addresses related vegetation management issues and the installation of fuses on distribution system taps in Chapter VI.

VI. Maintenance, Inspections, and System Conditions

In this chapter, Liberty uses the term Ameren-IL to mean all three Ameren companies in Illinois or a practice that is common to all three. In cases where there are differences among the companies, Liberty uses the terms Ameren-IP, Ameren-CIPS, or Ameren-CILCO. Ameren-CIPS-UE refers to the part of Ameren-CIPS in Illinois that Union Electric previously owned. Ameren-UE refers to the Ameren utility in Missouri. Ameren Services is an Ameren corporate function with responsibilities in both Illinois and Missouri. Recommendations apply to all three Ameren-IL companies unless specifically stated otherwise.

A. Objectives

This chapter contains the results of Liberty's determination of whether Ameren-IL's transmission system, distribution system, and substation[1] inspection, maintenance, reliability, and vegetation management programs and practices in place before the 2006 storms were consistent with good utility practices and applicable National Electrical Safety Code (NESC)[2] guidelines. It includes Liberty's assessment of the condition of the companies' electric delivery systems resulting from these programs and practices. Finally, this chapter addresses the extent to which these programs and practices and the condition of the system contributed to the effects of the July and November 2006 storms. Liberty makes note of related programs and practices that Ameren-IL implemented after the storms.

Liberty's objectives for the work reported in this chapter were to determine whether Ameren-IL conducted, resourced, and managed:

- Inspection programs and practices on its transmission and distribution systems and substations consistent with National Electrical Safety Code guidelines and good utility practices, and that these inspections adequately made the companies aware of system condition.
- Corrective and preventive maintenance, including vegetation management, and proactive replacement and refurbishment programs and practices on its transmission and distribution systems and substations consistent with good utility practices to maintain adequately its systems and to minimize customer service interruptions.

In addition, Liberty sought to determine whether Ameren-IL:

- Had reliability improvement programs that appropriately addressed outage causes and attempted to improve reliability and reduce customer interruptions.

[1] An electric delivery system contains high voltage lines and equipment (transmission system), lower voltage lines and equipment (distribution system), and substations that transform the voltage at various locations between the generating station and the customer.

[2] The National Electrical Safety Code, or NESC, covers basic provisions for the safeguarding of persons from hazards arising from the installation, operation, or maintenance of overhead and underground electric supply and communication lines and equipment. It includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The Institute of Electrical & Electronics Engineers (IEEE) publishes the NESC.

- Maintained its grounding, lightning protection, and animal protection systems consistent with National Electrical Safety Code guidelines and good utility practices.
- Had transmission and distribution systems and substation equipment that were in good condition before the 2006 storms.
- Had field workforces that were sufficient in numbers and training to inspect and maintain the transmission and distribution systems and substations consistent with National Electrical Safety Code guidelines and good utility practices.
- Had work practices and labor agreements that affected the use of their workforces.
- Provided adequate tools, equipment, and materials for inspection and maintenance.

Finally, Liberty sought to determine how:

- Transmission, distribution, and substation equipment conditions, and Ameren-IL's practices, affected the amount and causes of damage that occurred during the 2006 storms.
- Ameren-IL's initiatives implemented subsequent to the 2006 storms will likely reduce transmission and distribution system damage caused by any future storms.

This chapter addresses the following items included in the Illinois Commerce Commission's (ICC) Request for Proposals for this investigation:

- **4.3.2.5.7.** Distribution easements
- **4.3.2.5.8.** Vegetation management programs and practices
- **4.3.2.5.9.** Physical and electrical condition and age of facilities
- **4.3.2.5.10.** Inspection programs and practices
- **4.3.2.5.13.** Physical condition of poles
- **4.3.2.5.14.** Pole inspection programs and practices
- **4.3.2.5.15.** Maintenance programs

Along with other chapters in this report, it also addresses:

- **4.3.2.5.5.** Inspecting, testing, and maintaining the electricity delivery systems
- **4.3.2.5.6.** The hiring, training, and maintenance of the workforce
- **4.3.2.5.16.** Compliance with National Electrical Safety Code rules
- **4.3.2.5.17.** Actions to better withstand the forces of future storms
- **4.3.2.5.19.** Broken poles
- **4.3.2.4.20.** Substation equipment outages
- **4.3.2.4.21.** Utility initiatives directed at the delivery system

B. Background

Electric utilities use overhead linemen, underground linemen, and specialists to inspect, maintain, repair, and test transmission, distribution, and substation equipment. The purpose of the inspections, maintenance, and tests is to sustain reliability during the useful life of the equipment, to provide safety to the public and utility employees, and to determine when to upgrade or replace the equipment. Good utility practices include a regular and thorough

inspection of the transmission and distribution systems and substations to identify problems and monitor conditions for maintaining safety and reliability. The National Electrical Safety Code requires the inspection processes to include tracking of defects found.[3] Liberty has observed that some utilities did not sufficiently know the condition of their poles, hardware, and substation equipment because they did not have periodic and thorough inspection practices.

Electrical equipment may function adequately for many years if utilities identify and correct incipient defects and deficiencies caused by normal and extreme wear and exposure. For power lines, periodic patrol inspections generally will detect insulator, hardware, and cross arm deficiencies that could cause outages and customer service interruptions. Periodic ground-line pole inspections will detect when a pole does not have the strength required by the National Electrical Safety Code, and when the utility needs to reinforce or replace it. Weak poles can break during wind and ice storms. Utilities should proactively treat poles to extend their useable lives. Periodic servicing of line reclosers, regulators, and capacitor bank controls minimizes malfunctions that could cause or extend the duration of outages.[4] Periodic power line thermographic surveys will minimize outages caused by overheated line connections and switch contacts.[5] Installing animal and lightning protection can also reduce the number of outages.

Equipment failures and animal- and lightning-caused faults in substations can cause large-scale outages. Periodic inspections are necessary to detect obvious abnormal conditions that can eventually cause unexpected equipment failures. Circuit breakers require periodic servicing and testing to ensure that they will function when required and to detect deterioration. Power transformers require periodic inspections and insulation and oil tests to determine when they need servicing or replacement, to prevent unexpected failures. Periodic thermographic surveys of electrical connections and switch contacts in substations will identify over-temperature conditions that might cause outages. Protective relays require periodic servicing and recalibration to function as intended.[6]

Preventive maintenance practices consist of inspections, testing, and servicing to detect and prevent component deterioration and failure. Because component failures can lead to unscheduled outages and customer interruptions, a good maintenance program should include not only corrective repairs, but also proactive measures that attempt to minimize component failures.

Liberty has observed that some electric utilities place a low priority on distribution system inspection, reduce inspections by extending schedules, stop inspections to reduce expenditures,

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[3] The National Electrical Safety Code section 214A requires, in part, that "Lines and equipment shall be inspected at each interval as experience has shown to be necessary. … Any defects affecting compliance to this Code revealed by inspection or tests, if not promptly corrected, shall be recorded; such records shall be maintained until the defects are corrected. Lines and equipment with recorded defects that could reasonably be expected to endanger life or property shall be promptly repaired, disconnected, or isolated."

[4] Reclosers are devices that open a circuit when there is a fault and then attempt to energize the circuit after the fault has cleared. Voltage regulators and capacitor banks are devices that help maintain the proper voltage delivered to customers.

[5] Thermographic inspections use a device that measures heat radiating from a poor electrical connection.

[6] Protective relays measure system parameters such as the amount of electrical current, and cause circuit breakers to open and limit the effect of problems.

perform inspections with unqualified personnel, or do not make the repairs on defects found during inspections. Even when utilities have reasonable inspection programs, they sometimes do not conduct the inspections according to their own schedules. In addition, because of insufficient funding or resources, some utilities' rates of completion of work to address maintenance items discovered by the inspections produce a large backlog of relatively minor maintenance items. This accumulation of maintenance deficiencies, even when the defects are not significant individually, can produce a generally deteriorated system and contribute to poor reliability. Conditions can be worse if the backlog contains items that are more significant.

Electric utilities' measures the degree of interruptions to its customers in terms of frequency and duration by using reliability indices. Although useful as a tool for measuring system condition improvement over a long period, there are difficulties comparing reliability indices among utilities and even among areas within a utility because there may be differences in customer densities, weather patterns, vegetation concentrations, and system designs. Occasional large storms can have a significant effect on the reliability indices. If the utility knows outage causes and locations, the indices can be useful for measuring system conditions and determining where it needs maintenance and improvements. Utilities use the indices to justify maintenance work, in general, and in justifying where and what specific maintenance and other reliability improvement work it needs. Broken poles, cross arms, and insulators, malfunctioning substation circuit breakers, improper conductor clearances, failed lightning arresters, tree contact, improper protective device coordination, and un-insulated and un-grounded down guy wires are just a few of the defects that can reduce reliability for customers. Installing more lightning protection, fuses on circuit taps, line reclosers, and animal protection are a few examples of system work that can improve reliability.

It is good utility practice to track the worst performing circuits and correct defects on those circuits. Additional good practices include proactively installing additional protective devices such as fuses, reclosers, lightning arresters, and animal protection, improving protective device coordination, and performing additional tree trimming. Good utility practice identifies circuits supplying customers who experience a large number or duration of interruptions.

The State of Illinois requires that public electric utilities comply with the NESC (National Electrical Safety Code) guidelines. These guidelines set the ground rules for the safeguarding of persons during installation, operation, and maintenance of electric supply lines and associated equipment. Its purpose is not to provide electric utility reliability. Engineers use the NESC to design a safe system. However, because the NESC requires minimum line clearances and pole strengths, a minimum number of distribution line grounds, periodic inspections, and tracking of defects until corrected, compliance to the code affects system reliability. In 2006, Illinois Commerce Commission inspectors identified numerous violations of NESC requirements for guy wires and line clearances. The Illinois Commerce Commission told Ameren-IL that it should train its personnel to identify locations where distribution facilities do not comply with the NESC.

Trees and other vegetation can interfere with overhead power lines and have a significant effect on system reliability. An essential element of a utility's maintenance program is sound vegetation management. Good utility practice involves applying sufficient resources to vegetation management, inspection of tree trimming efforts, working with municipalities and

customers to balance effectively electric reliability and environmental considerations, identifying and dealing with trees that are a danger to power lines and poles, and managing effectively contractors who perform vegetation management work.

C. Chapter Summary

The organization of Ameren-IL's inspection and maintenance work was complex and presented unique management challenges. Ameren-IL managed its inspection and maintenance work like one electric utility receiving support from corporate organizations. Ameren-IL's service territory contained seven distribution divisions, three substation areas, and two transmission areas. However, it also contained differing cultures, methods, and standards from the original Ameren-IL companies and differing work rules from seven union agreements. Responsibilities for important parts of the electric delivery system, the transmission system and substations, were under the direction of an organization that did not report to the head of Ameren-IL.

Ameren-IL adequately staffed its distribution divisions and substation and relay areas with linemen, substation electricians, technicians, and contractors. However, Ameren-IL may need to increase its workforce because recent improvements in inspections methods will likely increase workloads. The staffing of substation maintenance engineers and relay engineers was not adequate to provide an acceptable amount of in-the-field technical guidance to the workforces.

Ameren-IL performed well in its inspection of transmission system poles. However, there were some weaknesses in its transmission line and substation inspection methods. Ameren-CILCO and Ameren-IP used good circuit patrol and pole inspections methods. Ameren-CIPS did not. While the number of sub-transmission system poles inspected was reasonable, none of the companies performed regular distribution pole inspections. It is likely that weak distribution poles contributed to the negative effects of the 2006 storms.

Ameren-IL's substation vegetation-management standards were reasonable and fully implemented. Ameren-IL's distribution and sub-transmission vegetation-management standards were also reasonable, but its transmission clearance standards were confusing and difficult to implement. All vegetation programs were sound, but Ameren-IL should inspect more of the vegetation contractors' work, conduct mid-cycle trimming on all tap lines, improve trimming along back-lot lines, and fully implement vegetation standards.

With some exceptions, the overall condition of Ameren-IL's electric delivery system was reasonably good. Liberty did not observe an unusually large number of items needing repair. With the exception of ungrounded guy wires in the Ameren-IP area, the number of issues related to compliance with the National Electrical Safety Code was not large or atypical. The number of condition issues noted on main lines was typical of aged distribution systems. On the transmission system, there were no specific, systemic condition issues and it was apparent that Ameren-IL had adequately maintained the system. The minor condition issues found at Ameren-IL's substations were small in number. Liberty found substation lightning protection good on transmission substations and animal protection adequate on substations with exposed, lower voltage equipment.

There were exceptions to the generally good system conditions. Weaknesses in maintenance practices adversely affected conditions in Ameren-IL's substations, particularly noticed by low oil levels, bad equipment paint conditions, and the protection provided against outages caused by animals and lightning. Ameren-IL's inspection and repair practices had not maintained the condition of distribution tap lines in consistently good condition. The poles, conductors, and equipment on the tap circuits were more aged and under-maintained than those found on the mainline circuits. Ameren-IL's distribution circuits also needed more protection from outages caused by animals and lightning.

Liberty found that Ameren-IL's transmission system inspection and maintenance practices and the condition of the transmission lines and substations did not contribute materially to the damage caused by the July and November-December 2006 storms. However, Ameren-IL's failure to inspect distribution poles, deficiencies in lightning protection on the distribution system, substation circuit breaker maintenance, vegetation practices on parts of the distribution system, and maintenance that permitted poor conditions of some distribution tap lines all contributed to the consequences of the storms.

After 2006, Ameren-IL implemented changes and improvements in its inspection and maintenance practices, including centralized management of distribution and sub-transmission line-patrol inspections, special inspections for National Electrical Safety Code compliance, and regular distribution pole inspections. Inspection and maintenance should also benefit from new local labor union agreements and Ameren-IL's monthly monitoring of maintenance and reliability work performance.

D. Work Management and Funding

1. Introduction

Utilities need to employ sound methods and tools to schedule and keep track of maintenance, repair, and inspection work. Work management methods should include accountability for successful implementation of programs and completion of required work. Utilities need to reserve or allow for the resources necessary to perform inspections and preventive maintenance. Too often when budgets or resources are strained, utilities will not perform or will cut back on preventive actions. This causes later situations that can cause a reduction in service reliability and require even greater expenditures to correct or catch up on preventive measures. Utilities should have budgeting processes that take input from those close to actual field conditions and that optimize the available resources to maintain the electric delivery system.

This section addresses work management and funding related to inspections and maintenance, exclusive of vegetation management. Section VI.I separately addresses these topics for vegetation management.

2. Findings and Analysis

a. Overview of Inspection and Maintenance Management

The Ameren-IL service territory contained three legacy companies[7] and seven distribution divisions, all of which covered service territory of more than one legacy company.[8] Each division contained multiple operating centers. Ameren-IL divided the same area into three non-contiguous substation areas that do not match the legacy companies[9] and two different transmission areas. Seven union agreements affected who can perform inspections and maintenance.[10] Organizations within Ameren-IL managed and conducted distribution line inspection and maintenance line work. Ameren Services has responsibilities in both Illinois and Missouri, and is a corporate organization that does not report to Ameren-IL. Ameren Services managed transmission system and substation inspection, maintenance, and testing work for Ameren-IL. Ameren Services used parts of the Ameren-IL organization or contractors to perform inspections and maintenance.[11]

It is common utility practice to have parts of the organization in relatively small geographic areas responsible for the distribution system and other parts in larger areas responsible for the transmission system. It is also common to have still different parts of the organization responsible for the unique requirements of substations. Some utilities use corporate-level service companies for specific functions. However, the areas of responsibility must be clear, especially when there are shared resources among the different parts of the organization.

Liberty found that Ameren-IL has the various parts of its organization working well together but that it should continue to make improvements in this area. Liberty found that in some ways Ameren-IL attempted to operate like a single utility within the overall Ameren structure, but that there remained practices unique to the three legacy companies that merged into Ameren over the last several years. This situation combined with responsibilities assigned to parts of the organization that do not report to the president of Ameren-IL, and the multiple union contracts in effect, presented management challenges. Ameren-IL should ensure that responsibility aligns with accountability. For example, the division managers are accountable for reliability in their divisions but are not responsible for important parts of the system that affect reliability. Division personnel may also be responsible for restoration from an outage but not responsible for some of the maintenance that should have prevented the outage.

The mergers brought together different inspection and maintenance practices, including inconsistent or non-existent inspection and repair recordkeeping practices. This made it difficult for management to monitor effectively the various maintenance and inspection activities discussed in the following sections of this report. Ameren-IL depended on the responsible groups within the divisions or Ameren Services to schedule and track inspection, repair, and maintenance work to completion. There was no monitoring of work completion by a centralized

[7] Ameren-IP, Ameren-CIPS, and Ameren-CILCO. Ameren-CIPS absorbed Union Electric in Illinois.
[8] Response to Data Request #4. In 2008, Ameren-IL eliminated one of the distribution divisions.
[9] Response to Data Request #533.
[10] Interview #111, December 18, 2007.
[11] Response to Data Request #544.

performance assessment group. In most cases, Ameren-IL and Ameren Services could not provide documents indicating whether the various responsible groups completed inspections and repairs in accordance with defined programs and on time.

b. Transmission System Inspections and Maintenance

Ameren Services was responsible for transmission line inspection and repair in Illinois. Ameren Services started directing the aerial transmission line and ground-line[12] pole inspections programs for the Ameren-IL companies beginning when Ameren acquired each company. One Ameren Services transmission superintendent was responsible for all transmission line and ground-line pole inspections conducted in both Illinois and Missouri.[13] Two Ameren Services transmission engineers were responsible for the two Ameren-IL transmission areas, one north, and one south of Highway I-70. Inspectors reported repair needs to the transmission engineers by e-mail or by cell phone if a repair was urgent.[14] Ameren-IL distribution linemen or contractors performed transmission system repairs. Ameren-IL did not have transmission linemen. Ameren Services notified Ameren-IL divisions of needed repairs or pole replacements. If the division did not have the resources to perform the repair, Ameren Services used a contractor.[15]

The Ameren Services transmission engineers for Illinois informally tracked the inspections and the repairs to completion either using a standard electronic spreadsheet program or paper records. There were no historical records indicating where the system needed repairs, which group made the repairs and when they made them, what caused the defect, and what could prevent recurrence.[16] Ameren reported that in 2007, the transmission engineers started using an electronic materials database program called EMPRV, which should improve record keeping.[17] However, Ameren needs to keep historical records showing whether people completed work on time.

Because transmission system problems affected Ameren-IL's service reliability and operations, Ameren-IL management should have had the means to know (1) whether Ameren Services conducted transmission-system inspection work as planned, (2) what defects the inspections found, (3) what defects Ameren Service had not yet repaired, and (3) whether Ameren Services completed line and pole work on time.

c. Substation Inspections and Maintenance

Ameren-IL has three substation areas, somewhat aligned with union jurisdictional lines, not legacy company boundaries. Each substation area contained parts of more than one company and more than one of the seven Ameren-IL union jurisdictional areas.

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[12] Ground-line pole inspections include excavating at the pole ground-lines to examine for external decay and boring the poles to examine for internal decay and voids that cause poles to weaken. Bad poles are either replaced or reinforced.
[13] Response to Data Request #544.
[14] Responses to Data Requests #16 and #17.
[15] Interview #5, October 4, 2007, and response to Data Request #16.
[16] Interview #5, October 4, 2007.
[17] Interview #5, October 4, 2007.

The Ameren Services Construction and Maintenance group was responsible for substation repair, testing, and maintenance work in the Ameren-IL service territory. One Ameren Services manager was responsible for substation construction, maintenance, and testing work in both Illinois and Missouri. One substation construction and maintenance superintendent managed the substation repair and maintenance work conducted in each substation area. Five Ameren Services substation-maintenance field engineers supported the maintenance and testing program in Illinois. These engineers dealt with specific substation issues and problems as they arose and did not monitor the quality of substation inspections, results, or repairs. They were accountable to the Ameren Services substation-maintenance engineering manager and not to the Ameren Services substation construction and maintenance managers, who were responsible for completing the substation maintenance work.

The Ameren Services Relay Construction and Maintenance group was responsible for protective relay maintenance and testing in the Ameren-IL service territory. One Ameren Services manager was responsible for relay construction, testing, and maintenance in both Illinois and Missouri. Two Ameren Services relay maintenance engineers supported the maintenance and testing program in Illinois, and were accountable to the Ameren Services relay maintenance manager.

In some parts of the Ameren-IL service territory, substation electricians performed inspections. In other parts, distribution linemen conducted substation inspections. The reason for this arrangement was differences in union agreements. The distribution linemen who performed substation inspections did not report directly to the substation superintendents.

Electricians or linemen inspected some substations on a monthly basis and others on a weekly basis. Reporting of inspection results was verbal or on paper forms. Some of the forms were unique for a particular substation and others were generic. Many substations are different from one another. They contain different equipment to inspect and different readings to take. Generic forms are either long and contain irrelevant items or are too short and can lead to missed inspection items.

Ameren Services used a material management database called EMPRV[18] to plan and track maintenance and testing work and to record completions. The system did not indicate whether people completed the work on time.[19]

Ameren Services also managed and conducted substation protective relay testing work. Ameren-CILCO and Ameren-CIPS tracked relay test data and dates in Ameren's Powerbase database. Ameren-IP tracked its testing schedule in a spreadsheet program and used another program to maintain test results. Ameren-IP was in the process of transferring test data and dates to the Powerbase system. Ameren Services standardized relay-testing schemes using a relay test program called RTS. It scheduled and tracked relay repair work using a program called Trouble Ticket.[20]

Ameren reported some changes to substation inspections and maintenance since 2006.

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[18] Electronic Data Systems Corp. Maintenance Process Reengineering Vision.
[19] Responses to Data Requests #23 and #560.
[20] Response to Data Request #552, Interview #32, December 2, 2007, and Interview #158, April 14, 2008.

- Ameren Services planned to implement an electronic inspection data-gathering system containing a database of equipment in each substation.
- Ameren Services implemented a semi-annual substation inspection program to supplement the weekly and monthly inspections. Substation maintenance electricians will perform these inspections.[21]

d. Distribution Line Inspection and Maintenance

Management Issues[22]

Ameren-IL had seven distribution divisions, each responsible for conducting all distribution and sub-transmission line and pole inspection, repair, and maintenance work within the division. However, company boundaries and union jurisdictions in effect further sub-divided each division because of differing cultures, work methods, standards, and labor rules. In some cases, a division had separate electrical superintendents to manage different company areas. Some linemen in a division could not work in certain geographic areas within the division due to contractual constraints. Pole inspections varied from area to area in the depth of the inspection and by whether in-house linemen or contractors performed them. In cases where contractors performed ground-line pole inspections, Ameren Services managed the contractors. Measurement of the timely completion of inspections and repairs was difficult or impossible because record keeping was poor or non-existent. Centralized oversight of division inspection and maintenance work by Ameren-IL was informal or non-existent.

Ameren-IL reported that several changes made since 2006 addressed these matters.

- In 2007, Ameren-IL centralized much of its distribution and sub-transmission line-patrol inspection and ground-line pole inspection work, using Ameren Services' line inspection contractors to conduct the inspections. Some divisions retained line inspection responsibilities until 2008, when changes in union agreements allowed more use of line inspection contractors.
- Also in 2007, Ameren-IL implemented centralized tracking of line repairs. Ameren-IL implemented a tracking method that allowed convenient executive and peer review of inspection, maintenance, and reliability work completions.
- Ameren-IL started conducting a reliability action-plan performance process, which included monthly meetings. Ameren-IL executives conducted the meetings attended by division managers and managers from substation, relay, reliability, vegetation, safety, and other groups. Ameren Services' transmission group was not part of this monthly reporting and repair performance indices.
- New labor agreements improved the Ameren-IL's ability to use linemen and contractors effectively. Ameren-IL moved line and ground-line pole inspection responsibility from the divisions to Ameren Services.

[21] Interview #173, May 5, 2008.
[22] Interviews Nos. 30 through 36, October 30, 2007 through December 5, 2007.

Work Management Tools[23]

All of the divisions used the same resource and job management systems. These were the:

- Customer Service System (CSS) to track new customer requests
- Outage Analysis System (OAS) to track new emergent and small, one-person line repair tasks
- Distribution Operational Job Management (DOJM) system to schedule resources for larger construction, maintenance, and reliability jobs
- Work Prioritizing and Scheduling (WPS) program to generate various reports needed to track planned jobs from being engineering to completion.[24]

These programs did not record job completion history (*e.g.*, pole replacements, completed inspections) and did not indicate whether the divisions completed jobs on time.

Supervisors or engineers entered into the DOJM system inspection, maintenance, reliability jobs, and other work with required start dates. The divisions reserved about 30 percent of workforce in the DOJM system for future maintenance and reliability work. They scheduled most, but not all, linemen using the DOJM system. Some linemen were not included with the scheduled work to cover contingencies such as handling emergent repair jobs or to fill short crews without disrupting scheduled work. The DOJM system assisted supervisors in scheduling by calculating future workforce needs using estimated person-hour requirements for each type of job scheduled. The programs also helped supervisors manage changes in job start times caused by weather and other issues. Each division used DOJM/WPS reports to review scheduled jobs status and planned work for the following week. The DOJM/WPS programs were good scheduling tools that helped to effectively maximize workforce efficiencies.

The companies used different methods for tracking planned versus timely completion of distribution inspections, repairs, and maintenance jobs. Ameren-IP uses its Electric Compliance System (ECS) program; Ameren-CILCO used a standard database program; and Ameren-CIPS did not formally keep these records.

Liberty reviewed and observed the use of the Distribution Operational Job Management (DOJM) system in division offices. It provided good tools for work management. It provided the capability to generate the type of reports and status that supervisors and management need for day-to-day work management. Although the divisions moved some job start dates forward, and each division had about three months of booked workload, the divisions did not have past-due repair work, or lists of incomplete repair tasks. However, Liberty was unable to verify line inspection, repair, maintenance, and pole replacement completions because record keeping of completed work was inconsistent or incomplete.

Ameren-IL provided to troublemen, the one-man crews that usually are the first to respond to outages, and to the repair crews in one division, mobile data terminals (MDTs), which were essentially truck-mounted laptop computers. The troublemen's MDTs permitted direct input to the Outage Analysis System. This saved time and paperwork required to receive and close jobs.

[23] Interviews Nos. 30 through 36, October 30, 2007 through December 5, 2007.
[24] Response to Data Request #171.

The MDTs also had digital system maps and satellite-based global positioning software to save time locating job locations.

In 2007, Ameren-IL began using CDIS (Circuit Device and Inspection System), an electronic inspection and maintenance scheduling, tracking, and recordkeeping system. CDIS should help to resolve the companies' inconsistent or lack of record keeping of distribution line and equipment inspection and maintenance work completions that occurred prior to 2007.

e. Funding

Budgeting

Ameren's Central Review Committee (CRC) managed Ameren-IL's annual capital and O&M (operating and maintenance) budgeting process. It determined the funds available for each of the Ameren-IL companies based on income, cash flow, and borrowing ability. The various division and corporate engineering groups that manage the transmission, substation, and distribution work submitted inspection, maintenance, and reliability capital and O&M budgeting needs to the CRC. Ameren prepared capital budgets five years in advance and O&M budgets two to three years in advance. The process starts each year in the first quarter and completes by the end of the year with approval by the Ameren board of directors. During the process, stakeholders have the opportunity to review budget decisions and to change planned projects as appropriate.[25]

Managers, superintendents, and supervisors developed O&M budget requests for future inspection and maintenance work on historical needs, changes in workforces, and other factors. Division managers reported that they received sufficient O&M funding each year to fund at least 30 percent of each division's workforce person-hours for maintenance and reliability O&M work.[26]

Prior to 2006, Ameren used its Service Availability Cost Factor (SACF) scoring process for prioritizing reliability projects based on the cost and projected reliability effect of each program. In 2006, for the 2007 through 2009 budgeting timeframe, Ameren implemented its new Integrated Spending Prioritizing (ISP) tool that included reliability and cost impacts for prioritizing capital budgets. The new program was a more sophisticated decision support tool. Project owners could enter estimated costs, expected reliability improvement, customer-satisfaction improvement data, and other information directly to the ISP tool from their computer terminals.[27]

Expenditures

Liberty analyzed the maintenance expenditures of the Ameren-IL companies. Liberty's review was not an in-depth study of expenditures as one might perform in a rate case. Rather, Liberty simply sought to determine whether expenditures in recent history or in comparison among the companies pointed to anomalies or indicators of problems in the areas of maintenance and

[25] Interview #29, October 22, 2007.
[26] Interviews Nos. 30 through 36, October 30, 2007, through December 5, 2007.
[27] Response to Data Request #293.

inspections. The tables on the following pages provide a summary of the data reviewed.[28] Other than the effect of the 2006 storms, this analysis did not point to any problem areas. The Ameren-IL companies were consistent over the years and among the companies in maintenance expenditures. The measures Liberty calculated (*e.g.*, distribution maintenance expense per customer) were in line with Liberty's experience with other utility companies. The effect of the 2006 storms was most noticeable from the significant increase in 2006 for distribution maintenance of overhead lines.

Ameren-IP

year	**2006**	**2005**	**2004**
Transmission Expense Maintenance of Overhead Lines	$2,455,921	$2,326,813	$2,033,988
Change from previous year	5.5%	14.4%	-11.3%
Transmission Line Miles	1,820		
Maintenance of Overhead Lines per (2006) mile	$1,349	$1,278	$1,118
Total Transmission Maintenance Expense	$3,492,645	$3,377,311	$4,643,520
Distribution Expense Maintenance of Overhead Lines	$45,290,001	$30,683,438	$29,730,402
Change from previous year	47.6%	3.2%	-0.1%
Distribution Overhead Line Miles	18,888		
Maintenance of Overhead Lines per (2006) mile	$2,398	$1,625	$1,574
Distribution Expense Maintenance of Underground Lines	$1,579,573	$1,705,753	$2,265,334
Change from previous year	-7.4%	-24.7%	8.7%
Distribution Underground Line Miles	2,594		
Maintenance of Underground Lines per (2006) mile	$609	$657	$873
Total Distribution Maintenance Expense	$60,128,859	$42,605,903	$43,526,155
Average Number of Customers	542,546	536,665	532,547
Distribution Maintenance Expense per Customer	$111	$79	$82
T&D Substation Maintenance Expense	$7,604,027	$6,567,246	$6,316,940
Change from previous year	15.8%	4.0%	-13.7%
Number of Substations	739		
Maintenance Expense per (2006) Substation	$10,290	$8,887	$8,548
Total Transmission & Distribution (T&D) Maintenance	$63,621,504	$45,983,214	$48,169,675
Change from previous year	38.4%	-4.5%	-3.8%
Total T&D Maintenance Expense per Customer	$117	$86	$90
Transmission Plant Capital Additions	$5,515,487	$12,734,911	$7,453,974
Distribution Plant Capital Additions	$128,005,597	$115,812,353	$93,712,689
Total T&D Capital Additions	$133,521,084	$128,547,264	$101,166,663
T&D Capital Additions per Customer	$246	$240	$190

[28] http://eforms1.ferc.gov, responses to Data Requests #6, #7, and #307.

Ameren-CIPS			
year	2006	2005	2004
Transmission Expense Maintenance of Overhead Lines	$2,912,288	$2,158,341	$1,715,244
Change from previous year	34.9%	25.8%	-28.1%
Transmission Line Miles	2,315		
Maintenance of Overhead Lines per (2006) mile	$1,258	$932	$741
Total Transmission Maintenance Expense	$4,512,207	$3,558,529	$3,152,913
Distribution Expense Maintenance of Overhead Lines	$21,818,233	$16,664,652	$14,728,653
Change from previous year	30.9%	13.1%	-8.8%
Distribution Overhead Line Miles	13,174	13,174	11,925
Maintenance of Overhead Lines per mile	$1,656	$1,265	$1,235
Distribution Expense Maintenance of Underground Lines	$968,190	$271,119	$555,779
Change from previous year	257.1%	-51.2%	105.4%
Distribution Underground Line Miles	1,669	1,669	1,517
Maintenance of Underground Lines per mile	$580	$162	$366
Total Distribution Maintenance Expense	$32,958,562	$25,986,085	$23,731,343
Average Number of Customers	331,991	314,383	277,145
Distribution Maintenance Expense per Customer	$99	$83	$86
T&D Substation Maintenance Expense	$7,330,809	$6,825,829	$6,215,310
Change from previous year	7.4%	9.8%	15.8%
Number of Substations	558	558	487
Maintenance Expense per Substation	$13,138	$12,233	$12,762
Total Transmission & Distribution (T&D) Maintenance	$37,470,769	$29,544,614	$26,884,256
Change from previous year	26.8%	9.9%	-2.7%
Total T&D Maintenance Expense per Customer	$113	$94	$97
Transmission Plant Capital Additions	$18,908,106	$517,280	$6,724,377
Distribution Plant Capital Additions	$48,867,177	$39,120,662	$29,933,360
Total T&D Capital Additions	$67,775,283	$39,637,942	$36,657,737
T&D Capital Additions per Customer	$204	$126	$132

Ameren-CILCO			
year	2006	2005	2004
Transmission Expense Maintenance of Overhead Lines	$688,731	$1,177,705	$743,803
Change from previous year	-41.5%	58.3%	508.7%
Transmission Line Miles	332		
Maintenance of Overhead Lines per (2006) mile	$2,074	$3,547	$2,240
Total Transmission Maintenance Expense	$1,081,920	$1,516,829	$1,389,587
Distribution Expense Maintenance of Overhead Lines	$9,519,785	$6,311,216	$7,147,264
Change from previous year	50.8%	-11.7%	4.1%
Distribution Overhead Line Miles	6,530		
Maintenance of Overhead Lines per (2006) mile	$1,458	$967	$1,095
Distribution Expense Maintenance of Underground Lines	$1,148,120	$785,276	$1,081,716
Change from previous year	46.2%	-27.4%	-24.7%
Distribution Underground Line Miles	2,188		
Maintenance of Underground Lines per (2006) mile	$525	$359	$494
Total Distribution Maintenance Expense	$15,128,912	$11,653,902	$12,073,942
Average Number of Customers	185,600	182,059	161,597
Distribution Maintenance Expense per Customer	$82	$64	$75
T&D Substation Maintenance Expense	$2,402,555	$3,441,232	$2,998,599
Change from previous year	-30.2%	14.8%	-10.7%
Number of Substations	183		
Maintenance Expense per (2006) Substation	$13,129	$18,805	$16,386
Total Transmission & Distribution (T&D) Maintenance	$16,210,832	$13,170,731	$13,463,529
Change from previous year	23.1%	-2.2%	1.2%
Total T&D Maintenance Expense per Customer	$87	$72	$83
Transmission Plant Capital Additions	$7,972,108	$19,575,272	$918,134
Distribution Plant Capital Additions	$36,508,053	$32,176,187	$24,375,457
Total T&D Capital Additions	$44,480,161	$51,751,459	$25,293,591
T&D Capital Additions per Customer	$240	$284	$157

3. Conclusions

1. The organization of Ameren-IL's inspection and maintenance work was complex and presented unique management challenges. (Recommendation VI-1.)

Ameren-IL managed its inspection and maintenance work like one electric utility receiving support from corporate organizations. Ameren-IL's service territory contained seven distribution divisions, three substation areas, and two transmission areas. However, it also contained differing cultures, methods, and standards from three companies and differing work rules from seven union agreements. Responsibilities for important parts of the electric delivery system, the transmission system and substations, were with an organization that did not report to the head of Ameren-IL.

It takes time to assimilate the policies and procedures from different companies. Union Electric's acquisition of CIPS in December 1997 formed Ameren. Ameren grew with the acquisition of CILCO in 2003 and Illinois Power in 2004. It is not surprising that processes remain from these long-standing companies. The acquisitions came with different union agreements that cannot change abruptly. However, there are clear advantages to management of inspection and maintenance work as one large utility. Ameren-IL can implement the best practices of the three companies and draw upon best practices from Ameren-UE. There can be efficiency gains and improved problem solving over the larger base of Ameren-IL.

There can also be disadvantages from having too much centralization of key functions, particularly when those functions do not report to the management of Ameren-IL. For example, having the substation inspection and maintenance function controlled by Ameren-IL instead of Ameren Services could bring this important aspect of service reliability closer to those directly responsible for that reliability. It could also lead to a more rapid development of consistent practices among the three Illinois companies.

Ameren-IL should continue to seek consistency in inspection and maintenance practices. It should also evaluate those functions currently managed by Ameren Services to determine whether some would be more effective if they were directly under Ameren-IL management.

2. Accountability of electric service reliability did not align with the responsibilities for inspections and maintenance that affected reliability. (Recommendations VI-2 and VI-3.)

The Ameren-IL distribution divisions were accountable for service reliability (*i.e.*, the number and duration of service interruptions). However, a different part of the Ameren organization, Ameren Services, was responsible for inspection and maintenance of the transmission system and substations, both of which affect service reliability.

Liberty found that Ameren-IL and Ameren Services have been working well together and cooperating. However, this working relationship was somewhat informal; no documentation clearly established the responsibilities. Ameren and Ameren-IL should make these responsibilities clear. Accountability and goals should align with responsibilities. The divisions should be accountable only for those aspects of service reliability that they manage. Under the existing organization, Ameren Services should be formally accountable for fulfilling its inspection and maintenance responsibilities.

The Ameren-IL distribution division engineers reported to the division managers, who had overall responsibility for maintenance in their divisions. However, the Ameren Services' substation and relay maintenance engineers reported to the maintenance-engineering manager and not to the substation area superintendents, who had overall responsibility for the substations and relay maintenance work completed in their areas. These engineers should be important for technical compliance of the maintenance work and should be accountable directly to the substation area management.

3. Records did not show whether Ameren-IL and Ameren Services completed inspection and maintenance tasks on time and in accordance with defined programs. (Recommendation VI-4.)

Ameren-IL and Ameren Services used several different formal and informal work management tools for various inspection and maintenance tasks. In general, however, these tools did not indicate whether completion of these tasks was consistent with schedules and programs. This made it difficult or impossible for management to monitor effectively maintenance and inspection activities. There was no central monitoring of work completion. Ameren-IL depended on the responsible groups within the divisions or Ameren Services to schedule and track inspection, repair, and maintenance work to completion.

Ameren-IL implemented or reported that it planned to implement several changes in the way it schedules and tracks work after 2006. It is not clear that these changes will permit a clear determination of whether responsible groups completed work on time and what work they have in backlog.

4. There were weaknesses in the substation inspection and maintenance processes. (Recommendations VI-1, VI-4, and VI-5.)

In addition to the issue of task completion record keeping noted in the conclusion immediately above, substation inspection and maintenance processes had the following weaknesses:

- Substation supervisors did not have direct control over managing all substation inspections. Linemen, who were not accountable to substation supervisors, were inspecting some of the substations.
- Substation maintenance engineers were not involved in the substation inspection process. They did not review inspection and repair procedures and inspection results.
- Recording of inspection results used paper forms, some of which were in a generic format that could lead to inspection errors and omissions. Some utilities have used an electronic data gathering system for years.

5. Ameren-IL's distribution divisions used good work management tools for managing their jobs and for optimizing the use of linemen.

Ameren-IL used good software programs for scheduling and tracking distribution work. They made good use of mobile data terminals with outage analysis software, digital system mapping, and Global Positioning System tracking.

6. Ameren-IL had a reasonable budgeting process for maintenance and inspection.

Ameren-IL used a typical utility budgeting process. It included tools to help evaluate projects and to receive input from the field regarding needed maintenance and inspection practices. Division managers reported that they received sufficient funding each year to permit at least 30 percent of each division's workforce person-hours for maintenance and reliability work.

4. Recommendations

VI-1 Evaluate whether inspection and maintenance functions under Ameren Services' responsibility would be more effective if Ameren-IL managed them directly.

There are clear advantages to centralized management of some inspection and management functions. However, too much centralization may not provide enough focus on particular, local issues and problems. For example, assimilation of the three Illinois companies and their union agreements brought inconsistencies and weaknesses to the substation inspection processes. Bringing substation inspection and maintenance directly under the responsibility of Ameren-IL could expedite the resolution of these inconsistencies and the elimination of weaknesses.

Ameren and Ameren-IL should conduct and report on an organizational evaluation of inspection and maintenance functions within six months of the date of this report. The evaluation should specifically consider the substation and relay inspection, testing, and maintenance functions, and the maintenance engineering support functions, assigned to the Ameren-IL substation areas. It should document programs aimed at eliminating inconsistencies. The results of the evaluation should provide a specific timetable for implementation of any changes that Ameren and Ameren-IL decide to make.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-2 Make the distribution divisions accountable only for the portions of service reliability goals for which they are responsible.

Accountability should align with responsibility. The Ameren-IL distribution divisions' reliability goals should not include reliability contributions under the responsibility of Ameren Services. Ameren-IL should implement this recommendation within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation pending the outcome of the evaluation called for by Recommendation VI-1. Liberty views this recommendation independent of that evaluation. Regardless of any organizational changes that may take place, distribution divisions should be accountable only for the portions of service reliability goals for which they are responsible.

VI-3 Formalize the responsibilities of organizations outside of Ameren-IL that manage inspection and maintenance of portions of Ameren-IL's electric delivery system.

Ameren and Ameren-IL should clearly document the responsibilities of Ameren Services in policy statements and organization charts. Ameren Services should be accountable to Ameren-IL for the timely completion of inspection and maintenance tasks. Ameren Services should provide periodic reports to Ameren-IL on the status of inspections, maintenance, testing, and repairs for which it is responsible. For example, Ameren-IL management should know the status of transmission system line and pole inspections and the status of any deficiencies detected by these inspections. Ameren Services should also report to Ameren-IL on the status of distribution line

and pole inspections that it manages. Ameren and Ameren-IL should implement this recommendation within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-4 Implement work management tools or change existing tools to show clearly inspection and maintenance work-task completions and past due work tasks.

All inspection and maintenance work tasks should have assigned completion dates and priorities consistent with defined programs. Work management tools should be capable of reporting on tasks completed on time and tasks that are past due or backlogged. Management should receive regular reports on the status of task completion. Ameren-IL should develop meaningful performance measures for the timely completion of inspection and maintenance tasks. Organizations responsible for inspection and maintenance tasks should be accountable for completing those tasks on time. Ameren-IL should implement this recommendation within 18 months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-5 Improve substation inspection practices.

(1) To the extent possible under local bargaining agreements, personnel performing substation inspections should report inspection results and be accountable to substation supervisors. If union agreements prevent this and until Ameren-IL can change those agreements, implement supplementary substation inspections.

(2) Substation maintenance engineers should review the quality and content of substation inspection results. These engineers are substation equipment specialists and should be responsible for the quality of the inspection process. They should personally conduct periodic follow-up substation inspections.

(3) Implement electronic data gathering for substation inspections to improve data gathering accuracy, reduce data submittal time, provide a means to process the data, and allow easy management and engineering review of the data. Ensure that inspection items identify observations and readings that are unique to particular substations.

In its comments on the draft report, Ameren-IL accepted this recommendation in principle but requested 30 months for implementation because of the need to increase staff. Liberty agrees to this implementation schedule provided that Ameren-IL demonstrates significant progress on improving substation inspection practices within one year of the date of this report.

E. Inspections and Repairs

1. Introduction

Electric utilities should conduct routine power line and substation inspections to find and repair conditions that jeopardize the safe and reliable operation of the electric delivery system.

Typically, utilities conduct power line inspections on one- to four-year cycles, substation inspections on weekly or monthly cycles, and ground-line pole inspections on seven- to fifteen-year cycles. The length of the inspection cycles depends on the importance of the equipment to safe and reliable operations, expected equipment deterioration rates, and the cost of the inspections compared to the risk and effect of equipment failure. Equipment deterioration rates depend on environmental and operating conditions, age, and neglect. Neglect occurs when utilities miss routine inspection, testing, and servicing, or when they do not effectively identify and correct deficiencies. Utilities should train the inspectors about equipment operation, equipment failure modes, and consequences of failures. When routine inspections or defect repairing are either ineffective or neglected, system reliability can suffer and utilities may need to perform more than the normal amount of maintenance work or equipment replacement to bring systems to good condition. Data gathering, verification, repair processing, and recordkeeping should be accurate, timely, and effective to ensure that utilities accurately monitor their inspection programs, and to ensure that they correct abnormal conditions in timely fashion.

Inspections should include vegetation, poles, power line devices, [29] underground networks,[30] and substations. Ground or aerial circuit patrols should identify broken or deteriorated line equipment, encroachments on right-of-ways, and compliance with the National Electrical Safety Code. Utilities commonly refer to pole examination, testing, and treatment as ground-line or pole inspections. They identify poles that have deteriorated or rotted and that may require chemical treatment, reinforcement, or replacement. These inspections examine poles for internal voids from rot and infestation by sounding, excavation at the ground line, and boring.[31] Inspectors can determine compliance to the National Electrical Safety Code pole strength requirements by measuring the size of internal voids. Line device inspections verify that equipment appears to be functional or requires repair. Substation and underground network inspections identify equipment problems and the repairs required to minimize equipment malfunctions and failures.

Good utility inspection practices include documented programs and schedules, trained inspectors, records of inspections and repairs, comprehensive inspection coverage, and checklists or other inspection aids.

2. Findings and Analysis

a. Transmission Line[32] and Pole Inspections[33]

Transmission Line Aerial Inspections

Ameren-IL has nearly 4,500 miles of transmission lines in its system.[34] A contractor managed by Ameren Services performed semi-annual inspections of these lines from an airplane. The

[29] Power line devices are reclosers, voltage regulators, and capacitor banks.
[30] Underground networks use cables, transformers, and circuit breakers located in vaults and manholes.
[31] Inspectors locate hollow spots in a pole by hitting it with a hammer. They may bore holes in a pole to measure the size of the hollow space and to inject chemicals.
[32] Ameren-IL's transmission lines are the power lines that operate at 138,000 volts and 345,000 volts.
[33] Pole inspection is the term used in this report for "ground-line inspection' to reduce confusion with line patrol or aerial inspections.
[34] Response to Data Request #7.

inspections included the identification of matters such as broken transmission insulators, loose and broken braces, broken shield wires, structure problems, and encroachments on the transmission right-of-ways.[35] Transmission line inspections did not include pole climbing inspections, thermographic inspections, or servicing of transmission line switches.

Identifying small defects is more unlikely from an airplane than from a helicopter because of an airplane's altitude restrictions and inability to hover. Transmission switch mechanisms and contacts can stick from lubricant failure, and lack of exercise and servicing.

Ameren Services did not maintain records of completed inspections.

Transmission Line Pole Inspection

Ameren-IL has nearly 55,000 transmission poles in its system.[36] A contractor managed by Ameren Services performed ground-line pole inspections.[37] The contractor provided pole inspection and condition reports to Ameren Services, and Ameren Services kept these reports as records of inspections completed. The contractor inspected poles at the rate of 10 percent per year on cedar poles over 20-years old and pine and fir poles over 15-years old.[38] It measured pole-ground resistance every 20 years on poles over 30-years old.[39] Ground-line inspections included identifying pole rot and structure problems, woodpecker damage, and anchor problems. The pole inspection contractor sounded and bored[40] the poles to verify pole strength,[41] and applied chemical treatments to extend pole life.[42]

Liberty reviewed transmission-line pole inspection contractor's reports. The reports identified pole number, age, length and class, species, treatments applied, effective circumference based on boring tests, ground resistance test, and other remarks. The inspection reports indicated whether a pole had adequate strength, needed trussing, or needed replacement. Rejected poles were classified as priority and non-priority reject, meaning whether they should be replaced within 90 days or within the following year. Liberty found that these reports indicated that the contractor conducted transmission-pole inspection work consistent with good utility practice.

The following table shows the total number of transmission poles and the number and percentages of these poles scheduled and inspected for the years 2004-2007.[43]

[35] Response to Data Request #11.
[36] Response to Data Request #559.
[37] Response to Data Request #558.
[38] Response to Data Request #558.
[39] Interview #5, October 4, 2007.
[40] Inspectors determined internal voids by soundings (hitting the pole with a hammer) and borings.
[41] The size of voids determines pole shell thickness, from which inspectors determined pole strength. Pole reinforcement or replacement is required if the pole strength was less than National Electrical Safety Code requirements.
[42] Response to Data Request #11.
[43] Responses to Data Requests #559 and #648.

Transmission Poles Inspected

year	2004	2005	2006	2007	Annual Average Percent of Total Poles
Ameren-IL Poles	54,387				
scheduled	5,739	5,072	6,439	4,311	9.9%
inspected	5,804	5,160	6,392	4,177	9.9%

Completion rates were consistent with a 10-year cyclic program for aged poles.

Transmission Line and Pole Repairs

Transmission line aerial inspectors notified transmission engineers by cell phone when they observed critical defects, and by e-mail for minor issues.[44] The ground-line pole inspection contractor called the engineers for critical defects and provided formal pole inspection reports on an electronic database for regular reporting of work performed and conditions observed.[45]

Ameren-IL distribution linemen or contractors repaired transmission line defects identified by the inspections.[46] They repaired critical defects and replaced broken poles when discovered. Ameren-IL scheduled defect repairs using its work management systems. Ameren-IL scheduled non-critical defective poles and cross arms for replacement within 24 months. It scheduled pole and cross-arm reinforcement work for completion within 12 months.[47] Ameren Services' transmission field engineers reportedly tracked defects until repaired. However, they did not keep these records for later examination. Ameren Services reported that in 2007 it started using a material-tracking program called EMPRV to track transmission repairs. However, Ameren needs to keep historical records showing whether people completed work on time.

Liberty could not verify whether Ameren-IL was timely in its repair of defects found by the aerial inspections, or whether it was timely in its replacement or repair of poles identified by the pole inspections, because the Ameren-IL companies did not maintain records specifically for these activities.[48]

b. Substation Inspections

The table below shows the number of substations in each Ameren-IL company in 2006.[49]

Company	Substations
Ameren-CILCO	183
Ameren-CIPS	558
Ameren-IP	739

[44] Response to Data Request #16.
[45] Response to Data Request #14.
[46] Interview #5, October 4, 2007.
[47] Response to Data Request #17.
[48] Response to Data Request #16.
[49] Response to Data Request #7.

Following the mergers that brought the three Illinois companies into Ameren, Ameren Services took control of substation inspections, but continued to follow the legacy companies' substation inspection policies and practices, which differed among the companies and within company areas.[50] Local offices tracked substation inspections and did not maintain inspection records.[51] Common elements of the substation inspection procedures among the companies were (1) notifying substations supervisors of defects, and (2) using Ameren-Services' EMPRV[52] system to prioritize and track repair work. Each company had different substation-inspection paper forms. Some of the forms were specific for a substation and some were generic. The forms contained places to record various readings and to check off inspection items.[53]

No forms or program documents indicated the response urgency that should apply to inspection findings such as high voltage bushing oil leaks and equipment oil levels near or below the bottom of equipment oil-level gauges. Urgent items are those that could result in an equipment failure or malfunction if not immediately corrected. Liberty observed these conditions in two Ameren-IP, two Ameren-CIPS-UE, and one Ameren-CILCO substations. (Refer to section VI.H in this chapter.) Ameren-IP had a substation inspection "measurement points" instruction sheet for evaluating substation defects, including low levels and checking bushings for cracks. It did not indicate any urgency for bushing leaks.[54]

The periodic inspection processes for the Ameren-IL substations was convoluted because of legacy procedures and labor work rules inherited from the legacy companies. Liberty describes each company's substation inspection procedures below.[55]

Ameren-CILCO Substation Inspection Procedure

Substation electricians inspected all substations monthly except for substations operating with 345,000-volt lines, which they inspected weekly. The electricians verbally notified substation supervisors of any defects found. These inspectors could repair minor defects found.

Ameren-CIPS –West Area Substation Inspection Procedure

Distribution linemen inspected all substations weekly, using paper inspection forms. In addition, substation troublemen inspected all substations quarterly and annually using inspection forms. Linemen left the completed weekly inspection reports in the substation until the first week of the following month, and then sent them to substation supervisors. Ameren-CIPS did not specifically train the linemen who performed the substation inspections to recognize potential substation equipment problems. These inspectors could not repair minor defects found.

[50] Response to Data Request #20.
[51] Response to Data Request #22.
[52] EMPRV is the EDS Maintenance Process Reengineering Vision computerized maintenance management and material control product developed by Electronic Data Systems Corporation.
[53] Response to Data Request #21.
[54] Response to Data Request #20.
[55] Response to Data Request #20.

Ameren CIPS – East Area Substation Inspection Procedure

Distribution linemen inspected all substations weekly. They sent paper inspection forms to local distribution engineers for evaluation. After some delay, the engineers sent the completed inspection reports to substation supervisors for additional review. Ameren-CIPS did not specifically train the linemen who performed the substation inspections to recognize potential substation equipment problems. These inspectors could not repair minor defects found.

Ameren CIPS – South Area Substation Inspection Procedure

Distribution linemen inspected all substations monthly. They reported defects verbally to the substation supervisors and noted them on the paper inspection forms. They sent the inspection forms to the distribution electrical superintendent. After some delay, substation supervisors received a copy. This was the only area that recorded completed inspection dates in an electronic database. Ameren-CIPS did not specifically train the linemen who performed the substation inspections to recognize potential substation equipment problems. These inspectors could not repair minor defects found.

Ameren-CIPS-UE Substation Inspection Procedure

Substation traveling operators, who reported to distribution supervisors, inspected substations weekly. They inspected three critical substations several times each week. Traveling operators received specific training in substation inspections. They did not use inspection forms. They indicated defects found on Ameren-CIPS-UE specific trouble tickets, which they submitted to substation supervisors. These inspectors could not repair minor defects found.

Ameren-IP - North Substation Inspection Procedure

Substation electricians inspected all substations monthly except for those operating at 345,000 volts and power plant switchyards, which they inspected weekly. They submitted paper inspection reports to substation supervisors for review. These inspectors could repair minor defects found. Ameren-IP provided inspectors with a detailed list of inspection items including descriptions of those items.[56] Ameren-IP also had a substation capacitor-bank[57] inspection program, and inspected substation capacitor banks on a semi-annual cycle.[58]

Ameren-IP - South Substation Inspection Procedure

Distribution linemen inspected all substations monthly, except for those operating at 345,000 volts and power plant switchyards, which substation electricians inspected weekly. Inspectors verbally reported defects either to substation supervisors or directly to substation maintenance crews. The substation supervisor reviewed the paper inspection reports only if the inspector reported a defect. Ameren-IP did not specifically train the linemen performing substation inspections for that job. These inspectors could not repair minor defects found.

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[56] Response to Data Request #20.
[57] Substation capacitor banks maintain distribution during peak load conditions.
[58] Response to Data Request #33.

Thermographic Inspections

Ameren Services conducted annual thermographic inspections at Ameren-IL substations. The history of the conduct of these inspections, the percentage of inspections completed, and the inspection recordkeeping varied from company to company.

Ameren-CILCO had been performing annual substation thermographic inspections since 1992. For the timeframe 2004 through 2006, Ameren-CILCO reported that it completed about 95 percent of planned thermographic inspections, although it did not keep documents that would show this.[59]

Ameren-CIPS (except the UE areas) had been performing substation thermographic inspections since 1988 on a 3-year cycle until 2005 when it changed to a 1-year cycle. Ameren-CIPS-UE started in 1992 and performed substation thermographic inspections on a 1-year cycle. Ameren-CIPS reported that it completed all scheduled inspections and maintained computerized tracking records.[60]

Ameren-IP had been performing substation thermographic inspections since 1980 and was performing the inspections on a 1-year cycle in 2004, 2005, and 2006. It reported that it completed 95 percent of planned inspections in 2004, and 51 percent in 2005 and 2006, and maintained its records on computerized tracking records.[61]

Substation Repairs

Ameren Services categorized Ameren-IL's substation critical defects as Priority 1 or Priority 2, and non- critical defects as Priority 3 repairs. They were to complete all Priority 1 repairs within one year and all priority 2 repairs within two years. There were no repair-time targets for Priority 3 defects.

Ameren Services defined the priorities as follows. Priority 1 defects must result in a loss of at least $100,000, create a safety, liability, or environmental hazard, or cause the loss of critical equipment function. Failure caused by Priority 2 items must result in a loss of at least $10,000, or the loss of critical equipment function. Reportedly, the substation maintenance and repair expenditures were limited during the 2000 to 2003 timeframe, and Ameren-IL implemented the P1, P2, and P3 priority system to limit expenditures to essential maintenance and repairs.[62]

Ameren Services tracked its substation repair orders, including those resulting from substation inspections, as corrective or unscheduled jobs in its maintenance database. Ameren-IL reported the number of incomplete or backlogged jobs at the end of each year as shown below. However, these data include some standing repair orders.[63]

[59] Response to Data Request #557.
[60] Response to Data Request #557.
[61] Response to Data Request #557.
[62] Interview #133, January 31, 2008.
[63] Response to Data Request #23.

Priority 1 Repair Jobs (goal of 100 percent complete within one year)			
Company	**Year**	**Repair Jobs**	**Jobs Backlogged**
Ameren-CILCO	2004	50	3
	2005	67	5
	2006	70	7
Ameren-CIPS	2004	251	13
	2005	301	28
	2006	441	75
Ameren-IP	2005	169	30
	2006	411	61
Priority 2 Repair Jobs (goal of 100 percent complete within two years)			
Ameren-CILCO	2004	29	3
	2005	43	7
	2006	36	8
Ameren-CIPS	2004	122	26
	2005	193	61
	2006	265	101
Ameren-IP	2005	340	137
	2006	318	105

The backlogged number of jobs does not necessarily indicate that repairs were overdue. They show open jobs at year-end, not those still open one year after detection. However, the data indicate that the number of priority 1 defects found increased in 2006 and pending repair work was increasing for Ameren-CIPS and Ameren-IP.

Significantly, Ameren Services was not able to determine the number of substation corrective maintenance repairs not completed within the Priority 1 and Priority 2 time limits.[64]

Ameren Services' priority system for substation repairs is not consistent with good utility practice. There are repairs that should not wait for one year. The use of priority P3 without any completion targets was problematic. Ameren Services might never repair defects that untrained linemen classified as minor and that the inspectors could not repair on the spot. A minor defect could develop into a critical problem or a series of small problems could result in a more significant issue.

c. Distribution and Sub-Transmission Circuit Patrol Inspections

Circuit Patrol Inspection Overview

The Ameren-IL companies had 32,294 miles of overhead distribution[65] lines and 6,299 miles of sub-transmission[66] lines. This section describes the practices used to inspect and repair those

[64] Response to Data Request #560.
[65] Distribution lines operated at 15,000 volts or less.
[66] Sub-transmission lines operated at 34,500 volts and 69,000 volts.

lines for each of the Ameren-IL companies as of 2006. Liberty also notes changes to these practices that Ameren-IL implemented after 2006.

Ameren-IP had formal inspection policies for its distribution and sub-transmission lines and conducted inspections on 4-year cycles using linemen. Ameren-CILCO also had a formal policy and conducted inspections on an annual basis using engineering personnel. Ameren-CIPS did not have a formal policy for distribution line inspections. However, the divisions reported that their linemen conducted line inspections as directed by division management on 4-year cycles.[67] Ameren-CIPS inspected sub-transmission lines on a 10-year cycle.

Ameren-IP and Ameren-CILCO retained line inspection and repair completion records; Ameren-CIPS did not.[68]

Each company had it own circuit inspection forms. The Ameren-CIPS inspection form provided to Liberty was good; it listed defect type and repair priority codes. While not as detailed, the Ameren-IP inspection form was adequate. The Ameren-CILCO form contained no detail and was not as good as the others.[69] None of the inspection forms referenced National Electrical Safety Code line clearance and facility design requirements.[70] The companies had not trained inspectors to identify National Electrical Safety Code compliance issues.[71]

In 2001, Ameren Services' Resource Management group implemented a 5-year cyclic program to inspect foreign company attachments (primarily cable TV) on Ameren-IL poles for National Electrical Safety Code compliance. Ameren Services used an inspection contractor for Ameren-CILCO, Ameren-IP, and Ameren-CIPS-UE in Divisions I, V, and VI. It used in-house linemen for these inspections in the other divisions. In addition to inspecting the attachments belonging to other companies, the inspectors reported electric line and pole defects needing repair. [72]

In 2007, Ameren-IL implemented a new sub-transmission and distribution line-patrol inspection program using a line inspection contractor, except in some areas where labor agreements did not permit the use of the contractor for line inspections until March of 2008. The program included a 2-year foot-patrol for sub-transmission lines, and a 4-year foot-patrol inspection cycle for distribution lines, including tap-lines, lagging the 4-year vegetation inspection cycle by two years. Unless terrain or topography prohibits access, the contractor's inspector stands at the base of every distribution pole every four years and at the base of every sub-transmission pole every two years. Either the line-patrol inspectors or the vegetation inspectors (who can identify line deficiencies) visit every distribution line approximately every two years.[73]

The line-patrol inspections included identifying defects, obviously bad poles, foreign company attachments, and National Electrical Safety Code (NESC) compliance issues. However, the

[67] Response to Data Request #29 and Interview #31, November 1, 2007.
[68] Response to Data Request #29.
[69] Response to Data Request #286.
[70] Response to Data Request #286.
[71] Interviews #30, #31, #32, #33, #34, #35, and #36, November 1 – December 5, 2007.
[72] Interview #6, October 5, 2007.
[73] Response to Data Request #784.

inspection program did not include identifying sections of distribution circuits that were not grounded at four locations per running mile, at a minimum, as required by the NESC.[74]

Ameren Services managed this inspection program using a contractor to conduct the line-patrol inspections. Although Ameren uses the same contractor for both the line-patrol inspections and the ground-line pole inspections, the crews used for line inspections are different from the crews used for ground-line pole inspections. Members of the line-patrol inspection crews received a three-week training course, followed by two weeks of on-the-job evaluation and a final written exam. The contractor retained the services of a National Electrical Safety Code (NESC) specialist to train the inspectors on identifying NESC issues. A quality control foreman headed each three-person line-patrol inspection crew. An Ameren Services specialist provided additional quality control by verifying the accuracy of the contractor's inspection results one day each week. The circuit inspection crews determined the digital location and age of each pole on each circuit inspected. This should result in the determination of all distribution and sub-transmission pole ages and digital locations within 3-4 years.[75]

The 2007 program also called for routine aerial thermographic inspections of sub-transmission lines, managed by Ameren Services, on a 4-year cycle. Forestry and engineering personnel also participated in these aerial thermographic patrols to identify concerns in their areas for responsibility.[76]

Ameren documents the completions of all cyclic visual and ground line inspections in the CDIS system.[77]

Additionally, the divisions performed ad hoc aerial inspections of their sub-transmission lines at the discretion of the local engineering office, based on circuit performance issues, past inspection history, and operating considerations. At least one division conducted ad hoc aerial inspections of sub-transmission lines on an annual basis. These ad hoc aerial inspections were in addition to the 4-year aerial thermographic patrols and were not recorded in the CDIS program because Ameren-IL did not attempt to track the history of these ad hoc inspections.[78]

Ameren-CILCO Circuit Inspections and Repair Completions

The table below shows Ameren-CILCO's distribution and sub-transmission circuits.[79]

Voltage	Number of Circuits	Miles
15,000 or less	344	5,831
34,500	12	176
69,000	50	523

[74] Interview #174, May 8, 2008.
[75] Interview #174, May 8, 2008, and response to Data Request #346.
[76] Response to Data Request #784.
[77] Response to Data Request #784.
[78] Response to Data Request #784.
[79] Responses to Data Requests #307, #464, and #563.

Ameren-CILCO had a policy and procedures document for routine distribution and sub-transmission line-patrol inspections.[80] This document indicated that Ameren-CILCO inspected its 69,000-volt lines three times each year by helicopter or by foot patrol where required and all lower voltage lines once each year by ground patrol. Inspection elements included poles, insulators, cross arms, hardware, conductors, ground wires, equipment, guys, trees, and earth conditions. Ameren-CILCO's inspection form was very generic and did not provide a checklist for identifying defects or National Electrical Safety Code violations. It simply provided for listing the map number, location, irregularity, and date repaired. Ameren-CILCO used a database program called Circuit Patrol to track circuit inspections and repairs resulting from the inspections, as indicated below.[81]

Inspections/Repairs	2004 Percent Completed	2005 Percent Completed	2006 Percent Completed
69,000-volt Aerial	89	95	89
34,500-volt Ground Patrol	18	9	9
12,000- and 4,000-volt Ground Patrol	50	43	43
Line Repairs	69	76	52

Ameren-IL indicated that the records used to generate the data in the above table were not accurate. Moreover, Ameren-IL said that it completed all planned distribution inspections in 2004, 2005, and 2006, and completed all inspections on 34,500-volt lines in 2005 and 2006. Ameren-IL indicated that the data were not accurate because Ameren Services performed some of the inspections and linemen performed others, and some information was in paper records stored in local offices. Many of the records were no longer available because of relocations caused by re-organizations.[82]

From interviews with division managers and review of work management reports, Liberty found that Ameren-IL had not backlogged circuit repairs. Liberty also concluded that Ameren-CILCO's patrol inspection programs were reasonable. However, either the inspection completion rates or the record keeping was not consistent with good utility practices.

Ameren-IP Circuit Inspections and Repair Completions

The table below shows Ameren-IP's distribution and sub-transmission circuits.[83]

Voltage	Number of Circuits	Miles
15,000 or less	1,046	16,441
34,500	570	1,335
69,000	194	1,113

[80] Response to Data Request #29.
[81] Response to Data Request #34.
[82] Response to Data Request #489.
[83] Responses to Data Requests #307 and #464.

Ameren-IP had a policy and procedures document for routine distribution and sub-transmission line-patrol inspections.[84] The sub-transmission patrol policy required Ameren-IP to inspect sub-transmission lines by ground patrol twice each year. The procedures document provided detailed instructions of what to inspect, and how to describe and classify defects. The distribution inspection policy indicated that Ameren-IP would inspect one-quarter of the circuits each year. The procedures included all appropriate inspection elements except inspecting for National Electrical Safety Code compliance. The inspection form contained sections for poles, insulators, trees, cross arms, and included instructions for prioritizing defects.[85] Ameren-IP used an electronic system called Electric Compliance System (ECS) that generated and tracked its line patrol and device inspections and repairs, as indicated below.[86]

Inspections/Repairs	2004 Percent Completed	2005 Percent Completed	2006 Percent Completed
69,000- and 34,500-volt Ground Patrol	91	51	59
12,000- and 4,000-volt Ground Patrol	81	75	77
Line Repairs	68	0	0

The 2004 and 2005 records came from legacy Illinois Power records. In 2006, Ameren-IP was in transition to the new, 2007 Ameren-IL program.[87] Based on division management interviews and review of work management reports, Liberty found that Ameren-IP did not backlog circuit repairs. Liberty also concluded that Ameren-IP's patrol inspection programs were reasonable. However, either the inspection completion rates or the record keeping was not consistent with good utility practices.

Ameren-CIPS Circuit Inspection and Repair Completions

The table below shows Ameren-CIPS' distribution and sub-transmission circuits.[88]

Voltage	Number of Circuits	Miles
15,000 or less	1,108	10,021
34,500	102	994
69,000	150	2,159

Ameren-CIPS had a documented distribution line-patrol inspection program. However, the document did not specify inspection cycles.[89] The electrical superintendent, with input from supervisors and engineers, directed the program and selected circuits for inspection.[90]

Ameren-CIPS inspected its sub-transmission lines by airplane in 2005 and 2006, and performed aerial thermographic[91] inspections on the entire sub-transmission system on a 3- to 4-year

[84] Response to Data Request #29.
[85] Response to Data Request #286.
[86] Response to Data Request #34 and #489.
[87] Response to Data Request #489.
[88] Responses to Data Requests #307 and #464.
[89] Response to Data Request #33.
[90] Response to Data Request #34, and Interview #31, November 1, 2007.

cycle.[92] Ameren-CIPS' inspection form was generic and did not reference National Electrical Safety Code issues. Tracking of the patrol inspections, the defects identified, and defect repair records was informal and kept in local offices; no records were available.[93] Based on division management interviews and reviews of work management reports, Liberty found that circuit repairs were not in a backlog.[94]

Ameren-CIPS' distribution circuit-inspection program was not consistent with good utility practice because it was not time-based, formal, or complete. It could have neglected parts of the system. Additionally, there were no records to allow a determination of whether Ameren-CIPS actually completed inspections on a reasonable basis.

d. Distribution and Sub-Transmission System Pole Inspections

Ameren-IL had a formal ground-line pole inspection program for its distribution and sub-transmission poles. The purposes of the program were to (1) identify and reduce wood pole deterioration and (2) to determine pole strength. Ameren Services directed Ameren-IL's ground-line pole inspections and provided the inspection contractors that conducted most of the inspections for the companies.[95] Contractors conducted industry-standard, ground-line inspections, including excavating around the pole base to examine for rot, sounding with a hammer to locate internal voids, boring to measure pole shell thickness to determine pole strength, and chemically treating poles, as needed. However, Ameren-CIPS used in-house linemen who only sounded the poles with hammers. They did not excavate, bore, or treat poles.[96]

The distribution and sub-transmission ground-line pole-inspection program had been in effect at Ameren-CIPS and Ameren-CILCO during 2004-2006, and in 2005 and 2006 at Ameren-IP. Program documents indicated that they only inspected poles that were at least 15 years old and had not tested within the last 10 years.[97] The documents did not clearly indicate the inspection cycle.[98] In interviews, Ameren-IL indicated that none of the companies had a formal periodic pole inspection cycle for distribution poles. For sub-transmission poles, Ameren-IP used a 10-year cycle, Ameren-CIPS used a 15-year cycle, and Ameren-CILCO had no regular cycle. The new program, starting in 2006, had a 12-year cycle for distribution and sub-transmission poles.[99]

Ameren Services reported that under its new program, each year the contractor inspects one-twelfth of the poles on Ameren-IL sub-transmission and distribution circuits. For poles 15 years old or less, the inspection is visual. For poles over 15 years old, the inspection includes at least sounding in a spiral pattern, using a special hammer, from the ground surface up the pole to the

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[91] This is an inspection using a camera that measures infrared energy emitted from overheated connections and switch contacts.
[92] Response to Data Request #588.
[93] Response to Data Request #34.
[94] Interview No. 31 on November 1, 2007.
[95] Response to Data Request #31.
[96] Interview #31, November 1, 2007.
[97] Another document indicated that they examined poles that they had not tested within the last seven years.
[98] Response to Data Request #31.
[99] Interview #110, December 18, 2007 and Interview #33, November 8, 2007.

limit of the inspector's reach, and boring downward through the pole center at the ground surface. For sub-transmission and three-phase distribution-mainline poles, the contractor:

- excavates to 18 inches below the ground surface
- sounds in a spiral pattern from below the ground surface up to the inspector's reach to identify internal voids caused by decay
- chemically treats on the external surfaces, as needed
- bores from about 9 inches below the ground surface and at several other locations on the pole, depending if and where there are apparent voids
- internally treats identified voids.

Ameren-IL had 163,973 sub-transmission poles and 1,104,898 distribution poles.[100] During the 2004 through 2006 timeframe, it inspected about 43,000 sub-transmission poles, or 8.2 percent of the total per year. It inspected about 42,000 distribution poles, or only 1.2 percent of the total poles per year.[101]

Ameren-CIPS pole inspections were inadequate. Although pole inspectors determined whether a pole had voids by sounding, or tapping with a hammer, they did not bore the poles to measure the size of the voids, as necessary to calculate pole strength, nor did they excavate around the pole to examine for external decay below the ground surface.[102] Aside from that matter, Liberty concluded that Ameren-IL's sub-transmission pole inspections methods and inspection completions were consistent with good utility practice. Because Ameren-IL regularly inspected very few distribution poles, its distribution pole inspection practices were not consistent with good utility practice.

The tables below indicate the combined distribution and sub-transmission pole-inspection completion rates for each company. To be on a 12-year cycle, Ameren-IL should have inspected about 8 percent of the poles each year. During 2004-2006, the actual pole inspections were about one quarter of that rate.

Ameren-CILCO

Year	**2004**	**2005**	**2006**
Poles inspected	6,101	5,191	3,356
Percent of total poles	2.8%	2.4%	1.5%

Over the 3-year period, Ameren-CILCO inspected an average of 2.2 percent of its poles, or the equivalent of a 45-year cycle.

Ameren-IP

Year	**2004**	**2005**	**2006**
Poles inspected	11,195	21,722	10,529
Percent of total poles	1.9%	3.6%	1.8%

[100] Response to Data Request #559.
[101] Responses to Data Requests #34, #169, and #488.
[102] Interview #150, March 26, 2008.

Ameren-IP's inspections focused on lines performing poorly due to pole failures and on worst performing distribution circuits. Over the 3-year period, Ameren-IP inspected an annual average of 2.4 percent of its poles, or the equivalent of a 41-year cycle.

Ameren-CIPS

Year	2004	2005	2006
Poles inspected	7,998	11,941	5,063
Percent of total poles	1.8%	2.6%	1.1%

Reportedly, in-house linemen inspected and sounded[103] sub-transmission poles on a 4-year cycle.[104] Ameren-CIPS did not bore or treat poles as required by the Ameren-IL program. A visual inspection and sounding is an acceptable pre-climbing practice, but does not constitute an acceptable ground-line inspection. Over the 3-year period, Ameren-CIPS inspected an annual average of 1.8 percent of its poles, or the equivalent of a 54-year cycle.

In 2007, Ameren-IL inspected about 89,500 distribution and sub-transmission poles, or about 7 percent of the total number of poles. Ameren-Il reported that the number of poles inspected varies from year-to-year because it schedules 1/12 of it circuits for pole inspections, and the number of poles on a circuit varies.

e. Distribution Device Inspections

Each of the companies' routinely inspected distribution devices, but they did not all include the same equipment. Ameren-CILCO inspected capacitor banks, reclosers, and 69,000-volt switches. Ameren-IP inspected capacitor banks, reclosers, and voltage regulators. Ameren-CIPS inspected only capacitor banks. None of the companies routinely inspected or maintained distribution switches used to tie circuits together for line outages for scheduled and emergency line repairs.[105] Each company used a different method of tracking the inspections.

All Ameren-IL companies began using the Circuit and Device Inspection System (CDIS) software in 2007 to schedule and track inspection-completion dates, descriptions of defects found, and the repair orders. The system included capacitor, regulator, and recloser inspections.[106]

Ameren-CILCO Device Inspections

Ameren-CILCO performed routine inspections on its distribution capacitor banks twice each year, reclosers every three months,[107] and 69,000-volt switches on a 3-year cycle.[108] It also had a recloser replacement program. Ameren-CILCO replaced reclosers every eight years or 100

[103] "Sounded" is to hit the pole with a hammer to identify hollow volumes.
[104] Interview No. 31 on 11/1/07.
[105] Response to Data Request #645.
[106] Response to Data Requests #29 and #33.
[107] Proper operation of voltage regulators and capacitor banks is necessary to provide proper voltage to customers.
[108] Response to Data Request #33.

operations.[109] Ameren-CILCO did not have a regular voltage regulator inspection.[110] It used paper-tracking methods for the inspections and replacement work.[111]

The table below shows the percent of planned work Ameren-CILCO completed for capacitor bank inspections, recloser inspections, and recloser replacements.[112]

Ameren-CILCO Device Completion Percentage			
year	**2004**	**2005**	**2006**
Capacitor Inspection	82%	102%	53%
Recloser Inspection	93%	90%	69%
Recloser Replacement	42%	124%	59%

Ameren-CILCO had 69,000-volt switch inspection and maintenance programs in its north and south areas on 3-year cycles.[113] During 2004 though 2006, it completed more than 100 percent of planned inspections in the north area but only 61 percent in the south area.[114]

Ameren-CILCO's device inspections completion rates were not consistent with its program.

Ameren-IP Device Inspections

Ameren-IP performed routine inspections on 4-month cycles on its distribution system reclosers, voltage regulators, and capacitor banks.[115] Prior to 2005, Ameren-IP had a formal program to inspect its sub-transmission switches on an annual cycle.[116] Ameren-IP discontinued this program in 2005.[117] Ameren-IP used its Electric Compliance System to generate and track the inspections.[118] Ameren-IP also had an inspection program for routinely inspecting streetlights.[119] The table below shows the percentage of planned Ameren-IP completed for these inspections.[120]

Ameren-IP Device Completion Percentage			
year	**2004**	**2005**	**2006**
Capacitor Inspection	100%	100%	33%
Recloser Inspection	100%	100%	68%
Regulator Inspection	100%	100%	53%

Ameren-IP's completion of its distribution-device inspections was consistent with its program in 2004 and 2005. However, it was substantially short of its goals in 2006.

[109] Response to Data Request #33.
[110] Response to Data Request #590.
[111] Response to Data Request #34.
[112] Response to Data Request #34
[113] Response to Data Request #33.
[114] Response to Data Request #34.
[115] Response to Data Request #33.
[116] Response to Data Request #588.
[117] Response to Data Request #590.
[118] Response to Data Request #33 and #34.
[119] Response to Data Request #33.
[120] Response to Data Request #34.

Ameren-CIPS Device Inspections

Ameren-CIPS had a documented, routine distribution capacitor-inspection program.[121] It inspected line capacitor banks annually prior to summer peak loads.[122] Ameren-IL did not provide data that would permit verification of device inspection-completion rates.[123] Ameren-CIPS did not have voltage regulator or recloser inspection programs.[124] Ameren-CIPS included sub-transmission switches in its aerial sub-transmission system thermographic[125] inspection program conducted on 3-4 year cycles. It conducted additional inspection on switches identified as needing maintenance on contacts.[126]

f. Underground Network Inspection

Underground networks provide electric service for some urban areas in Decatur, Bloomington, and Peoria. These networks contain cables, transformers, and circuit breaker called network protectors.[127] Ameren-CILCO had a formal underground network maintenance program, including inspections on a 3-month cycle. It could not provide any inspection completion data.[128] Ameren-IP had a documented routine underground systems inspection program. It inspected all manholes, service boxes, cable junctions, and service taps at least on a 6-month cycle.[129] Local service centers scheduled the work on Ameren-IP's Electric Compliance System (ECS), but maintained the inspection records on paper. Ameren-IL could not provide annual inspection completion rates. [130]

Liberty could not verify completion of the Ameren-IL underground network equipment inspection and maintenance programs because it did not retain inspection completion data.

In 2007, all Ameren-IL companies began using the Circuit and Device Inspection System to schedule and track inspection-completion dates, descriptions of defects found, and the repair orders. The system included underground networks.[131]

3. Conclusions

1. There were weaknesses in the inspection practices of Ameren-IL's transmission lines. (Recommendations VI-4 in section VI.D above and VI-6 below.)

Ameren Services did not maintain records of completed inspections.

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[121] Response to Data Request #33.
[122] Response to Data Request #33.
[123] Response to Data Request #34.
[124] Response to Data Request #590.
[125] This is an inspection using a camera that measures infrared energy emitted from overheated connections and switch contacts.
[126] Response to Data Request #588.
[127] Response to Data Request #565.
[128] Response to Data Request #565.
[129] Response to Data Requests #30 and #33.
[130] Response to Data Request #565
[131] Response to Data Request #29.

Aerial inspections conducted from an airplane are not as effective and detailed as inspections conducted from a helicopter. A helicopter can hover and come closer to towers and lines than an airplane.

Periodic ground inspections of transmission switches, including cleaning and lubricating of rotating and sliding surfaces in switch mechanisms is a good preventive maintenance practice that can help assure proper switch operation.

Periodic and ad hoc thermographic inspections from a helicopter of the transmission lines during or near peak load conditions could be effective in identifying transmission line connector and switch contact problems.

2. Ameren Services conducted transmission-line pole inspections consistent with its program and good utility practices.

A contractor performed ground-line transmission pole inspections on a cycle of 10 percent per year for aged poles. Ameren Services maintained records of these inspections.

3. Ameren Services did not maintain records of completed repairs and replacements resulting from transmission line and pole inspections. (Recommendation VI-4 in section VI.D above.)

Liberty could not verify whether Ameren-IL was timely in its repair of defects found by transmission line aerial inspections, or whether it was timely in its replacement or repair of poles identified by the pole inspections, because there were no records specifically for these activities.

4. Substation inspection practices had weaknesses. (Recommendations VI-1 and VI-5 in section VI.D above and VI-7 below.)

The intervals for performing substation inspections were appropriate. However, there were many inconsistencies in substation inspection practices. Ameren-IL should place an increased emphasis on resolving these inconsistencies.

Some inspection training and practices need improvements. As a result of Liberty's review of substation inspection practices and its review of substation conditions reported in section VI.H below, it was apparent that inspectors need additional training in substation equipment theory and operations, failure modes, actions required for critical abnormal conditions, and National Electrical Safety Code compliance. In addition, it was apparent that substation inspectors should be capable of initiating minor repairs such as correcting minor oil leaks at valves and flanges, adding nitrogen to transformers, and removing debris. They could complete these minor repairs at the time of the inspections and not let them go until a maintenance crew could correct them. Labor rules prevented some inspectors from performing substation repairs.

After 2006, Ameren Services reported that it planned to implement an electronic inspection data-gathering system containing a database of equipment in each substation. This should improve the accuracy and recordkeeping of the substation condition reports.

5. Ameren-IL substations had annual thermographic inspections. However, Ameren-IP did not complete all planned inspections in 2005 and 2006 and Ameren-CILCO did not keep records of inspection completions. (Recommendations VI-3 and VI-4 in section VI.D above.)

Conducting annual thermographic inspections of substations is good utility practice. Ameren Services should be accountable to Ameren-IL for the completion of planned inspections and for keeping records of completed inspections.

6. The priority system and record keeping for substation repairs was not consistent with good utility practice. (Recommendations VI-4 in section VI.D above and VI-8 below.)

Ameren-IL needs a better priority system for substation repairs. Some substation repairs should be complete within hours or days. Ameren Services' highest priority calls for completion within one year and some had no assigned completion dates. All substation repairs should have assigned completion dates and priorities consistent with defined programs. Work management tools should be capable of reporting on repairs completed on time and repairs that are past due or backlogged. Management should receive regular reports on the status of repair completion. Ameren-IL should develop meaningful performance measures for the timely completion of substation repairs. Organizations responsible for the repairs should be accountable for completing those tasks on time.

7. Ameren-CILCO and Ameren-IP had reasonable circuit-patrol inspection programs. Ameren-CIPS did not. None of the companies kept records adequate to show whether they complied with their programs and completed repairs resulting from inspections. (Recommendation VI-9.)

Ameren-CILCO and Ameren-IP had adequate programs and procedures for circuit-patrol inspections. The Ameren-CIPS program was informal. Ameren-CILCO and Ameren-IP kept records of inspections, but those were either inaccurate or the companies did not complete inspections in accordance with their programs. No Ameren-CIPS records were available. To the extent that the companies recorded defects found by the inspections, Liberty found that the companies had not backlogged repairs (*i.e.*, they completed repairs).

In 2007, Ameren-IL implemented a sub-transmission and distribution-line patrol inspection policy that included a 4-year patrol inspection cycle for distribution lines and a 2-year foot-patrol inspection cycle for sub-transmission lines. Based on its review of the program documents, Liberty found that the new program is complete and consistent with good utility practices. Ameren-IL needs to effectively implement this program and maintain accurate and complete records of inspections, inspection results, and the resolution of defects identified by the inspections.

8. Ameren-IP and Ameren-CILCO had good ground-line pole inspection methods. Ameren-CIPS did not have good methods. For all of the companies, the number of poles inspected on the sub-transmission system was reasonable. They did not regularly inspect distribution poles. (Recommendation VI-10.)

In the Ameren-IP and Ameren-CILCO areas, ground-line pole inspections were thorough. Ameren-CIPS only sounded poles. Sub-transmission pole inspections occurred on about a 12-year cycle. Overall, however, only about 2 percent of the poles received inspections. Ameren-IL needs to inspect poles to determine whether they meet National Electrical Safety Code strength requirements. Weak poles are both reliability and a safety hazards.

9. Although all of the Ameren-IL companies inspected some devices in their distribution and sub-transmission systems, they did not consistently include all devices. Ameren-CIPS did not retain inspection records. (Recommendation VI-11.)

Distribution device inspections should include voltage regulators, line reclosers, line regulators, and switches. Distribution line devices have moving elements, lightning arresters, controls, or fuses that require periodic inspection or maintenance to assure reliability. None of the companies inspected or test operated distribution line-tie switches to determine that they will operate when needed to transfer loads under planned or emergency conditions. Ameren-CIPS did not retain inspection records.

10. Ameren-CILCO and Ameren-IP had adequate underground network inspection programs. However, the companies did not retain inspection completion records. (See Recommendation VI-4 in section VI.D above.)

Based on the descriptions of Ameren-CILCO's and Ameren-IP's underground network inspection programs, Liberty concluded that they were adequate. There were no underground networks on the Ameren-CIPS area. The companies did not have records to confirm that they completed the inspections in accordance with the programs.

4. Recommendations

VI-6 Improve transmission line inspection practices.

1. Ameren-IL should require the use of helicopters in the inspection of its transmission lines. Ameren Services should develop a plan for Ameren-IL's approval that considers at least annual inspections using a helicopter, helicopter inspections for more aged transmission lines, and helicopter inspections on lines that have exhibited more defects than on other lines.

2. Ameren-IL should require periodic preventive maintenance of transmission line switches. Ameren Services should develop a plan for Ameren-IL's approval that provides for switch inspection, cleaning, and lubricating consistent with good utility practices and manufacturer recommendations.

3. Ameren-IL should conduct periodic and ad hoc thermographic inspections of its transmission line connections and switch contacts during peak, or near peak load and temperature conditions.

Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-7 Improve substation inspector training.

Substation inspector training should include substation equipment theory, operation, expected abnormal conditions, equipment failure modes, and in actions required for critical abnormal conditions, such as bushing oil leaks. Training should include the identification of National Electrical Safety Code compliance issues.

Ameren-IL should develop an improved training program for substation inspectors and should develop a plan for administering the training within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-8 Develop a new priority system for substation repairs.

Substation repair items should have assigned priorities and associated completion dates. The priority range should go from immediate to one year with appropriate points in between to classify the urgency of the repair. Even minor repair items should have an expected completion date, which should not be longer than one year. Work management tools should be capable of reporting on repairs completed on time and repairs that are past due or backlogged. Management should receive regular reports on the status of repair completion. Ameren-IL should develop meaningful performance measures for the timely completion of substation repairs. Organizations responsible for the repairs should be accountable for completing those tasks on time.

Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-9 Implement a complete distribution and sub-transmission circuit-patrol inspection program.

Ameren-IL implemented a new distribution- and sub-transmission-system inspection program in 2007. Based on its review of the program documents, Liberty found that the new program is complete and consistent with good utility practices. Ameren-IL needs to effectively implement this program and maintain accurate and complete records of inspections, inspection results, and the resolution of defects identified by the inspections.

Ameren-IL has implemented this recommendation. Liberty will verify the effectiveness of the program and Ameren-IL's record keeping during the verification phase of this investigation.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-10 Implement a periodic and thorough ground-line inspection of distribution and sub-transmission wood poles.

Ameren-IL should ensure that its poles receive periodic and thorough inspections according to a defined program. Ameren-IL should also ensure that the inspection of distribution poles includes those on lines that tap or branch off main distribution circuits. Ameren-IL should maintain inspection records and records showing completion of replacements, reinforcements, and treatments of poles as called for by the inspection results. Organizations conducting or managing the inspections should be accountable to Ameren-IL for completing them on schedule.

Ameren-IL implemented a 12-year cyclic program in 2007 and inspected nearly 90,000 poles during the year. Liberty will verify the completeness of the program and Ameren-IL's record keeping during the verification phase of this investigation.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-11 Conduct periodic inspections of distribution system regulators, line reclosers, capacitor banks, and switches, and sub-transmission system switches.

Ameren-IL should have a consistent and complete device inspection program. The inspections should be consistent with manufacturers' recommendations and good utility practices. As with other inspection programs, Ameren-IL should maintain adequate records and have the tools necessary to determine easily the status of inspection completions.

Ameren-IL should implement this recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

F. Preventive Maintenance and Reliability Programs

1. Introduction

Utilities perform preventive maintenance to minimize equipment malfunctions, to extend equipment life, and to determine when to restore or replace equipment or equipment components. Utilities perform routine equipment inspections to trigger, at least in part, the need for corrective maintenance, preventive maintenance, and reliability improvements. Corrective maintenance reduces equipment failure risk by repairing or replacing failed components. Preventive maintenance tasks are activities such as adjusting, cleaning, lubricating, painting, and testing. Testing supplements inspections by identifying abnormal conditions, which inspectors cannot observe. Examples of abnormal conditions are water in transformers and drift of relay settings.

The type of conditions that trigger maintenance actions and the level of the maintenance intensity are known equipment deterioration rates (time-based preventive maintenance), excessive

equipment operations[132] or extreme operating conditions (operating-based preventive maintenance), and inspection and test results (condition-based preventive maintenance). Time-based preventive maintenance is the foundation of a maintenance program; utilities should determine time-base maintenance by evaluating preventive maintenance costs compared to the costs and reduced reliability caused by unplanned repairs, by reviewing historical data, and by using its own, the utility industry's, and the manufacturers' experience. Utilities should select testing procedures to identify most effectively any abnormal conditions.

Personnel performing maintenance activities should be sufficiently skilled to perform the work, should have good maintenance and testing tools and sound methods available, and should be capable of recognizing abnormal conditions. Maintenance engineers and supervisors should provide technical guidance to field personnel, be able to evaluate analytically the results of inspections and tests, should understand how and why equipment deteriorates and fails, and should be involved with evaluating triggering conditions. Maintenance managers should closely monitor maintenance activities and verify that they are consistent with the programs. Utilities should provide managers with sufficient resources to complete maintenance work consistent with the programs.

Equipment failures caused by inadequate inspection, repair, and maintenance is one cause of electric faults that result in service interruptions to customers. The number and length of service interruptions affect a utility's customer service. Utilities can improve customer service by minimizing electrical faults. Improving service reliability includes identifying the causes and locations of faults, correcting the causes of faults, and using coordinated fault isolation devices in appropriate quantities and locations to minimize the effect of faults that do occur. Utilities sometimes initiate reliability programs aimed at curing common causes of problems or faults on the electric delivery systems. Faults on transmission and sub-transmission lines, and in substations also contribute to poor reliability. However, faults on distribution lines and equipment cause most service interruptions.

2. Findings and Analysis

The previous section (VI.E) of this chapter described Ameren-IL's preventive maintenance programs that logically fit with the description of inspections. This section focuses on:

- Underground Residential Distribution (URD) Cable Replacement
- Substation Preventive Maintenance
- Relay Testing an Maintenance
- Reliability Improvement Programs.

[132] Substation inspectors or the Supervisory Control and Data Acquisition (SCADA) system can determine counts of operations of components such as load tap changers, voltage regulators, and circuit breakers.

a. Underground Residential Distribution (URD) Cable

URD Cable Replacement Programs

Utilities sometimes perform preventive maintenance work to reduce equipment repair costs and to improve reliability. An example case is the replacement of failure-prone, aged, and deteriorated direct-buried underground residential distribution (URD) cables that are expensive to replace, but only nominally affect overall reliability when they fail. It is difficult or impossible to identify which underground residential distribution cables are failure-prone by inspections or historical records, and utilities generally are not able to justify the high cost of replacing all suspect cable. Mass replacement can result in a substantial cost, especially considering the marginal improvement in overall system reliability. Many utilities have determined that the cost to replace a specific cable is justified by the cost of repairing a cable multiple times, and will replace a cable after it has faulted several times.

Prior to 2007, Ameren-IL conducted its URD cable replacements according to the companies' legacy programs. Each program was somewhat different, but should have accomplished essentially the same results.[133]

Ameren-CIPS-UE tracked underground residential distribution cable failures in the Alton and East St. Louis areas. It tracked failed direct-buried, single-phase residential subdivision cable sections using paper records. It used contractors to replace cable sections within 75 days of the second failure within any 12-month timeframe.

In other Ameren-CIPS areas, operating centers tracked failures of all direct-buried, single-phase cable and three-phase cable sections using an electronic equipment database. It used contractors to replace faulted sections after a timeframe determined by the operating center. It replaced larger cables immediately if an autopsy of a faulted cable showed it had deteriorated. It replaced smaller cables sections after the third failure during the cable's lifetime.

No formal database for tracking Ameren-CIPS URD cable replacements existed prior to 2007. However, Ameren-CIPS reported that it spent $455,655 for underground cable replacement in 2006.[134]

Ameren-CILCO's local operating centers tracked failures of direct-buried single-phase and three-phase cables on a spreadsheet, and budgeted replacements of failed cable sections and adjacent sections, if determined necessary, after cable sections failed for the third time during the cable's lifetime.

Ameren-CILCO retained records of URD cable replacements, but its underground cable-replacement expenditure data was not available. However, Ameren-CILCO budgeted $1,500,000 in 2004, $1,000,000 in 2005, and about $1,200,000 in 2006.[135]

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[133] Response to Data Request #35.
[134] Response to Data Request #36.
[135] Response to Data Request #36.

Ameren-IP's local operating centers tracked failures of all direct-buried single-phase and three-phase cables on a spreadsheet, and used contractors and its in-house workforce to replace cable sections after the third failure during the cable's lifetime. In 2004, Ameren-IP began to replace some, or all, cable sections in a cable loop in addition to the failed section, based on the failure history of the cable sections in the loop.

No formal database for tracking Ameren-IP URD cable replacements existed prior to 2007. However, Ameren-IP tracked cable replacement costs. It expended $446,066 for cable replacement in 2005, and $1,087,310 in 2006.[136]

Ameren-IL implemented a system-wide URD cable replacement program in 2007. The program called for cable section replacement after the fourth failure of that section during the cable's lifetime, or, if two of the failures occurred during a twelve-month timeframe (if the last was the third failure during the cable's lifetime). It replaced all cable sections in a loop, or subset of a loop, if the average failure rate of the loop was 0.6 failures per section within a three-year timeframe, or at least six failures occurred among all cable sections in the loop within a three-year timeframe. Ameren-IL estimated that the new program would increase the companies' cable replacement workload by about 10 percent. Ameren-IL indicated that it might conduct cable replacement projects not meeting these guidelines if they do, however, meet Ameren's reliability project funding criteria. Ameren-IL is now tracking URD repairs on its reliability action plans.[137]

Liberty concluded that all Ameren-IL URD cable replacement programs were reasonable, but tracking of the work and retaining records of completions were inadequate for Ameren-IP and Ameren-CIPS. The new Ameren-IL URD cable program should have better effectiveness than the legacy programs and facilitate monitoring of cable replacements by Ameren-IL management. The new Ameren-IL method for monthly tracking its URD cable replacements should satisfy the need to track and retain URD cable replacements for management review.

URD Repair Performance

In addition to having a URD cable replacement program, a utility must react quickly to URD cable faults. Until the utility replaces failure-prone URD cables, it must repair or replace faulted cable sections quickly, and before a second cable-section fails, to minimize the effect of URD cable faults on customers. URD cables typically are in loops fed from one source and an open tie switch to another source. Service to customers comes through transformers connected all along the loop. When a URD cable section fails, a few customers would experience a short interruption until a troubleman isolates the faulted section and closes the tie switch. However, if a second cable section fails before the utility repairs or replaces the first section, an extended outage with a larger number of affected customers could occur.

Ameren-IL reported that it generally repairs or replaces faulted URD cable sections within 10 days.[138] The Ameren-IL divisions reported that they restored customer service quickly after URD cable faults, but that in some cases it took a month or more to repair or replace faulted cable

[136] Response to Data Response #36.
[137] Response to Data Request #179.
[138] Response to Data Request #395.

sections.[139] One division reported that it had 40 to 50 URD cable faults each year. Other divisions reported smaller numbers of faults.[140] Liberty could not determine the number of URD cable failures that occurred each year in each company because URD cable faults did not have a specific code in the Ameren-IL work management system, nor did the companies have a specific method to track the amount of days a URD loop was open.[141] Liberty could not determine how many URD cables Ameren-IL did not repair or replace within 10 days because it did not have a formal tracking mechanism specifically for replacing URD cable sections.[142] Ameren-IL indicated that it started tracking in 2007 URD cable replacements scheduled in each division. However, this tracking did not include how long URD cable loops had remained open.

Ameren-IL management did not have the means to monitor closely how long the divisions took to repair or replace faulted sections of URD cable loops. A ten-day limit to repair of replace faulted URD cable sections is reasonable for most utilities; one month or more is too long.

b. Substations

The three Ameren-IL companies had documented substation maintenance programs. The programs included predictive testing for detecting abnormal conditions that would trigger a repair or overhaul.

Ameren-CIPS' and Ameren-CILCO's substation maintenance programs were time-based, but the trigger points for initiating specific maintenance activities outside of the normal maintenance cycles were not well-defined.

Ameren-IP's substation maintenance program was largely time-based. It had many well-defined trigger points based on inspection and test results and equipment criticality for deviating from the maintenance schedule. Ameren-IP also used some leading edge, special oil tests for its transformers, load tap changers, and oil circuit breakers as sources for triggering maintenance.

Ameren Services' Substation Maintenance and Construction group directed the companies' substation-maintenance program work in the three Ameren-IL substation areas. Ameren-IL's EMPRV[143] work management system scheduled all program work. Ameren Services' substation maintenance engineers provided the expertise needed to evaluate test results and maintenance issues and controlled the substation equipment testing and maintenance program methods. Superintendents and supervisors directed the companies' substation electricians in performing the maintenance and testing work. All substation electricians received training in substation maintenance and testing work through their apprenticeship and on-the-job training. Engineers provided testing training to the electricians. Ameren-IP and Ameren-CILCO substation electricians received four years of apprentice training. Ameren-CIPS substation electricians received their training during four 9-month training periods.[144]

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[139] Interviews Nos. #30 through 36, October 30-December 5, 2007.
[140] Interviews Nos. #30 through 36, October 30-December 5, 2007.
[141] Response to Data Request #394.
[142] Response to Data Request #395.
[143] EMPRV is "EDS Maintenance Process Re-engineering Vision."
[144] Interviews #131 and #133, January 31, 2008.

Ameren prioritized substation maintenance work and repairs as Critical Priority 1, Less Critical Priority 2, or non-critical Priority 3. Beginning in 2007, all scheduled maintenance work was Priority 1, but substation repairs could be in any of the three priorities.[145] The table below shows the percentage of Priority 1 and Priority 2 work that each company completed.[146]

year	2004	2005	2006
Priority 1 Work Completion			
Ameren-CILCO	96%	156%	100%
Ameren-CIPS	96%	98%	100%
Ameren-IP		100%	100%
Priority 2 Work Completion			
Ameren-CILCO	24%	41%	61%
Ameren-CIPS	33%	73%	91%
Ameren-IP		91%	79%

The completion rates shown in the above table included, for Ameren-CIPS and Ameren-CILCO, routine maintenance for that year plus corrective repairs not completed during the previous year. For Ameren-IP, the table included corrective maintenance not completed for the past year, plus corrective and routine maintenance for that year. Ameren-IL could not go back and separate the types of maintenance work conducted during those years.[147]

The following sections provide summaries of the individual companies' substation maintenance programs.[148]

Substation Batteries

Substation battery banks provide power to the operate circuit breakers and other devices.

Ameren-CIPS and Ameren-CILCO inspected and tested batteries on a 6-month cycle. This included cell voltage, specific gravity, and cell resistance tests. They performed battery-load performance tests on a 5-year cycle.

Ameren-IP inspected and measured cell voltages on its batteries on a 3-month cycle. Depending on the battery type, it measured cell resistances on a 3-month or 1-year cycle.

Substation Transformers

Transformers reduce high voltages to lower voltages for eventual distribution to customers.

For transformers operating at 69,000 volts or less, Ameren-CIPS and Ameren-CILCO performed minor maintenance, including standard oil tests, combustible gas-in-oil tests, and nitrogen-gas space tests on a 3-year cycle. The companies performed major maintenance, including winding

[145] Interview #133, January 31, 2008.
[146] Response to Data Request #22.
[147] Response to Data Request #589.
[148] Response to Data Request #20.

turns-ratios measurements,[149] and insulation resistance and power-factor tests[150] on a 10-year cycle. For transformers operating at 138,000 volts or greater, Ameren-CIPS and Ameren-CILCO performed the same maintenance work as conducted on the lower voltages transformers, but on a 1-year cycle for minor maintenance and on a 6-year cycle for major maintenance.

Ameren-IP inspected and tested oil from transformers operating less than 30,000 volts and less than 10 MVA (megavolt amperes, a measure of transformer capacity) on a 2-year cycle. It inspected and tested oil from transformers less than 30,000 volts and greater than 10 MVA on a 1-year cycle; and tested gas-in-oil on a 2-year cycle. It inspected, tested oil, and performed gas-in-oil tests on transformers operating at greater than 30,000 volts on a 1-year cycle. It performed power-factor insulation tests on a 4-year cycle on transformers operating at greater than 200,000 volts on the high side and greater than 100,000 volts on the low side. It performed this same test on transformer bushings on a 2-year cycle. It performed power-factor tests on a 6-year cycle on transformers operating at greater than 100,000 volts on the high side and less than 100,000 volts on the low side, and on their bushings on a 2-year cycle. It performed power-factor insulation tests on all other transformers larger than five MVA on a 6-year cycle.

Substation Voltage Regulators and Load Tap Changers

Voltage regulators and load tap changers maintain proper voltage on the substation end of distribution circuits.

Ameren-CIPS and Ameren-CILCO verified load tap changer operation, and tested oil for gases, metals, and acid either on a 6-month cycle for troublesome types, or on a 1-year cycle for others. The results of tests triggered internal maintenance. They tested oil in three-phase voltage regulators on a 1-year cycle and in single-phase regulators on a 3-year cycle. Oil test results triggered overhaul work.

Ameren-IP checked voltage regulator operation and performed oil tests on 2-year cycles. It performed external inspection, operational checks, and gas-in-oil tests on vacuum load tap changers on a 1-year cycle, special winding-condition oil tests on a 3-year cycle, and internal inspections on a 12-year cycle. It performed external inspections and operational checks and special winding-condition oil tests on its load tap changers on a 1-year cycle and performed internal inspections on a 12-year cycle.

Substation Oil Circuit Breakers (OCBs)

Oil circuit breakers interrupt fault currents and use mineral oil for insulation and arc extinguishing.

Ameren-CIPS and Ameren-CILCO performed insulating oil and contact resistance tests, and lubricated the operating mechanisms on all oil circuit breakers. In addition, on oil circuit breakers operating at more than 34,500 volts, they serviced the hydraulic and pneumatic

[149] Each winding of a transformer contains a certain number of turns of wire. The turns-ratio is the ratio of turns of wire in the primary winding to the number of turns of wire in the secondary winding.
[150] A power factor test results in a measure of voids, moisture, or weaknesses in insulation.

mechanisms, performed dissolved-gas analysis and insulation power-factor quality tests, and measured contact movement and speed on all oil circuit breakers operating at more than 34,500 volts. The table below shows the Ameren-CIPS and Ameren-CILCO oil circuit breaker maintenance cycles.

Voltage	Minor Maintenance	Major Maintenance	Overhaul
< 34,500	2 years		10 years or 12 fault trips
34,500 – 72,000	2 years	12 years or 12 fault trips	12 years or 12 fault trips
> 73,000	2 years	6 years	Per test results

Ameren-IP conducted an external inspection and performed oil tests on all oil circuit breakers on a 1-year cycle, adjusted oil circuit breaker mechanisms on a 3-year cycle. For oil circuit breakers operating at less than 30,000 volts, the company performed internal inspection on a 3-year cycle, except for those oil circuit breakers that were difficult to isolate, such as transformer or tie circuit breakers, had a 6-year maintenance cycle. On oil circuit breakers operating at greater than 30,000 volts, the company performed circuit breaker oil analysis tests and mechanism adjustments on a 6- and 9-year cycle, and it performed internal inspections on a 12-year cycle.

Substation Air, Vacuum, and Gas Circuit Breakers

These circuit breakers use air, vacuum, or a gas to extinguish arcing.

Ameren-CIPS and Ameren-CILCO performed reduced battery voltage trip verifications and contact resistance and vacuum interrupter tests. They lubricated the mechanisms and serviced the circuit breakers. Major tests and servicing performed on gas circuit breakers included power-factor insulation tests, moisture-in-gas measurements, contact resistance measurements, and servicing of the pneumatic and hydraulic mechanisms. They maintained air circuit breakers on a 4-year cycle and vacuum circuit breakers on a 5-year cycle. Depending on type, minor maintenance of the gas circuit breakers was on 1- or 2-year cycle. Major maintenance was on a 5- or 6-year cycle. Overhauling was on a 20-year cycle.

Ameren-IP inspected air circuit breakers internally on a 3-year cycle. It inspected vacuum circuit breakers internally and lubricated the mechanism on a 2-year cycle; it performed power-factor insulation tests on a 4-year cycle. It inspected gas circuit breakers and lubricated the mechanisms on a 1-year cycle, performed moisture-in-gas tests on a 3-year cycle, and performed internal inspections on a 12-year cycle.

Substation Reclosers

Reclosers are circuit breakers with self-contained over-current detection mechanisms operating at less than 15,000 volts. Reclosers attempt to energize a circuit after a time delay to minimize outage durations. Reclosers use either oil or vacuum for interrupting faults.

Ameren-CIPS and Ameren-CILCO refurbished single-phase oil reclosers on a 3-year cycle and vacuum reclosers on a 10-year cycle. It inspected recloser batteries on a 3-month cycle. It tested the oil in three-phase reclosers on a 3-year cycle, and serviced them internally on a 10-year cycle

or after 65 operations. It tested contact resistance, speed, and vacuum on vacuum reclosers on a 10-year cycle or after 150 operations.

Ameren-IP changed the recloser battery on a 5-year cycle, replaced complete single-phase vacuum or gas reclosers on a 10-year cycle, and replaced single-phase oil reclosers on a 5-year cycle. It inspected, lubricated and tested the oil on three-phase oil reclosers on a 2-year cycle, and performed an internal inspection on a 2-year cycle.

Summary

Liberty found that the Ameren-IL substation maintenance programs were reasonable, except for the 1-year interval for gases-in-oil testing of its large transformers. Testing the oil in these large, expensive transformers could identify a problem before the transformer fails. Ameren-IL should conduct this test more frequently on large transformers.

c. Relays

Relays, technically called protective relays, are electro-mechanical, electronic, or microprocessor devices, located in substations. Relays measure power system voltages and currents and cause circuit breakers to open (or "trip") to remove abnormal conditions such as line faults. Proper operation of relays is critical for good system reliability. However, heat generated in relays, dirt, and component failures may cause relay trip and time delay settings to change (or "drift") or cause relays to malfunction. Utilities should routinely inspect, clean, and test relays. Some troublesome electro-mechanical and electronic relays need testing and recalibration more often than other relays. Some microprocessor relays perform self-tests and send alarms to dispatchers.

Ameren Services' T&D Design group designed relay schemes and determined relay settings. Ameren Services' Relay Maintenance Engineering group controlled the relay testing and maintenance program methods and the Relay Construction and Maintenance group (relay technicians) conducted relay testing work in the three Ameren-IL substation areas. These groups also designed, directed, and conducted Supervisory Control and Data Acquisition (SCADA) maintenance work.

Ameren-IL's EMPRV[151] work management system scheduled all relay testing program work. A database system called Power Book tracked relay work completion. Ameren-IL tracked relay test results in electronic formats specific for relay testing. Relay maintenance engineers provided the expertise needed to evaluate test results and issues. Supervisors and engineers directed the companies' relay technicians in performing the testing work. The relay maintenance engineers came from the relay design group. Newly hired relay technicians attended classes four times each year.[152]

[151] EMPRV is "EDS Maintenance Process Reengineering Vision."
[152] Interview #132, February 12, 2008.

All Ameren-IL Companies – In 2006 [153]

At the beginning of 2006, Ameren-IL had implemented a consolidated, system-wide relay testing program. It scheduled about 25 types of relays known to fail or experience trip-setting drift for testing on a 3-year cycle. It scheduled modern microprocessor relays with ability to self-diagnostic and signal an alarm if they fail and all other electro-mechanical relays for testing on a 6-year cycle. Ameren-IL verified the operation of lockout relays by trip checking whenever it tested the other relays. It periodically trip checked critical transmission-line relays when it could arrange line outages. Ameren-IL reported that its program was consistent with the Institute of Electrical & Electronic Engineers (IEEE) relay testing survey and the requirements of the Southeastern Electric Reliability Council, the regional transmission reliability group. Ameren-IL was replacing various types of relay test equipment used by the companies with a standard system of leading-edge relay test equipment using automated relay testing programs and test record keeping. It also had a program for replacing problematic and obsolete relays in all companies.

Ameren-CIPS – Prior to 2006 [154]

Until the end of 2005, Ameren-CIPS tested transmission line relays on a 3-year cycle, and all other transmission and distribution relays on a 6-year cycle. It trip checked critical transmission circuits to verify proper operation of relay schemes.

Ameren-IP – Prior to 2006 [155]

Until the end of 2005, Ameren-IP tested the types of relays known to experience problems on a 3-year cycle and all other relays on a 6-year cycle. It tested microprocessor-based relays on an 8-year cycle.

Ameren-CILCO – Prior to 2006 [156]

Until the end of 2005, Ameren-CILCO tested relays on a 4-year cycle. However, it was behind schedule in 2003, and the Illinois Commerce Commission Staff determined that Ameren-CILCO's transmission relay testing practice was not consistent with its program. The Illinois Commerce Commission Staff requested the company return to the 4-year cycle and conduct a company-wide relay-setting study by the end of 2004. The company tested nearly all of its relays by the end of 2004 and had a relay setting study underway. The relay setting study initiated many changes in relay settings and the replacement of obsolete relays.[157]

[153] Response to Data Request #29 and Interview #132, February 12, 2008.
[154] Response to Data Request #29.
[155] Response to Data Request #29.
[156] Response to Data Request #29.
[157] Response to Data Request #28

Relay Testing Performance[158]

The table below provides a summary of relay testing completion.

year	2004	2005	2006
Ameren-CIPS relays	100%	100%	
Ameren-IP – North relays	100%	100%	
Ameren-IP – Central relays	100%	74%	
Ameren-IP – South relays	75%	94%	
Ameren-CILCO	99%	- -	
All Ameren-IL companies			
Transmission			77%
Distribution			100%

Summary

Ameren-IL implemented the system-wide relay testing program in 2006. Ameren-CILCO conducted very little relay testing in 2005 because it had tested all relays in 2003 and 2004. Ameren-IL explained that Ameren-IP delayed some relay testing into January of the following year and did not include the testing in the year-end reports provided. Ameren-IL delayed some relay testing because it had to schedule the work with substation-equipment maintenance outages. In addition, workforce deficiencies and labor-agreement limitations on using other workforces at Ameren-IP delayed completion of some relay work. Ameren-IL now mandates completing all relay testing within the year. Recent local union rule changes allow relay technicians to work in other areas, if needed.[159]

Liberty found that Ameren-IL relay testing programs were reasonable. However, its relay testing task completions did not fully comply with its programs.

d. Reliability Improvement Programs and Practices

This section of the report covers reliability improvement programs and practices not discussed in other sections or chapters. More specifically, the Ameren-IL reliability programs in place before 2007 included the sub-transmission automation program, the distribution tap-fuse program, and the worst performing circuits program. The reliability practices discussed below are installing animal protection devices on distribution line and substation equipment, installing electrified animal fencing in distribution substations, and installing lightning arresters on distribution equipment.

Liberty also makes note of three practices that Ameren-IL initiated during 2007. These are National Electrical Safety Code (NESC) reliability-related compliance matters, Ameren-IL's "normalized" worst performing circuit program, and a reliability review program.

[158] Response to Data Request #28.
[159] Interview #132, February 12, 2008.

Ameren-IP identified the need for in-mass replacement of a type of cross-arm brace with incipient defects on one 345,000-volt transmission line. It replaced about one-half of these by the fall of 2006. It replaced the remaining braces in 2007 and scheduled the replacement of the braces on another line of the same design for 2008. Ameren-IL is investigating methods to mitigate breakage of a specific type of damaged transmission-line shield wires. Ameren-IL was not aware or any other systematic deficiencies of its transmission lines equipment.[160]

Sub-Transmission Automation[161]

The Ameren-IL companies used Supervisory Control and Data Acquisition (SCADA) to monitor substation and line loads, voltage, and alarms, and to provide remote control of transmission circuit breakers, sub-transmission circuit breakers and switches, and some distribution circuit breakers, load tap changers, and capacitor banks.

Ameren-IP began installing SCADA systems in its transmission substations and generating plants in the early 1980s. However, Ameren-IP had not installed SCADA in its distribution substations because the majority of them have only single-phase reclosers and voltage regulators, and were not compatible with SCADA applications. Ameren-IP had 200 locations connected to its SCADA system.

Ameren-CILCO began installing SCADA systems in the 1970s. It had installed SCADA in all of its transmission and sub-transmission substations, and 60 percent of its distribution substations. SCADA-controlled distribution circuits served 68 percent of Ameren-CILCO's customers. Ameren-CILCO had 109 remote SCADA terminals.

Ameren-CIPS also installed SCADA systems in the late 1970s in its transmission and sub-transmission substations. SCADA controlled only 9 of Ameren-CIPS' 952 distribution circuits. The former Union Electric substations in Alton and E. St. Louis had a substantial amount of distribution SCADA installed because these substations had SCADA-compatible switchgear and transformers with load tap changers. Ameren-CIPS had 195 remote SCADA terminals.

Additional remote control and monitoring by dispatchers, and automatic sectionalizing and switching for the distribution and sub-transmission circuits can benefit the safe and timely restoration from outages. Ameren-IL reported that it funded capital programs for additional SCADA and automatically controlled operations for its sub-transmission and distribution substations and circuits.
In 2006, Ameren started a sub-transmission automation-upgrade program that it plans to complete in 2009. The projects funded for 2006 and 2007 included two automatic throw-over switch schemes and six remote-control switches for substations and circuits for Ameren-CIPS. For Ameren-CILCO, the projects included installing three automated switches and two reclosers. For Ameren-IP, the projects included three automated switches and a circuit recloser.

Ameren-CIPS expended $186,923 in 2004 for sub-transmission line automation, $129,143 in 2005, and $36,839 in 2006. Ameren-IP expended $49,513 for sub-transmission line automation

[160] Response to Data Request #553.
[161] Response to Data Request #40.

in 2005, and $77,729 in 2006. Ameren-CILCO could not report sub-transmission automation expenditures because it did not have a specific work order for automation work. However, it budgeted about $49,000 in 2006.[162]

Ameren-IL's rate of progress on its sub-transmission automation system improvements was reasonable.

Distribution Tap-Fuse Program[163]

Lines connected to or "tapped" off main circuits supply electricity to customers located hundreds or thousands of feet away from main distribution circuits. These tap lines sometimes run through wooded areas. Fuses were not always installed where these tap lines connect to the main circuits. A fault on an un-fused tap line could affect service to all customers on the main circuit. Such a fault could also affect service restoration time because locating faults on tap lines can be difficult.

Ameren Services' Distribution Planning and Asset performance engineers implemented Ameren-IL's tap-fuse program for Ameren-CIPS and Ameren-CILCO in 2003 and for Ameren-IP in 2005. The group used its Tap Fusing Program software to evaluate outages, determine optimum fuse locations, and expected outage reductions with additional fuse installation. Ameren-IL scheduled the current tap-fuse program for completion in 2008. The objectives of the program were to identify circuits with un-fused taps and to install systematically tap fuses on selected circuits each year for the greatest reliability improvement per dollar of cost. Ameren-IL's criteria required that the fuse installations cost less than $25 per unit of estimated avoided energy (kVA-hour)[164] interruption, as derived from circuit outage history and circuit load data. The companies' division engineers conducted circuit inspections to assist in the evaluation of circuits selected by Ameren Services. The division engineers, using distribution system protection coordination software programs, selected fuses with ratings and characteristics that coordinated with, or blow before, upstream devices operated. Each company was responsible for its program budgeting, application, and tracking. In 2007, the companies' started to track completion of tap-fuse jobs on Ameren-IL's Reliability Action Plan Performance Reports,[165] which regional vice-presidents reviewed monthly.[166] Ameren-IL concluded that by 2008 the tap-fuse program would save about 70,000 customer interruptions each year. Ameren-IL reported that it is considering implementing a new tap-fuse program in 2008 with less stringent selection criteria and a main-line circuit sectionalizing (additional fuses or reclosers) program to reduce further customer interruptions.

Ameren-CILCO expended $55,988 in 2005 and $142,055 in 2006 on its tap-fuse program. Ameren-CIPS expended $570,525 in 2004, $526,635 in 2005, and $459,486 in 2006. Ameren-IP expended $105,955 in 2005 and $511,633 in 2006.

Ameren-IL's tap-fuse program was reasonable for improving distribution system reliability.

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[162] Response to Data Request #36.
[163] Response to Data Request #35.
[164] kVA-hour is a measure of energy in thousands of volts times amperes times hours.
[165] Response to Data Request #179.
[166] Interview #25, December 19, 2007, and interview #26, December 17, 2007.

Worst Performing Circuits Program

The Illinois Commerce Commission requires each of the Ameren-IL companies to identify each year's worst performing one-percent of its distribution circuits based on certain reliability measures. After the identification, the companies had to determine the appropriate steps to take to improve circuit reliability.

The Illinois Reliability Program (IRP) group in the Ameren-IL Dispatch Operations department monitored the program using outage data collected from the Outage Analysis System (OAS). After the worst performing circuit designation, division-engineering groups reviewed reports from scheduled and special circuit patrol inspections to determine the circuit conditions that caused outages. If a circuit performed well under normal conditions, but was a worst performing circuit because of the unusual weather, division engineering may have determined that the circuit needed minimal or no corrective action because storm restoration work corrected defects contributing to weather-caused outages. If equipment malfunctions were significant contributors to outages, the division reviewed the historical inspection and maintenance records to identify a pattern of failures, and ordered any pending maintenance work completed. The Reliability Program group notified the forestry department to take actions to correct any tree-related issues.

Ameren-IL indicated that the worst performing circuit inspection and engineering assessment included:

- condition assessments of vegetation, poles, cross arms, braces, lightning arresters, insulators, cable spacers, ground wires, and other equipment
- design evaluations as to whether portions of the circuit should be reconfigured or rebuilt to current construction standards
- circuit protection evaluations for the possible need to install additional animal guards, grounding, and lightning arresters to meet current construction standards
- a determination of whether the circuit protection could be improved with better coordination, more tap and mainline circuit fuses, and more automatic circuit reclosers.

Distribution Animal Protection Practices

Animal interference with distribution line equipment was a leading cause of customer interruptions. Ameren-CILCO was the only company that had a formal animal guard policy. It required the installation of animal protection on all new overhead distribution transformers and retrofitting existing equipment experiencing an animal-related outage with animal guards.[167]

Ameren-IL reported that it assumed the potential for animal interference anywhere on the distribution system and installed animal protection accordingly.[168] It required animal guards on new distribution line equipment, such as overhead transformers, capacitors banks, reclosers, capacitor banks, and voltage regulators. Ameren-IL indicated that its companies retrofitted existing distribution line equipment with animal guards and replaced bare equipment wires with

[167] Response to Data Request #35.
[168] Response to Data Request #414.

insulated wires on existing pole-mounted distribution equipment based on the results of circuit line patrols, specific reliability improvement project reviews, and worst performing circuit reviews.[169] Ameren-IL indicated that it also was installing animal guards when repairing or maintaining equipment on distribution equipment poles, regardless of known need.[170]

The Ameren-IL companies did not have a specific work order to track animal protection project expenditures. Linemen and management in all companies reported to Liberty that troublemen and other linemen routinely retrofitted line equipment with animal guards when performing other work.[171] The companies also reviewed protective device coordination to reduce the number of customer outages caused by animal interferences.[172]

Distribution Lightning Protection Practices[173]

Lightning-caused distribution circuit flashover was another leading cause of customer outages. Ameren-IP was the only company that had conducted a formal lightning evaluation study. The three-year study of lightning performance, which it completed in 2004, evaluated circuits with substantial lightning-caused outages in 2001. Ameren-IP engineers evaluated circuit exposure, lightning strike counts, and pole and equipment design issues. Ameren-IP conducted various improvements on eight circuits and compared the reliability results to other circuits. It found that the improvement reduced the number customer interruptions.[174]

Lightning protection improvements were included in Ameren-IL's worst performing circuit improvement work. Ameren-CIPS expended $178,580 for lightning-related projects for specific circuits in 2004, $268,406 in 2005, and $138,707 in 2006. Ameren-IP expended $103,206 in 2005 and $108,065 in 2006. Ameren-CILCO did not have specific work orders to track lightning protection project expenditures.[175]

Proactive Distribution Circuit Protection Coordination

Distribution line, tap, and equipment fuses and line reclosers have specific characteristics for clearing faults. If the utility does not select and install these devices according to analytically derived coordination studies, they will not operate as intended, and line and equipment faults could affect more customers than necessary. Proper protective device coordination is necessary for good reliability. In addition, when Ameren-IL linemen or others during storm jobs replaced fuses to restore service after outages, reportedly it occasionally used larger fuses than indicated on the digital mapping system to ensure re-energizing of load. Ameren-IL was to replace these fuses later. However, there no assurance that fuses were always replaced with the specified fuses.[176] Fuse equipment poles did not indicate fuse sizes, nor were spare fuses kept at these poles.

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[169] Response to Data Request #36.
[170] Interviews Nos. #30 through #36, October 30-December 5, 2007.
[171] Interviews Nos. #30 through #36, October 30-December 5, 2007.
[172] Response to Data Request #36.
[173] Responses to Data Requests #35 and #413.
[174] Response to Data Request #413.
[175] Responses to Data Requests #36 and 414.
[176] Response to data Request #568.

Ameren-IL conducted coordination studies on new, modified, and worst performing circuits, and on some circuits selected by division engineers. Except for Ameren-IP, the companies had not had a systematic coordination review of all circuits, other than studies for some of the worst performing circuits. In the 1990s, Ameren-IP implemented a systematic distribution circuit protective device coordination and adequacy review. Distribution engineers performed the studies to determine the changes necessary for about 10 percent of Ameren-IP's circuits each year. This program continued until 2004 when Ameren-IP had reviewed and modified about 70 percent of its circuits. The program discontinued in 2004.[177]

2007 Reliability Initiatives

In 2007, Ameren-IL placed increased emphasis on identifying and correcting conditions not consistent with the National Electrical Safety Code. While the primary purpose of the Code is to establish guidelines for public and employee safety, an additional benefit of some of the criteria is to improve service reliability.

Ameren-IL implemented a 2004-2006 Normalized Worst Performing Circuits Program in 2007.[178] The purpose of the 2007 program was to identify those distribution circuits in each company that had a high interruption frequency after excluding the effects of large storms and to study and correct the causes of outages on those circuits.

In 2007, Ameren-IL implemented a reliability action-plan review process, which operating vice presidents, the division managers, and Energy Delivery Technical Services management reviewed at monthly meetings. The items reviewed included:[179]

- tracking of special circuit performance improvement projects
- the tap-fuse program
- the new multiple device operation investigations program
- the customers exceeding Illinois Commerce Commission reliability targets program
- circuit repairs planned and completed
- device inspections and repairs planned and completed
- underground residential distribution cable replacements planned and completed
- vegetation management
- substation improvements
- substation maintenance
- circuit inspections.

3. Conclusions

1. The Ameren-IL companies had reasonable programs for repair and replacement of underground distribution residential cables. However, the

[177] Response to Data Request #409.
[178] Response to Data Request #35.
[179] Response to Data Request #179.

companies' replacement criteria were different and some repairs to close cable loops took too long. (Recommendation VI-12.)

All of the companies' underground distribution cable-replacement programs were consistent with good utility practice, but some provided more reliability than others did. Ameren-CIPS replaced cable sections it determined deteriorated after one failure and the other companies replaced cable sections after three failures. When only one section of a cable loop had failed, they restored customer service in a reasonable time by switching customers to the undamaged part of the loop. However, the time to restore the integrity of cable loops (closing the loops by repairing or replacing the failed section after customer restoration) was inconsistent among the divisions, and sometimes took a month or more. A second cable failure in a loop would expose customers to possible extended outages. It is important to restore cable loops quickly to maintain reliability. Ameren-IL did not maintain records to determine the number of cable failures that occurred each year and to determine the delay times for restoring each loop. In addition, they did not consistently track underground residential cable repair and replacement expenditures. In 2007, Ameren-IL began tracking open loops, but not the amount of time loops remained open.

2. The Ameren-IL companies had reasonable substation maintenance and testing programs but they did not complete all maintenance activities in a timely fashion and the 1-year interval for conducting gas-in-oil testing of its large transformers was too long. (Recommendations VI-13 and VI-14.)

All of the companies' substation equipment maintenance and testing programs were consistent with good utility practice. All programs were time-based, but modified to initiate specific activities based on operation-, inspection-, or testing-based triggers.

The companies applied priorities to repairs and maintenance program activities. All three companies essentially completed Priority 1 repairs and preventive maintenance and testing activities, but did not complete all Priority 2 activities. They may not have completed non-critical Priority 3 repairs (refer to Recommendation VI-9). As noted in other parts of this chapter, Liberty found some equipment deficiencies, at least one of which was critical, during its substation inspections. This brought into question the effectiveness of the companies repair and maintenance priority practices, and concern about whether Ameren-IL fully trained inspectors and maintenance personnel to evaluate properly the urgent need to repair critical deficiencies, such as leaking high voltage bushings and excessively low oil levels.

The companies tracked whether they completed activities, but not whether they completed the activities within assigned time limits. In addition, they did not separate maintenance activities and track completions consistently.

The 1-year interval for testing the oil in large transformers for dissolved gas-in oil is excessively long, considering the low cost of the test compared to the large losses if a large transformer fails. Dissolved gas-in-oil testing is the most effective means to identify many types of incipient faults in transformers that can result in complete transformer failure. For these tests to be of optimum value, the testing interval should be short to identify incipient faults before they cause transformer failure.

3. The Ameren-IL companies had appropriate relay testing programs, but did not complete all scheduled relay testing. (Recommendation VI-15.)

At the beginning of 2006, Ameren-IL consolidated the companies' protective relay testing programs. Prior to that date, Ameren-CILCO tested its relays on a 4-year cycle. The 2006 program was based on Ameren-IP's and Ameren-CIPS' 3-year cycle for some relays and 6-year cycle for other relays. These relay testing schedules were consistent with good utility practices. However, the companies had not completed all relay testing consistent with its programs. Ameren-CILCO conducted very little relay testing in 2005 because it had tested all relays in 2003 and 2004. Ameren-IP did not complete all relay testing scheduled in 2004 and 2005 because of relay workforce deficiencies and because labor agreements limited using other workforces. Ameren-IL explained that it delayed some relay testing in 2006 into January of the following year and did not include the testing in the year-end reports provided. Ameren-IL reported that it now mandates completing all relay testing by year-end. Recent local union rule changes allow relay technicians to work in other areas, if needed.

4. The Ameren-IL companies had good reliability improvement programs that should continue. The companies need to supplement some programs. (Recommendation VI-16.)

The Ameren-IL companies' sub-transmission automation program, tap-fuse, and worst performing circuit programs, and its animal and lightning protection practices, were good programs and practices for improving reliability. However, the tap-fuse program will expire in 2008, Ameren-CIPS and Ameren-CILCO did not conduct lightning protection studies, no company conducted animal protection studies, and only Ameren-IP had a program, which concluded in 2004, for systematically verifying distribution circuit protective device coordination on circuits not included in the worst performing circuit program. There were no records to permit the determination of the extent of animal protection work, nor, for Ameren-CILCO, the extent of lightning protection work.

4. Recommendations

VI-12 Improve the Underground Residential Distribution cable program.

Ameren-IL reported that it integrated components of various programs in a new system-wide underground distribution cable-replacement program implemented in 2007. Ameren-IL should ensure that its new program includes tracking methods for cable repair and replacement costs and for evaluating division performance in restoring cable loops in reasonable times. Management should have the tools available to track not only the number of open underground residential distribution cable loops but also the time required to close each loop. Reportedly, some cable repairs took a month or more to complete. This was too long.

In its comments on the draft report, Ameren-IL accepted this recommendation in principle but requested two years for implementation to coincide with the implementation of Ameren's updated mapping systems. Liberty agrees with this implementation schedule provided that Ameren-IL demonstrates improved timeliness of underground cable repair and replacement within one year of the date of this report.

VI-13 Improve the substation maintenance program.

Ameren-IL reported that it integrated components of various programs in a new system-wide substation maintenance program implemented in 2007. Ameren-IL should complete all maintenance program work consistent with its new substation-maintenance program schedules and triggers. It should take measures to ensure that it has adequately trained and instructed its personnel to identify accurately and to correct critical deficiencies that require immediate corrective action, such as leaking high-voltage bushings. It should correct all Priority 3 minor deficiencies, such as rusted paint and small oil leaks, within finite timeframes. Uncorrected Priority 3 defects that might appear to be cosmetic issues can cause operational problems later and could contribute to a general lack of concern by Ameren-IL personnel regarding the upkeep of equipment in good condition. It should take measures to track the completion of all repairs and all maintenance activities to verify that it completed the activities within the new program timeframes. Ameren-IL should implement this recommendation within nine months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation in principle but only wanted to monitor Priority 3 deficiencies and correct them if problems worsen. Liberty disagrees with this approach. An important part of this recommendation was to require the correction of minor deficiencies within a defined timeframe.

VI-14 Shorten the intervals for gas-in-oil testing for large transformers.

Ameren-IL's substation maintenance programs were reasonable, except for the 1-year intervals for gas-in-oil testing of its large transformers (345kv transformers and 138kv and above transformers with load tap changers). Unless there is a continuous gas-in-oil monitor on a large transformer, Ameren-IL should test for gas-in-oil at least quarterly to have a better chance of detecting many of the deteriorating conditions that lead to catastrophic transformer failure. The Ameren-IL companies experienced failures of four large transformers since 2002. Although Liberty does not know whether more timely gas-in-oil tests might have prevented the failures, it is prudent to spend a little for this economical test compared to the losses caused by failure of more of these large transformers. Ameren-IL should implement this recommendation within six months of the date of this report.

In its comments on the draft report, Ameren-IL proposed annual gas-in-oil testing for large transformers. Liberty disagrees. Such testing should be quarterly at a minimum.

VI-15 Complete all relay testing work consistent with the 2006 program.

Ameren-IL implemented a system-wide relay testing program in 2006 consistent with good utility practices. However, Ameren-IL did not fully comply with its relay testing schedules because of some workforce issues. Ameren-IL should take measures to provide adequate workforces for testing its relays consistent with program schedules. Ameren-IL should implement this recommendation within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-16 Continue current reliability-improvement programs and implement additional programs.

Ameren-IL should continue its tap-fuse program, with reduced criteria for implementation, when it completes the current program in 2008, implement additional programs, and improve tracking of all reliability-related programs, including lightning and animal protection work.

(1) The Ameren-IL tap-fuse program should continue past 2008 because un-fused taps contribute to poor reliability by causing main circuit outages for tap line faults. Typically, tap fusing is more cost effective than other reliability improvement programs.

(2) Ameren-IL should continue its "normalized" (excluding major storms) worst performing circuits program implemented in 2007. This program supplemented the ICC-mandated program and used valuable non-storm related outage cause data as a basis for improving conditions that affect reliability on certain circuits.

(3) Ameren-IL should continue the programs, both ongoing and those implemented in 2007, as tracked in the Reliability Action Plan Performance Report.

(4) Ameren-IL should conduct analytical system-wide studies specifically for identifying how it could reduce lightning-caused outages by actions in addition to current lightning protection practices. Ameren-IP conducted such a study in 2004.

(5) Ameren-IL should also determine whether there is value in conducting an animal-protection study that could result in supplementing current animal protection practices.

(6) Ameren-IL should conduct a systematic system-wide distribution system protective device coordination program, similar to the program conducted by Ameren-IP prior to its merger with Ameren.

Ameren-IL should complete a plan for the above items within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation in principle, but suggested only an evaluation of the value of the system-wide coordination study in item (6) above.

G. Work Force

1. Introduction

Liberty has found that some utilities started in the 1990s to reduce in-house staffing and workforce levels to save money. They balanced some of the reductions in workforce levels with increased efficiencies in better work management systems and procedures. Others used contractors to supplement the workforces. Since the utilities had to complete new business and government-required work, they reduced maintenance work to match the available workforce.

It is good practice for a utility to maintain adequate engineering and management staffing levels to plan and manage its transmission, distribution, and substation inspection and maintenance programs, and adequate in-house and contractor workforce levels to timely complete the work. However, a reduction in staffing and workforces does not necessarily lead to incomplete maintenance. Other factors involved include efficiency improvements in maintenance programs, maintaining a reasonable backlog of pending work, increased effectiveness of the work management programs, changes in the quality of personnel training, improved field work efficiencies, improved equipment and materials supplied, improved quality control, changes in labor agreements, and management/workforce relationships.

If a utility's inspection and maintenance programs are adequate and the utility applies sufficient staffing and workforces for the work, the condition of the utility's systems should be consistent with good utility practices. A utility should have sufficient workforces to complete inspection, repair, maintenance, and reliability work consistent with sound policies and programs. Many utilities maintain a staffing level of in-house engineers, linemen, and substation electricians sufficient to conduct these activities, and use contractors to complete large construction jobs and to provide specialized services such as pole inspections and tests. Utilities and the labor unions must cooperate to provide safe and good working conditions for the employees, yet provide optimum productivity and emergency response for the ratepayers.

2. Findings and Analysis

a. Distribution Inspection and Maintenance Workforce[180]

Ameren-IL division management and linemen reported that the distribution line workforces had decreased about 10 percent over the previous ten years, in part, due to legacy companies' early retirement programs. However, they reported that the combination of in-house linemen and contract linemen had been generally sufficient for both regular and emergency work. They were concerned that the in-house linemen and available contractors may not be sufficient if the new, more intense inspections beginning in 2007 generated substantially more maintenance work. Hiring had been restricted because of unsettled labor agreements. They were concerned that at least three years were required before they could fully use apprentices as linemen.

Since the mergers, the companies hired more supervisors and implemented a new work management program to manage jobs and crews. Linemen reported that management generally planned, started, and finished regular and storm jobs on time, and that material supply, tools, and trucks supplied were adequate. Linemen reported that some waiting occurred before starting repairs for large 2006 storm jobs, but most acknowledged that some restoration planning was required to attack effectively large storm repairs.

Each of the companies' divisions scheduled about 30 percent of the available workforces for line maintenance work, and Ameren-IP had special maintenance line crews. All companies required linemen to carry and install guy guards and animal guards, report blown lightning arresters, and repair defects found not specifically included in job orders.

[180] Interviews #30, #31, #32, #33, #34, #35, and #36, October 30 and December 5, 2007.

Ameren-IP and Ameren-CILCO troublemen and crews were either on-the-job or on-call 24 hours each day. Ameren-CIPS troublemen and crews were not required to respond to emergency calls, which sometimes slowed emergency responses. Some Ameren-IP and Ameren-CIPS linemen did not like the Ameren-IL automatic call out (ACO) system because it did not provide sufficient information to determine whether to accept a job. Ameren-CIPS was using its own semi-automatic call out system based on lineman seniority.

Concerns about their continued employment affected linemen's attitude because of the Ameren buyouts, possible rate reductions, and unsettled labor agreements.[181] Some Ameren-IP and Ameren-CIPS linemen reported that their management teams did not always respond adequately, in their opinion, to workforce complaints and suggestions. Ameren-IL reported that it is conducting relationship building with the unions to better resolve employee issues with the company.

All linemen received about four years of union-provided apprentice training. Ameren-IL provided specific training at its Decatur training center (since moved to St. Louis).

Labor agreements did not allow Ameren-CILCO linemen to work on energized 12,000-volt lines using high voltage gloves, as was done in the other companies. Ameren-CILCO needed maintenance outages in some cases to perform repairs. Linemen in the other companies could "glove" 12,000-volt lines.

Ameren-IL organized the companies into seven divisions.[182] Six of the seven divisions were responsible for inspecting and maintaining distribution equipment owned by at least two of the companies, and each of these divisions had to comply with more than one labor agreement. Agreement rules prevented line crew sharing for regular and restoration work between different companies' areas within the each division, and limited the use of line inspection and pole inspection and testing specialty contractors. Ameren-IL reported that the company and the labor unions recognized that they needed to resolve some efficiency issues and they have been working together to improve efficiencies that will positively affect the ability of the companies to provide more reliable service to the customers.

Ameren-IL and the various labor unions have agreed to a number of changes that allowed Ameren-IL:[183]

- to be able to work 12,000-volt lines energized in all companies, using gloves
- to have more reasonable flexibility for emergency response and regular work using linemen, substation electricians, and relay technicians outside their companies and union local jurisdictions,
- to be able to use smaller, more cost effective crew sizes when reasonable and safe
- to use contractors when necessary without unreasonable limitation on in-house staffing size and without requirement to pay house overtime when contractors are hired.

[181] Interview #30, October 30, 2007.
[182] Changed to six divisions in 2008.
[183] Interview #111, December 18, 2007.

Some of these agreed items were effective in late 2007. They were to implement others during 2008. These changes should appreciably reduce the limitations imposed on the companies by the legacy labor agreements. Ameren-CIPS' linemen still are not required to respond to emergency calls.

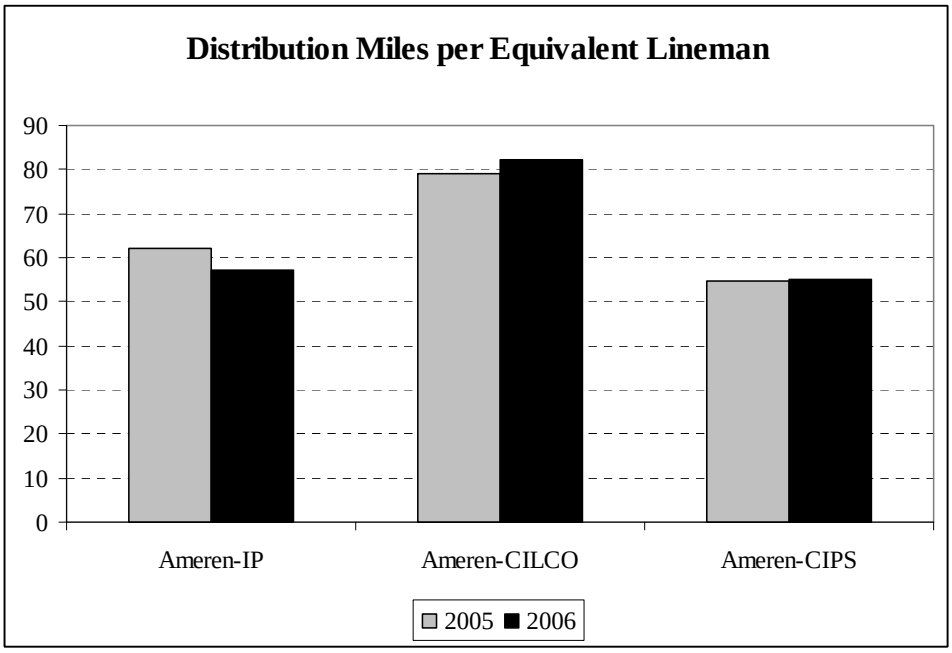
Ameren-IP and Ameren-CILCO used contractors to perform up to 20 percent of their total workloads in 2005 and 2006, while Ameren-CIPS did not appreciably use contractors during those years.[184] Ameren-CIPS did not use contractors for normal work because it did not need to do so,[185] and the Ameren-CIPS labor agreement limited contractor use with minimum staffing requirements and limited contractor use to work not customarily performed by in-house linemen.[186] The company's December 2007 labor agreement reduced these minimum staffing levels.

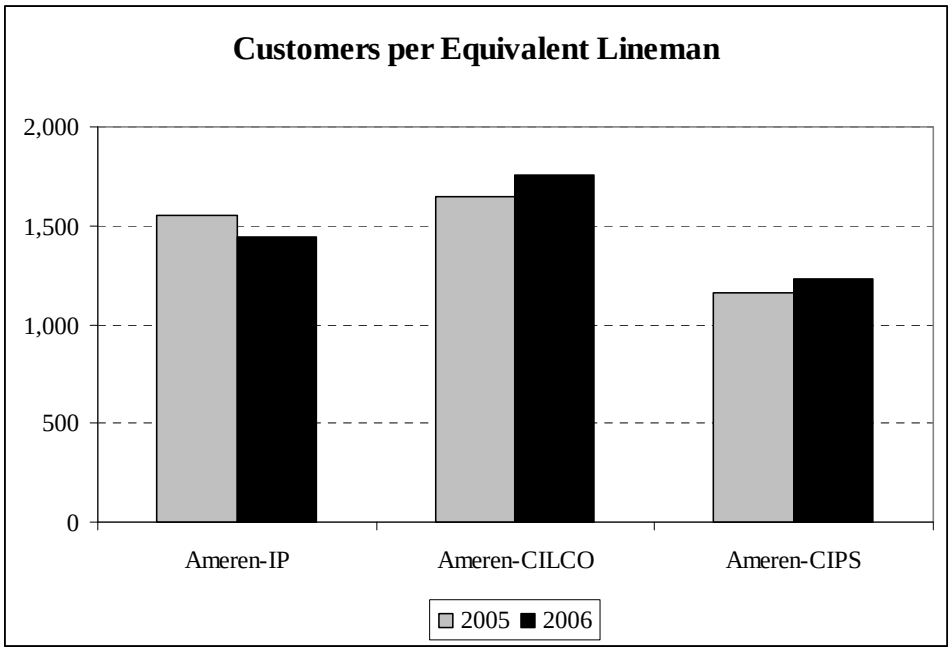
Ameren-IL had about 630 linemen and apprentices in 2004, 638 in 2005, 651 in 2006, and 615 in 2007. In 2007, it had 37 open positions available.[187] The tables below show the number of linemen in each company for 2005 and 2006 and an estimate of the total workload performed by contractors.[188] Liberty estimated an equivalent workforce by increasing the number of linemen in relation to the work done by contractors.

Linemen		
	2005	**2006**
Ameren-IP	283	301
Ameren-CILCO	95	91
Ameren-CIPS	260	259
Percent Contractor Work		
Ameren-IP	18%	20%
Ameren-CILCO	14%	14%
Ameren-CIPS	0.4%	0.4%
Equivalent Workforce		
Ameren-IP	345	376
Ameren-CILCO	110	106
Ameren-CIPS	261	260

The charts below show a comparison of the miles of distribution line and number of customers per equivalent lineman.

[184] Response to Data Request #405.
[185] Interview #35, December 4, 2007.
[186] Interview #35, December 4, 2007.
[187] Response to Data Request #406.
[188] Responses to Data Requests #405 and #406.





By the measures used for these charts, the smaller Ameren-CILCO had the smallest relative workforce. It is also apparent that neither of these measures was significantly anomalous, and there was no material change between 2005 and 2006.

Considering the records available regarding work completion and backlogs, Liberty found that the levels of in-house workforces were adequate. Ameren-CIPS had a larger in-house workforce, based on the number of customers per linemen. The companies will need additional linemen or firm contractor commitments for completing the expected increase in workload caused by ICC commitment work and the more intense line and pole inspection work.

b. Substation Maintenance Workforce[189]

Ameren's substation and relay groups included 36 engineers in 2004, 30 engineers in 2005, and 30 engineers in 2007.[190] It assigned five substation-maintenance field engineers[191] to Ameren-IL's 1,480 substations, or about 300 substations per engineer. This ratio is too high for the substation engineers to get actively involved in day–to-day substation inspections, repair, and maintenance. A more reasonable upper limit is one engineer for every 100 to 150 substations.

Substation management reported that the three substation areas had sufficient workforces and other resources to complete substation maintenance work, except in the high growth Champaign-Urbana area where there was substantial new construction work. Except for Ameren-CIPS, the companies used contractors for substation construction work to relieve in-house electricians for maintenance work. The Ameren-CIPS union agreement restricted use of contractors, but the new December 2007 agreement allows more use of contractors. Substation apprentices receive about four years of formal training, plus on-the-job training.[192]

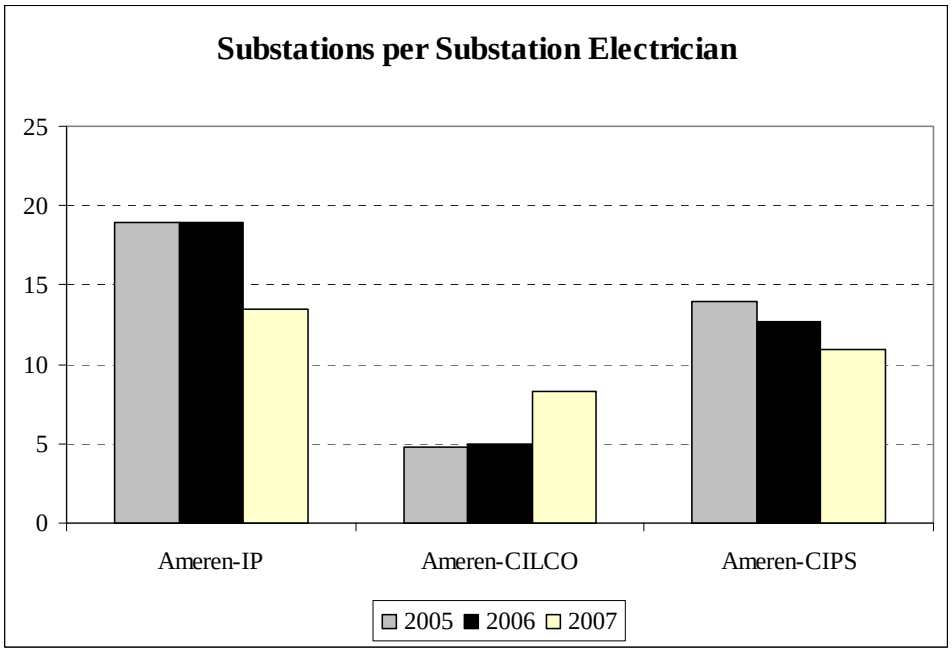
The table below shows the number of substation electricians for each company for the years 2005, 2006, and 2007. In 2007, there were three open positions for substation electricians.[193]

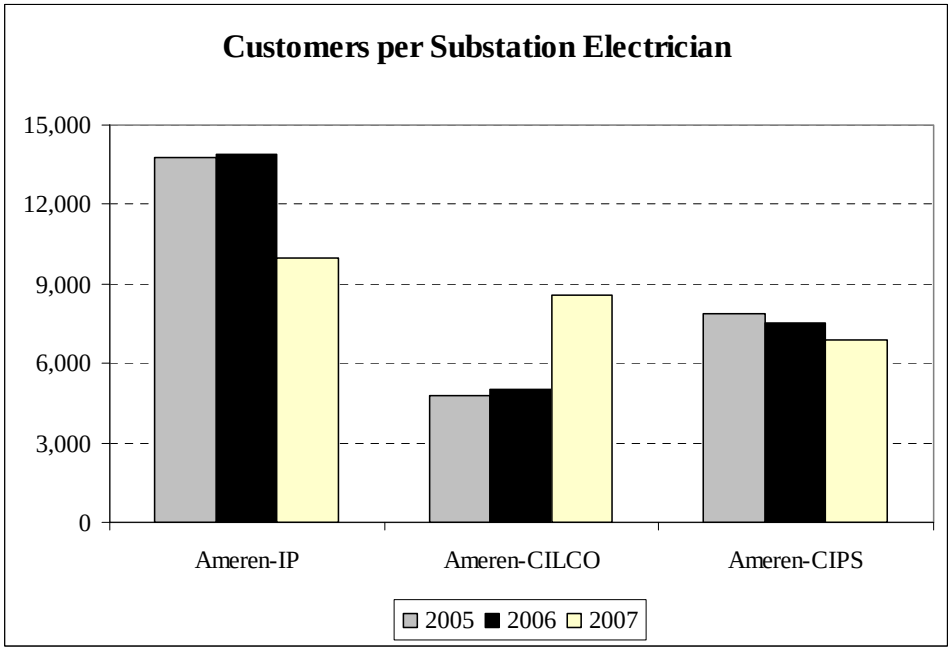
Substation Electricians

	2005	2006	2007
Ameren-IP	39	39	55
Ameren-CILCO	38	37	22
Ameren-CIPS	40	44	51

The charts below show measures of substations and customers per substation electrician for 2005-2007.

[189] Response to Data Requests #42 and #406.
[190] Response to Data Request #41.
[191] Interview #133, January 31, 2008.
[192] Interview #131, January 31, 2008.
[193] Responses to Data Requests #7, #406, and #608, and Interview #131, January 31, 2008.





Ameren-IL changed substation electrician staffing in 2007, increasing staff for Ameren-IP and Ameren-CIPS, and decreasing staff for Ameren-CILCO. These changes brought the relative staffing among the three companies more in line with one another. Considering the urban/rural make-up of the companies, Liberty found that the 2007 staffing levels are more reasonable than staffing in earlier years. In addition, considering the use of contractors by Ameren-IP and Ameren-CILCO, it is likely that the 2007 staffing levels per customer were nearly equivalent.

From the records available, Liberty found that Ameren-IL was completing routine and priority work at its substations up through 2006. Inspections that are more rigorous and more attention to minor maintenance items could cause staffing to be insufficient in the future.

c. Relay Maintenance Workforce

For the period 2004-2007, Ameren-IL had only two relay maintenance engineers, or about one for every 14 technicians.[194] Relay engineer staffing was inadequate to provide a reasonable level of technical expertise. Although relay technicians conduct the physical work on the relays, the engineers have more training for analytically verifying relay scheme designs and relay settings, troubleshooting relay schemes, evaluating relay test results, and determining the best use of relay testing equipment. A ratio of one engineer to five technicians is reasonable.

In this same period, Ameren-IL had between 24 and 28 relay technicians. In 2007, it had 24 relay technicians and 4 unfilled openings. Liberty examined individual company staffing of relay technicians and found that staffing was relatively constant and, on a per customer basis, nearly equivalent among the three companies. From the records available regarding the completion of relay testing, Liberty concluded that relay technician staffing was adequate. The unionized technicians from an area under one labor agreement could not help complete relay testing work in another area. The new agreements settled in December 2007 allowed more movement of the relay technicians.[195]

3. Conclusions

1. The distribution maintenance and inspection workforce staffing was adequate but will not be in the future. (Recommendation VI-17.)

Considering the records available regarding work completion and backlogs, the levels of in-house workforces were adequate, considering that Ameren-IP and Ameren-CILCO used contractors to supplement them. Ameren-CIPS had a larger in-house workforce, based on the number of customers per linemen. The companies will need additional linemen or firm contractor commitments for completing the expected increase in workload caused by ICC commitment work and the more intense line and pole inspection work.

2. Recent changes to labor union agreements should make for a more efficient use of Ameren-IL's workforce.

The labor agreements provide more flexibility in the use of personnel outside their normal company and local jurisdictions, allow the use of smaller crews where appropriate, and reduce the limitations on the use of contractors.

3. Substation maintenance engineer staffing is too low. (Recommendation VI-18.)

Ameren-IL had only five maintenance engineers, about one engineer for every 300 substations, in the field to assist with substation activities. Substation maintenance engineers should monitor substation repair and maintenance activities and provide technical guidance to maintenance crews. They should be in sufficient numbers to provide effectively quality assurance to substation maintenance and testing work.

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[194] Response to Data Request #608.
[195] Response to Data Response #470.

4. Substation electrician staffing was adequate but may not be in the future. (Recommendation VI-19.)

From the records available, Liberty found that Ameren-IL was completing routine and priority work at its substations up through 2006. Ameren-IL made appropriate changes to substation electrician staffing levels in 2007. Inspections that are more rigorous and more attention to minor maintenance items could cause staffing to be insufficient in the future.

5. There were adequate numbers of relay technicians but insufficient number of field relay engineers. (Recommendation VI-20.)

The relay engineering staff in the Ameren Services Design group performed most of the calculations and made decisions to produce relay scheme design, relay selections, and relay settings. However, there were only two engineers for the three Ameren-IL companies to provide technical guidance to 28 relay technicians in the field for using relay test equipment, troubleshooting relaying issues, training, and quality control.

4. Recommendations

VI-17 Increase the distribution system workforce.

Ameren-IL should conduct a comprehensive study to determine the required number of in-house linemen, or have firm commitments for contractor linemen. The companies' distribution system workload will increase because Ameren-IL has intensified its line inspections, including identifying variances from the National Electrical Safety Code, and because of ICC commitment work. Ameren-IL held a number of open linemen positions until the settlement of its labor agreement, which occurred in December 2007. Once the results of this comprehensive study are complete and Ameren receives the recommendations from an on-going staffing study (HB825), Ameren-IL should act promptly to implement short-and long-term staffing changes for this recommendation.

Ameren-IL should estimate the necessary staffing levels based on known additional work (*e.g.*, correcting National Electrical Safety Code deficiencies) and on an estimate of additional work that will result from new or more rigorous inspections. Improved tracking of defects to resolution and not permitting a buildup of backlogged maintenance items will be the key measures for deciding what staffing adjustments from the initial estimates Ameren-IL will need to make.

In its comments on the draft report, Ameren-IL suggested the comprehensive study, which Liberty included in the final recommendation.

VI-18 Increase the number of substation maintenance engineers.

Ameren-IL has five substation maintenance engineers in the field, or about one for every 300 substations. This ratio of engineers to substations is insufficient to provide adequate quality control of substation inspection, repair, and maintenance activities. One engineer for every 100 to 150 substations is a more reasonable ratio, depending on the mix of smaller and larger substations in an area. Ameren-IL should complete the implementation of the recommendation within two years of the date of this report.

In its comments on the draft report, Ameren-IL proposed only a staffing study. Liberty disagrees with this approach. The need for substation maintenance engineers is apparent now.

VI-19 Increase substation electrician staffing.

Ameren-IL may need to increase its substation electrician staffing levels because of more intense substation inspections, more repair work, and possibly more substation reliability work. Ameren-IL should conduct a study that determines substation-staffing requirements for its estimated future substation workloads.

As proposed in its comments of the draft report, Ameren-IL could include this study as part of the comprehensive staffing study mentioned in Recommendation VI-17 above. However, Ameren-IL should have a preliminary assessment of the need for more substation electricians within one year of the date of this report.

VI-20 Increase relay field engineer staffing.

Ameren-IL had only 2 electrical relay engineers to provide technical guidance for 28 relay technicians. Ameren-IL should conduct a comprehensive study to determine the required number of graduate electrical engineers needed to provide the appropriate level of technical guidance and to adequately assist the technicians. In addition, field relay engineering is good "training ground" in a utility electrical engineer's career path that produces engineers that are more knowledgeable when they later advance into management positions in other operating groups. One engineer for every five relay technicians may be a more reasonable ratio. Ameren-IL should complete the implementation of the short-and long-term staffing study results as quickly as possible.

H. System Conditions

1. Introduction

Electric utilities typically conduct thorough and well-managed inspection and maintenance programs on their transmission systems and keep them in good condition. Some, however, neglect the distribution system. They put a low priority on distribution system maintenance, particularly when new business work uses up resources and funding. These utilities only fix defective components when they cause outages. If they perform only minimal maintenance, circuits go un-inspected, poles need treatment or replacement, and aging line and substation equipment needs serviced or replaced. That is, system conditions deteriorate.

Old poles, lines, transformers and other equipment, if properly maintained, do not necessarily have higher failure risk than new equipment. A pole may look deteriorated, but may comply with National Electrical Safety Code strength requirements. Conversely, a pole may look good, but contains voids that reduce strength. Visual inspections alone are not sufficient to determine condition of many system components. However, visual inspections can detect many defects, such as broken ground wires, blown lightning arresters, broken cross arms, failed insulators, and pole hardware defects. Usually, poor visual appearance of system components is one indicator

that the utility has not maintained the system. Substations contain buses[196] that usually supply more than one circuit. When substation equipment fails because of poor maintenance large-scale outages can occur. Therefore, it is even more important for substations to be in good condition.

In 2006, an Illinois Commerce Commission inspector found that Ameren-IL had been non-compliant with the National Electrical Safety Code (NESC) guidelines at 28 locations on its electric circuits, all of which posed a risk to service reliability and public safety. Seventeen non-compliance issues involved the lack of guy-strain insulators in ungrounded down-guys or overhead guys, four locations involved inadequate clearances, and seven locations involved single wood cross arms supporting Ameren-IP's primary circuit crossings over railroads. The Illinois Commerce Commission Staff also reported the need for Ameren-CILCO to clear substations of debris, including bird-nesting materials.

To determine the condition of Ameren-IL's electric delivery systems and to determine whether the Ameren-IL companies' inspection and maintenance programs had been effective, Liberty:

- Reviewed Ameren-IL's reported reliability indices and outage causes.
- Reviewed the electrical loading of equipment in the electric delivery system.
- Evaluated equipment age and failures, focusing on wood poles and substation transformers.
- Reviewed the Ameren-IL companies' historical line and pole inspection practices.
- Conducted inspections of the electric delivery systems.

An important aspect of system conditions is the state of vegetation in proximity to lines, poles, and other parts of the electric delivery system. The next major section of this chapter, Section H, provides Liberty's evaluation of Ameren-IL's vegetation management and the condition of vegetation system conditions.

2. Findings and Analysis

a. Reliability Indices and Outage Causes

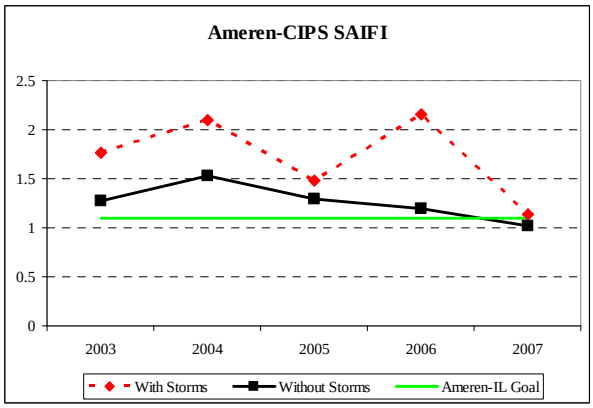
Interruption Frequency and Causes

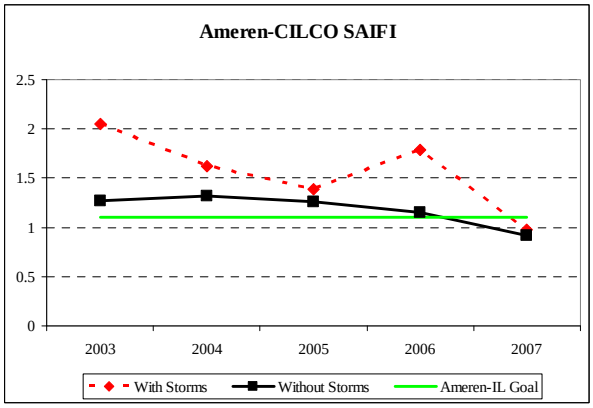
The System Annual Interruption Frequency Index (SAIFI) can be an indicator of general system conditions. Deteriorating system conditions can lead to more frequent service interruptions (outages) caused by equipment malfunctions or structure failures. Because of many different conditions faced by utilities across the country, comparing reliability indices can lead to erroneous conclusions. However, Liberty's experience shows that a SAIFI index of about 1.0 (meaning that on average a customer will experience one service interruption per year) is comparatively very good. Liberty reviewed Ameren-IL's reported indices for SAIFI for each company.[197] Liberty reviewed this performance measure both including and excluding the effects of major storms. While Ameren-IL cannot control the weather, poor system conditions could

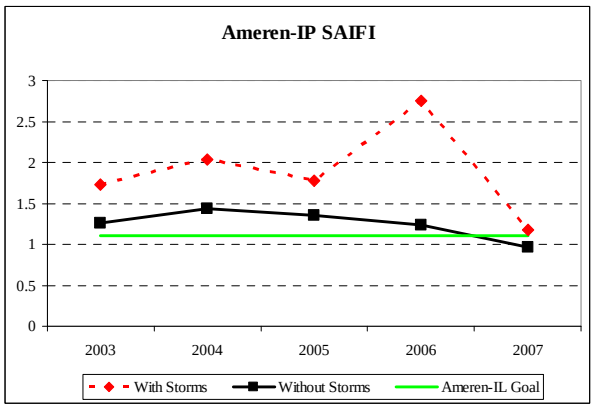
[196] Buses are aluminum or copper wires or tubes that connect incoming and outgoing circuits and transformers in substations.
[197] Response to Data Request #268.

contribute to the adverse effects of storms. Therefore, it is appropriate to review the index calculated both ways.

Aside from the 2006 increase caused by significant storms, all Ameren-IL companies showed a recent, slightly declining trend in this measure of interruption frequency as displayed in the three charts below.

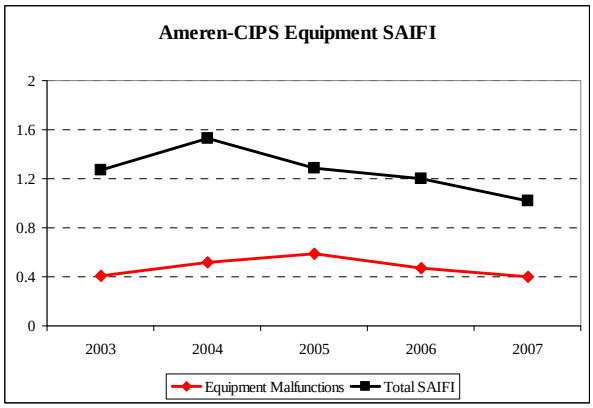


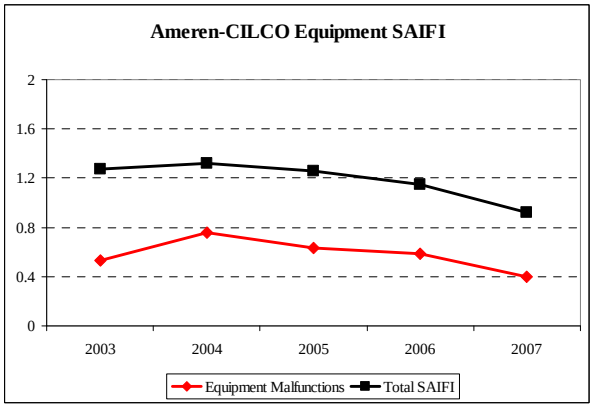




The customer interruptions used to calculate these SAIFI indices had many different causes, some of which do not reflect on the condition of Ameren-IL's electric delivery systems. Ameren-IL assigned cause codes to electric outages. It has 23 codes that identify whether things like animals, overhead equipment malfunction, public vehicles, or operating errors caused the outage. The causes of many outages were unknown. Liberty examined the customer interruptions caused by equipment malfunctions (overhead, underground, and substation) to determine whether they showed the same or different trend than the overall number of interruptions. Liberty calculated the SAIFI excluding major storms for equipment malfunctions as shown in the charts below.[198]

[198] Response to Data Request #269.





For Ameren-CIPS, equipment problems contributed between 32 and 46 percent of the total SAIFI. For Ameren-CILCO, equipment problems contributed between 42 and 58 percent of the total SAIFI. In general, this evaluation showed that equipment problems made about the same proportional contribution to SAIFI during recent years. In addition, interruptions caused by equipment malfunctions showed the same slightly declining trend at the total SAIFI. Because Illinois Power used different cause codes before joining Ameren, the analysis of Ameren-IP's equipment malfunction SAIFI over these same years was not useful. For the years 2006 and 2007, equipment problems contributed 38 and 45 percent of Ameren-IP's total SAIFI.

The improving trend in the overall and equipment malfunction SAIFI indices may point to improving system conditions, but clearly are not indicators of declining conditions.

Reports from Ameren-IL Division Personnel

Division personnel responded to outages and system problems on a daily basis. They should have a good awareness of general system conditions. During interviews,[199] Liberty asked linemen, engineers, superintendents, and managers what were the most common causes of outages in their divisions. They reported that the causes of most outages were (in no particular order):

- arresters not protecting equipment from lightning strokes
- animals interfering with line and substation equipment
- substation malfunctions
- trees interfering with lines
- underground cable failures
- pole-mounted transformer failures, particularly a type of transformer that does not have an external primary fuse
- old #6 and #8 wire breaks
- cutout switch failures
- automobile accidents
- planned outages.

[199] Interviews #30, November 30, 2007, #32, November 6, 2007, #33, November 8, 2007, #34, December 6, 2007, #35, December 4, 2007, and #36, November 29, 2007.

Division personnel indicated that the companies' overhead lines were in acceptable to good condition. They acknowledged that they did not have periodic ground-line inspection programs for their distribution poles until 2006,[200] but did not believe that the number of broken distribution poles they had to replace was excessive. Some personnel reported that the underground residential distribution (URD) cables were problematic. They suggested that the greatest increase in reliability would come from improving fuse coordination, continuing to install more lightning protection, and continuing to install more animal protection devices, particularly in substations.

Outage Analysis System Information

The Outage Analysis System (OAS) is the primary system used by the Ameren-IL companies to manage all gas and electric service requests and service orders, including: service connects, service disconnects, special reads, meter change-outs, meter installs, meter removals, tampering investigations, as well as service trouble orders—lights out, gas leaks, and wire downs.[201] The OAS is about 15 years old.

The historical information in the Outage Analysis System (OAS) is a prime source for Ameren-IL engineers to evaluate system conditions from the perspective of what caused service interruptions, what equipment failed, and what solutions might reduce service interruption frequency or duration most cost effectively. Orders in the OAS contain codes for various types of troubles, causes, weather, components, damage, and order completions. It also contains remarks fields that personnel can use to amplify on or explain the use of these codes.

In its evaluation of system conditions, Liberty used Outage Analysis System information. For example, Liberty evaluated the contribution to interruption frequency from equipment malfunctions and determined the number of customer interruptions caused by animals. Liberty also wanted to evaluate the extent to which Ameren-IL determined that lightning caused outages. However, lightning was not one of the available cause codes. Ameren-IL indicated that typically field personnel indicate a lightning-caused outage by using the OE code (Other, Explain) with lightning written in a comments field.[202] The weather code T (thunderstorms) could be another clue. When reviewing outages on a particular circuit, it would not be a difficult task to assess the effects of lightning. However, the current Outage Analysis System is not suitable or expedient for performing a more general assessment of the effects of lightning on system reliability.

Liberty evaluated how well Outage Analysis System information served Ameren-IL's engineers for their assessment of equipment problems or other condition issues that caused outages. To do this, Liberty requested that Ameren-IL provide a report from the Outage Analysis System for a particular time (May 2006) and outage cause (Overhead Malfunction).[203] The file contained 1,000 outage records, and Ameren-IL placed the data in a form that was easy to manipulate on a personal computer. An Ameren-IL distribution engineer could search, sort, and group records as required for whatever analysis he or she was performing. The file contained remarks fields that

[200] Response to Data Request #488.
[201] Response to Data Request #257.
[202] Response to Data Request #671.
[203] Data Request #669.

contained both customer call comments and comments made by dispatchers or troublemen. Liberty found that the main drawback from making the data useful was the quality of the information that people entered in the system. There were cases of inconsistent and conflicting use of the various codes and remarks. Liberty has seen this at other utilities, and it takes a concerted effort by dispatchers and in the training of all who enter data into the system to capture useful information. Most utilities could improve their data collection in this area. One way to help accomplish this is to structure the various codes in a hierarchical and logical fashion, and provide typical scenarios for dispatchers and troublemen from which to choose and learn.

In early 2007, the Ameren Standards group evaluated reported problems with porcelain breakage on 15,000-volt fused cutout switches.[204] To assess the magnitude of the problem within Ameren, the Standards group surveyed superintendents in the divisions and asked how many cases they could identify (or remember) within the last year. While Liberty expects that superintendents would be familiar with the problem if there were failures within their divisions, the Standards group in part relied on some superintendents' memory to decide that the problem was not significant enough to take specific actions. The group decided that the problem required no specific actions. Liberty does not question this decision. However, it is possible that a more complete and systematic determination of the number of such failures in the entire Ameren area could have produced a different result and may have been more efficient than conducting an informal survey of superintendents.

As another example of a specific equipment problem, Ameren-IP extensively used completely self-protected (CSP), pole-mounted, transformers on its distribution lines. These transformers contain internal 12,000-volt fuses that may not blow when animals or lightning causes a bushing flashover. When a CSP transformer bushing fails, an outage event occurs for the entire circuit. Liberty asked whether Ameren-IL had studied problems with CSP transformers and learned that they had not done so.[205] It is possible that had Ameren-IL captured information on this particular type of transformer, it would know the extent of any problem that existed.

Liberty concluded that the service interruption information recorded in the Outage Analysis System has value but is not ideal for Ameren-IL's evaluation of system conditions and specific equipment problems. Ameren-IL should add cause codes for lightning. Ameren-IL, like other utilities, should continue to emphasize the importance of capturing consistent and useful information. Ameren-IL should also study whether there are relatively easy changes it could make to the Outage Analysis System data collection to improve the quality of the data collected and the usefulness of historical information.

b. Electrical Condition

Electric current will heat the wires and equipment that carry it. If the load (*i.e.*, the electrical current) goes above the equipment's limits, damage or failure can occur. For example, overloading power transformers beyond the nameplate rating can cause a rise in temperature of both transformer oil and windings. If the winding temperature rise exceeds the transformer limits, the insulation will deteriorate and may fail prematurely. Prolonged or frequent thermal

[204] Response to Data Request #591.
[205] Response to Data Request #420.

heating weakens the insulation over time, resulting in damage or accelerated transformer loss-of-life. Switch contacts, cable insulation, and electrical connections can also suffer accelerated aging or damage from too much load.

Excessive loading of the electric delivery system can occur when the construction of new or higher capacity facilities does not keep up with the demand for more power (*e.g.*, new customers) and when abnormal system arrangements put more load than designed on parts of the system. Chapter V of this report discusses system planning and equipment ratings. In general, Liberty's assessment reported there is that Ameren-IL's rating of equipment was conservative, load growth has generally been low, and distribution circuits have not been highly loaded. Several interviews with Ameren personnel confirmed that transmission system loading has been low and not close to ratings and limits.[206]

Liberty reviewed the loading on substation transformers. During Ameren-IL's peak-load period in the summer of 2006, only 2 of the 1,372 substation transformers[207] were overloaded. One Ameren-CILCO distribution substation transformer (a 12,500 kilovolt-ampere transformer) experienced an 8.6 percent overload and one Ameren-IP distribution substation transformer (a 5,390 kilovolt-ampere transformer) experienced a 15 percent overload. Utilities occasionally overload distribution transformers by 20 percent or less. None of Ameren-IL's transmission and sub-transmission transformers experienced an overload condition. Most saw a load of 80 percent of ratings or less and many experienced maximum loads that were less than 50 percent of rating.[208]

One of Ameren-IL's outage cause codes is "overloaded." Liberty reviewed data from the Outage Analysis System and found that during the period 2003-2007, Ameren-IL attributed only 0.3 percent of the customer interruptions to overload.[209] The highest percentage in any one year was 1.4 percent in 2005.

Liberty reviewed data from the Outage Analysis System with orders that Ameren-IL marked with the OL (overload) cause code.[210] The sample selected was all orders with this cause code for the months of April and May 2006. The data showed that these were outages that affected just one or a very few customers, and most of them were the result of a blown fuse or the failure of a small transformers that fed a customer's service. New load added by the customer could have caused some of the outages, while others could have been simply a fuse or transformer failure without excessive load. The data did not give a complete description of each outage. However, it was clear that the outages were not the result of some systemic electrical condition problem on Ameren-IL's system.

Overall, Liberty found no indications of degraded electrical conditions in Ameren-IL's systems.

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[206] For example, Interview #156, April 4, 2008.
[207] The total includes substation transformers, regardless of size, and excludes generating plant transformers and portable substations.
[208] Responses to Data Request #37 and #518.
[209] Response to Data Request #269. 22,636 / 7,227,815 = 0.0031. This excludes Ameren-IP in 2003-2005 because it used different outage cause codes before joining Ameren.
[210] Response to Data Request #670.

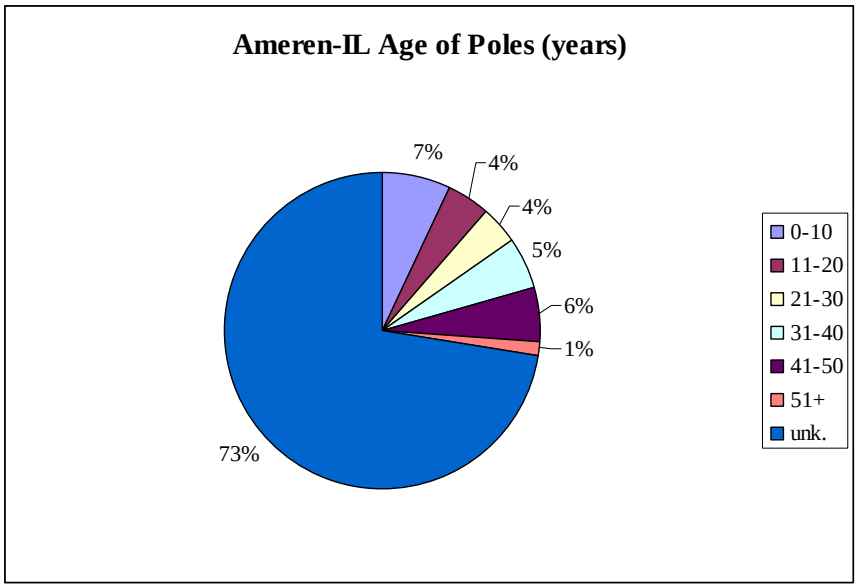
c. Equipment Age and Failures

In its review of electric delivery system age and failures, Liberty focused on wood poles and substation transformers over 5 MVA (megavolt-amperes).[211] Liberty also reviewed analyses that Ameren-IL performed on various equipment failures.

Wood Poles

It is important for a utility to know the age of its poles so that it can appropriately apply its pole inspection program. Typically, pole inspections start after a pole has been in service for 15 or 20 years. In addition, while some poles can maintain the required strength for many years, poles of a particular age, type, and location could begin to weaken at about the same time in life.

Ameren-IL has over 1.3 million poles. It did not know the age of 73 percent, or over 960,000, of them. Ameren-IL could have over 60,000 poles that are over 50 years old.[212] The chart below shows the age distribution of Ameren-IL's poles.[213]



Over 83 percent (1.1 million) of the poles were on distribution systems operating at 15,000 volts or less. As discussed above in the Maintenance and Inspections section of this chapter, the Ameren-IL companies did not have a regular distribution-pole inspection program until 2007. The table below shows the results of distribution and sub-transmission pole inspections that the utilities performed.[214]

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[211] MVA, megavolt amperes, is a measure of transformer capacity.
[212] Assuming the age distribution of the unknown category is the same as the distribution of pole ages that Ameren-IL knows.
[213] Response to Data Request #336. Chart explanation: Ameren-IL knew that it installed 7 percent of its poles within the last ten years. Ameren-IL knew that 1 percent of its poles are 51 years or older. Liberty noted that three poles had a recorded age of 105 years.
[214] Responses to Data Requests #169 and #673. In this table, "rejected" means requires replacement or requires reinforcement.

Distribution & Sub-Transmission Poles Inspected and Rejected				
Year		Inspected	Rejected	Percentage
2004	Ameren-CILCO	6,101	73	1.2%
	Ameren-IP	11,195	580	5.2%
	Ameren-CIPS	7,998	151	1.9%
	Ameren-IL	25,294	804	3.2%
2005	Ameren-CILCO	5,191	119	2.3%
	Ameren-IP	21,722	1,451	6.7%
	Ameren-CIPS	11,941	559	4.7%
	Ameren-IL	38,854	2,129	5.5%
2006	Ameren-CILCO	3,356	85	2.5%
	Ameren-IP	10,529	299	2.8%
	Ameren-CIPS	5,063	123	2.4%
	Ameren-IL	18,948	507	2.7%
2007	Ameren-IL	89,479	2,111	2.4%
2004-2007	Total	172,575	5,551	3.2%

Despite the lack of a regular inspection program, the overall rejection rate of 3.2 percent does not indicate that distribution and sub-transmission poles are in bad condition. The 2007 results were from the first full year of Ameren-IL's new, 12-year cycle inspection program. It is not surprising that those results (2.4 percent) were less than the results from prior years because at least some of the earlier year inspections came from worst performing circuits.

Liberty expected a pole reject rate of about 6-9 percent for systems where ground-line pole inspections had not been conducted on a routine basis. Ameren-IL's pole reject rate was lower than expected, in part, because Ameren-IL included all poles, regardless of age, in its number of poles included in the ground-line pole inspection program. In addition, the Ameren companies originally constructed many of their distribution poles in accordance with the National Electrical Safety Code's (NESC) more conservative, higher strength Class B construction (greater pole diameter) specifications, even where Class C construction (smaller diameter poles) met the NESC's minimum strength requirements. Ameren-IL's ground-line pole inspection program bases the acceptable pole strength on Class C strength and not the Class B strength. This is an industry accepted practice, but it reduces the number of poles that are rejected. The inclusion of the young poles (15 years old or less), and the original use of larger diameter poles than required explain why Ameren-IL pole rejection rates were lower than expected.

For the most part, the Ameren-IL companies regularly inspected transmission poles. The table below shows the rejection results from recent inspections of transmission poles.[215]

[215] Response to Data Request #648.

Transmission Poles Inspected and Rejected				
Year		Inspected	Rejected	Percentage
2004	Ameren-CILCO	122	18	14.8%
	Ameren-IP	3,111	83	2.7%
	Ameren-CIPS	2,571	65	2.5%
	Ameren-IL	5,804	166	2.9%
2005	Ameren-CILCO	0	- -	- -
	Ameren-IP	2,642	85	3.2%
	Ameren-CIPS	2,518	183	7.3%
	Ameren-IL	5,160	268	5.2%
2006	Ameren-CILCO	0	- -	- -
	Ameren-IP	2,459	33	1.3%
	Ameren-CIPS	3,933	146	3.7%
	Ameren-IL	6,392	179	2.8%
2007	Ameren-CILCO	0	- -	- -
	Ameren-IP	2,234	49	2.2%
	Ameren-CIPS	1,943	61	3.1%
	Ameren-IL	4,177	110	2.6%
2004-2007	Total	21,533	723	3.4%

The overall rejection rate of 3.4 percent is about the expected rejection rate for poles over 20 years old. In addition, this rate, which results from a history of regular inspections, adds confirmation that the distribution-pole rejection rate does not indicate poor system conditions despite the lack of regular inspections.

Without results from good pole inspections, the condition of distribution poles would be suspect. There are several reasons why the condition of these poles is not poor. First, the informal inspections and pre-climbing sounding of poles by linemen may have been effective in identifying weak poles. Second, significant storms, like those that occurred in 2006, may have taken down weak poles.

Overall, Liberty concluded that the condition of wood poles was acceptable. Ameren-IL should closely monitor the results of its regular inspection of distribution poles. If those inspections start identifying a significantly higher rejection rate than the 2007 results, Ameren-IL should implement a more aggressive inspection program (*i.e.*, reduce the 12-year cycle).

Examination of failed equipment can help a utility determine whether there may be additional incipient failures in the system, take appropriate preventive measures, and know better the condition of the electric delivery system. The Ameren-IL companies did not routinely examine failed poles.[216] Among the materials required in the 2006 storm restorations were over 800 poles

[216] Response to Data Request #672.

for the July storms and over 1,300 poles for the November/December storm.[217] There were likely many causes of the pole failures including winds in the July storms, damage from falling trees, and vehicle accidents. Poor pole conditions could have also been a major contributor. Ameren-IL did not acquire or retain evidence to permit an understanding of the causes. Liberty recognizes that the first priority in a storm is restoration of service and not forensic examination of failed equipment. Nevertheless, Ameren-IL could have gained useful information had it retained a sample of failed poles for later investigation.

There was at least one pole failure for which Ameren-IL determined the cause to be decayed poles. A two-pole, H-frame structure on the 138,000-volt transmission system failed during the July 2006 storm. Pole inspectors for the Illinois Power Company classified the poles as "priority-reject" in April 2004.[218] The company should have replaced the poles in 2004. During the transition of Illinois Power to Ameren, personnel overlooked this replacement.[219]

Liberty concluded that Ameren-IL did not know the age of many of its wood poles, the condition of wood poles was acceptable, and Ameren-IL should examine poles that failed to determine the reason for failure.

Substation Transformers[220]

Liberty confirmed that Ameren-IL knew and documented the ages of its substation transformers over 5 MVA.[221] The following table describes the ages of these transformers.[222]

Company	Number of Transformers > 5 MVA	Percent of Transformers ≥ 50 years
Ameren-CIPS	671	14%
Ameren-IP	669	8%
Ameren-CILCO	158	7%

Ameren-CIPS' three oldest transformers were 66 years old. Ameren-CIPS had some very large transmission substation transformers over 40 years old, including a 240 MVA, a 300 MVA, a 560 MVA, and two 460 MVA transformers.

The oldest Ameren-IP transformers were seven, small 77-year-old sub-transmission transformers. Ameren-IP had some very large transmission substation transformers over 40 years old, including three 300 MVA and two 448 MVA transformers.

Ameren-CILCO's oldest transmission substation transformers were only 33 years old.

Liberty reviewed the transformer failures that occurred during the 2002-2006 timeframe. The following table describes those failures.

[217] Response to Data Request #123.
[218] Response to Data Request #176.
[219] Interview #156, April 4, 2008, and response to Data Request #672.
[220] Responses to Data Requests #20, #38, and #39.
[221] MVA, megavolt amperes, is a measure of transformer capacity.
[222] Includes power station and switchyard transformers, but excludes portable and mobile transformers.

Company	# of Failures / % of Total	Failures
Ameren-CIPS	10 / 1.5%	9 small distribution transformers and 1 large 28-year-old, 448-MVA transformer failed. Failures ranged from 20-49 years old.
Ameren-IP	19 / 2.8%	15 distribution transformers and the following sub-transmission transformers: a 46-year-old 100 MVA, a 48-year-old 26.7 MVA, a 32-year-old 50 MVA, and a 49-year-old 50 MVA. Failures ranged from 2 to 49 years old.
Ameren-CILCO	5 / 3.1%	The largest failure was only 25 MVA. Failures ranged from 35 to 40 years old. All failed transformers were distribution substation transformers.

Utilities experience transformer failures from time to time. The number of transformer failures experienced by Ameren-IL over this 5-year period is not comparatively large. In addition, excessive age was not a factor in the failures. However, Ameren-IL did not evaluate consistently the causes of these failures.[223] Large transformers are very expensive. The failure of the four very large (*i.e.*, 50 MVA and larger) transformers may have been preventable if Ameren-IL had monitored transformer conditions more frequently. Refer to section VI.F for a discussion of transformer preventive maintenance.

Ameren-IL's Evaluation of Equipment Failures

Liberty requested that, for the period 2001 through July 2006, Ameren-IL list and provide summary reports of any root-cause analyses of incidents or accidents related to the electric delivery system.[224] In response, Ameren-IL provided:

- Three reports from the Ameren Services Standards group on distribution outages involving pole failures.
- A report prepared by Ameren-CILCO on an outage in August 2002 caused by a failed current transformer and a relay coordination problem that interrupted service to over 44,000 customers for a few hours.
- Reports (126 files) on substation and transmission problems and equipment failures prepared by Ameren-IP.

Liberty reviewed these reports and concluded that they did not provide any evidence of deteriorated general system conditions. The failures reported were typical of those experienced by electric utilities.

However, Ameren-IL reported that for the distribution systems in Illinois, there were three different reporting programs, one for each of the legacy companies. These were (1) Major Outage Report (MOR) for Ameren-CIPS, (2) RESUME for Ameren-CILCO, and (3) System Interruption Reports (SIR) for Ameren-IP. Ameren-IL also reported that it established a team to "Explore simple, practical solutions to establish consistency in procedures, policies, and

[223] There were few matches between the list of transformer failures (response to Data Request #39) and the equipment failure reports (response to Data Request #392).
[224] Data Request #392.

processes across the Ameren-Illinois operating companies."[225] Liberty agrees that Ameren-IL would benefit from having consistent methods for reporting on incidents and accidents. Analyses of incidents in one area should be available to personnel in other areas and should be in a format and content that is familiar to others.

Liberty also concluded none of the materials Ameren-IL provided constituted a true root cause analysis. This is not to say that many of the incident investigations were inadequate. Root cause analyses require a significant dedication of resources, and for many of the straightforward problems that occurred, a simple engineering assessment was all that was necessary and practical. However, some incidents warrant a more thorough evaluation, one that can uncover fundamental causes and can lead to recommendations effective in preventing a recurrence.

A root cause analysis is a method for finding and correcting the most important reasons for undesired outcomes or performance problems. A root cause analysis differs from typical troubleshooting and problem solving in that these efforts seek solutions to specific difficulties, whereas a root cause analysis attempts to determine the underlying issues. A root cause analysis can help to seek out unnecessary constraints and inadequate controls. It can help to target corrective action efforts at the points of most advantage. A good root cause analysis is essential in pointing change management efforts in the right direction and finding the core issues contributing to tough problems. A "Root Cause" is one of the underlying events, conditions, or factors that created or allowed the undesired outcome. A root cause should be specific, something over which management has control, and something for which analysts can generate effective recommendations.

Three specific examples show that there were potentially important, unanswered questions in Ameren-IL's evaluations.

1. In April 2005, there was a problem with transformer 31 at the Bloomington-Washington Street substation. Ameren-IL's evaluation indicated that there was excessive acetylene in the transformer oil and that the cause was loose bolts on a barrier board. Obvious but unanswered questions were how and who caused the loose bolts on the transformer barrier board? Was it an incipient problem from the factory? Was it failure to follow instructions by an Ameren-IL maintenance crew? Were the instructions insufficient? Should Ameren-IL change its maintenance procedure? Where does it have similar equipment? Should Ameren-IL inspect the bolts in other transformers? Where? Should it distribute a technical bulletin to the substation maintenance crews? What specific conditions created or allowed this event to occur? What management actions can Ameren-IL take to prevent a similar occurrence?

2. In August 2007, there was a breaker problem at the Madison-State Street substation causing over 750,000 customer-interruption minutes. Ameren-IL's evaluation indicated that the cause was hardened grease on the breaker that it last serviced in December 2002. Obvious but unanswered questions were how and why did the lubricant fail and cause the circuit breakers to stick? Were the maintenance program scheduling, procedures, and type of lubricate used adequate and proper? Did Ameren-IL perform maintenance according to its procedures and

[225] Response to Data Request #392.

schedules? What does Ameren-IL need to do to make the circuit breakers available for maintenance? Does Ameren-IL have this problem in other substations? Where? What should Ameren-IL do to prevent recurrence of stuck breakers? Would a technical bulletin on the incident be of benefit to others in the Ameren-IL companies? What specific conditions created or allowed this event to occur? What management actions can Ameren-IL take to prevent a similar occurrence?

3. In December 2004, three problems at the South Bloomington substation caused almost 3,000,000 customer-interruption minutes. The problems were: (a) a fireball came out of the expulsion port of a lightning arrester on the line side of a circuit breaker and traveled down conductor to a feeder circuit breaker; (b) the fireball then caused an electrical fault on the feeder circuit breaker bushings and on the bus, preventing the circuit breaker from clearing the fault; and (c) the back-up transformer circuit breaker failed to trip because it was stuck. The last breaker lubrication was in 1997 because "it is very hard to get this breaker out for maintenance." Obvious but unanswered questions were why did the arrester expulse a fireball when it operated such to cause electrical faults on the circuit breaker and the bus? Was the fireball unusual? Was there an incipient defect in the arrester, or did arrester placement cause the damage from the fireball? Where are identical arresters located? Has Ameren-IL experienced other problems with these arresters? Is there a substation design issue? Should Ameren-IL relocate the arresters at this substation and at other substations? What specific conditions created or allowed this event to occur? What management actions can Ameren-IL take to prevent a similar occurrence?

Liberty concluded that Ameren-IL's failure reports did not indicate deteriorated system conditions. However, Ameren-IL did not have a consistent program for evaluating equipment failures and disseminating information from those failures. In addition, Ameren-IL did not employ root cause analysis techniques.

d. History of Line and Pole Inspections

If a utility had a long-standing practice of inspecting the lines and poles in its electric delivery system, and correcting defects found from those inspections, one would expect that those lines and poles would be in reasonably good condition. In the section of this chapter on Inspections and Repairs (VI.E), Liberty discusses its evaluation of Ameren-IL's practices in this regard as of 2006. In this section, Liberty discusses its review of the historical practices of the three Ameren-IL companies. Each company reported that they had historically performed some aerial and patrol inspections on lines and some ground-line pole inspections.

Ameren-CIPS[226]

Ameren-CIPS reported that at least since 1998, it conducted semi-annual aerial inspections on its transmission lines. Since before the 1980s to 2005, CIPS and Ameren-CIPS annually patrolled distribution and sub-transmission lines. It extended the distribution-line inspection cycle to four years in 2005. It started aerial inspections of its sub-transmission lines in 2005.

[226] Interview #31, November 1, 2007, Interview #35, December 4, 2007, Interview #150, March 26, 2008, responses to Data Requests #488, #613, #614, and #615.

Starting in the mid-1980s, CIPS conducted ground-line pole inspections on its transmission and sub-transmission poles on a 5- to 7-year cycle, which it changed to a 10-year cycle in about 1997. It had three divisions. In the Eastern and Western divisions, it used a pole inspection contractor who inspected, excavated, and bored the poles. The Southern division used in-house personnel who inspected and sounded the poles but did not bore and excavate the poles.

CIPS never had periodic distribution ground-line pole inspection program. There were some ground-line inspections on a small percentage of distribution poles in the Eastern and Western divisions. Linemen conducted distribution pole inspections in the Southern division using a hammer to sound poles suspected to be weak. However, it did not determine pole strength because it did not bore the poles to measure the size of decay-caused voids, and it did not perform ground-line inspections to find pole rot below ground surface level.[227]

Ameren-IP[228]

Since before the 1980s, Ameren-IL reported that Illinois Power (IP) conducted semi-annual aerial inspections of its transmission lines and foot patrols of its distribution and sub-transmission lines on 4-year cycles.

Until the late 1980s, IP scheduled transmission lines for ground-line pole inspections based on pole age and electrical loading, and then re-inspected the poles on a 10-year cycle. However, between the years 1990 to 2005, completions fell behind resulting in a 15- to 17-year cycle.

IP conducted ground-line pole inspections on its sub-transmission poles on a 10-year cycle using a contractor. It never had a routine distribution ground-line pole inspection program. It performed some inspections on worst performing circuits and specific distribution lines that exhibited very poor structural performance.

Ameren-CILCO[229]

Ameren-IL reported that CILCO conducted semi-annual aerial inspections on its transmission lines, and had been attempting to patrol every distribution and sub-transmission line on a one-year cycle. It fell behind in 2001, but returned to an annual inspection cycle by 2003.

Ameren-CILCO only has about two miles of wood transmission poles. Although a contractor performed some transmission and sub-transmission ground-line pole inspections before 1991, CILCO performed no other transmission pole inspections until Ameren purchased the company. Ameren-IL reported that CILCO performed some sub-transmission and distribution ground-line inspections until the mid-1990s.

[227] Interview 3150, March 26, 2008.
[228] Interviews #32, November 6, 2007, #33, November 8, 2007, #34, December 5, 2007, and #150, March 26, 2008. Responses to Data Requests #488, #613, #614, and #615.
[229] Interviews #32, November 6, 2007, #33, November 8, 2007, and #150, March 26, 2008. Responses to Data Requests #613, #614, and #615.

Liberty Evaluation

If the companies conducted their inspection programs as reported and corrected problems found in the inspections, the conditions in 2006 should have been:

- All companies' transmission, sub-transmission, and distribution line equipment was in good condition.
- The condition of Ameren-CIPS' and Ameren-IP's transmission poles was acceptable to good. The condition of Ameren-CILCO's few wood transmission poles is problematic because of the long period without ground-line pole inspections. Since Ameren's 1998 purchase of CIPS, its 2003 purchase of CILCO, and its 2004 purchase of IP, Ameren-IL's 10-year cycle transmission ground-line pole inspection program has been good for maintaining transmission pole condition, except for one area of Ameren-CIPS, which conducted less than complete pole inspections. Under the current program, it will require several more years of ground-line pole inspections before Ameren-IL can be assured that all aged transmission poles are in good condition.
- The condition of Ameren-CIPS' and Ameren-IP's sub-transmission poles was acceptable. Ameren-CILCO's were suspect because it did not conduct routine ground-line inspections. Ameren-IL started conducting the sub-transmission ground-line, 12-year cycle pole-inspection program in 2007. Under the current program, Ameren-IL will require many years of ground-line pole inspections before it can be assured that all aged sub-transmission poles are in good condition.
- The condition of Ameren-IL's distribution poles was suspect. None of the legacy companies or Ameren-IL had any routine distribution ground-line pole inspection programs in place until 2005. Ameren-IL implemented a new system-wide, 12-year cycle distribution ground-line pole inspection program in 2007. Under the current program, Ameren-IL will require many years before it knows that all distribution poles are in good condition.

In summary, Liberty concluded that, based on the companies' historical practices, the condition of Ameren-IL's electric delivery line equipment should have been good. The condition of transmission and sub-transmission system poles in different areas likely varied from good to acceptable to suspect. The condition of Ameren-IL's distribution poles was suspect. However, the results of Ameren-IL's inspections indicate that the condition of wood poles was acceptable.

e. Liberty's Inspections

Liberty conducted several inspections of Ameren-IL's electric delivery system. These included:

- A detailed inspection of portions of many distribution circuits
- A review of distribution and sub-transmission systems material conditions conducted in conjunction with Liberty's vegetation management inspections
- An aerial inspection of the material condition of the transmission system
- An aerial inspection of transmission substations
- A detailed inspection of several older substations
- Several opportunistic reviews of systems, including those substantially rebuilt after the 2006 storms.

Distribution Systems

Liberty inspected portions of 94 overhead distribution circuits[230] selected to include a representative sample of circuits in each of the seven divisions, in each of the three companies' service territories, and covering both urban and rural areas. Liberty's circuit inspections included 7,688 poles and focused on the:

- Physical condition of line equipment
- Need for repairs
- Compliance to the National Electrical Safety Code (NESC)
- Adequacy of animal guarding and lightning protection.

Conditions and Need for Repair

The Illinois Commerce Commission and National Electrical Safety Code (NESC) rules require utilities to maintain its lines in good working order and in a safe condition. Liberty inspected lines, equipment, and poles. The pole inspections included only external conditions. Liberty did not examine poles for sub-surface decay, internal infestations, internal voids, and pole strength.

Liberty identified several types of equipment conditions requiring repair or replacement including:

- decayed or split pole tops
- broken or slack guy wires
- broken guy markers
- blown lightning arresters
- broken pole ground wires
- broken cross arms or braces.

The table below shows the number of repair items Liberty observed.

[230] This inspection included sub-transmission circuits. Ameren-IL considers sub-transmission part of the distribution system.

	Ameren-CILCO	Ameren-CIPS	Ameren-CIPS-UE	Ameren-IP
Poles Sampled	1,130	2,570	570	3,418
Overall Number (%) of poles found with repair items	23 (2 %)	40 (1.6 %)	18 (3.2 %)	77 (2.3 %)
Details				
Number of poles w/decayed or split tops	3	5	0	10
Number of poles w/broken or slack guy wires	10	0	4	18
Number of poles w/broken guy markers	0	7	3	8
Number of poles w/ blown lightning arresters	3	13	1	16
Number of poles w/ broken pole grounds	1	2	9	8
Number of poles w/ broken cross arms or cross arm braces	6	4	0	3
Number of poles w/ misc. items	0	6	1	14

Liberty's general observations were:

- Liberty did not observe an unusually large number of items needing repair.
- Poles on mainline circuits were in good condition, while poles on aged tap lines were generally not in an acceptable condition. Nearly all of the poles with decayed or split pole tops were on residential tap lines.
- Poles in the Ameren-CIPS-UE urban service areas of East St. Louis and Alton had a relatively high percentage of broken ground wires.
- Sub-transmission poles and lines were in better condition than the distribution lines and poles operating at 15,000 volts or lower. Ameren-IL had recently replaced many sub-transmission poles and conductors.
- Ameren-IL had constructed new distribution line sections to appropriate standards, including framing, clearances, guy insulating, animal protection, and lightning protection.
- Some lines did not have four grounds per mile as required by the National Electrical Safety Code (Rule 096-C).
- Ameren-IL properly repaired lines and poles damaged by the 2006 storms.

In a separate survey inspection of distribution and sub-transmission systems, Liberty also observed that some distribution lines did not have four grounds per mile as required by the National Electrical Safety Code and that some did not have four lightning arresters per mile as required by Ameren-IL's current construction standards. In this inspection, Liberty did not observe any other specific systemic condition issues but did identify some condition issues that Ameren-IL should have identified in circuit patrols and corrected unless the problems were new. These issues included:

- Split or rotted pole tops
- Broken or rotted cross arms and braces

- Lightning arresters blown or not connected
- Guy wires not insulated
- Broken pole ground wires
- Excessive wire sag
- Undersized and leaning poles
- Insufficient line clearances
- Broken aerial cable spacer
- Floating wire not tied to insulator.

These inspections noted that the number of these issues on the main lines was typical of aged distribution lines, and the general condition of the main line circuits was good. However, the condition of many of the aged tap lines was not good. Ameren-IL clearly did not maintain the tap lines as well as the main lines.

National Electrical Safety Code Compliance

In addition to the lack of four grounds per mile on some distribution lines, Liberty's circuit inspections identified several types of National Electrical Safety Code (NESC) non-compliance issues. These included not:

- Grounding or insulating guy wires
- Marking guy wires where they are exposed to pedestrian traffic
- Using more robust construction at railway crossings
- Providing minimum clearances between lines to ground or communication cables

The table below provides data on Liberty's findings related to NESC compliance issues.

	Ameren-CILCO	**Ameren-CIPS**	**Ameren-CIPS/UE**	**Ameren-IP**
Poles Sampled	1,130	2,570	570	3,418
Number of poles with guys not grounded or insulated	0	4	4	329
Number of poles with guys wires not marked	2	8	0	9
RR crossing construction	0	4	0	0
Clearance issues	1	2	1	4

The lack of grounds or strain insulators on guy-wires on Ameren-IP lines made up the vast majority of non-compliance issues. Aside from this problem, the relative number of non-compliance issues identified in the inspections was not out of line with other utilities. All of the items, however, illustrate the need for Ameren-IL to train its circuit patrol inspectors in identifying NESC non-compliance issues.

Application of Animal Protection

Animal interference caused 11.6 percent of Ameren-IL's customer interruptions in 2006.[231] Ameren-IL reported that it installed animal guards on all new distribution equipment, and its practice was to install animal guards whenever working on equipment poles. It also installed animal guards on its worst performing circuits, where needed. Liberty recorded the number of poles on the inspected circuits that needed animal protection, as shown in the table below.

	Ameren-CILCO	Ameren-CIPS	Ameren-CIPS-UE	Ameren-IP
Number (%) of poles without wildlife protection	30 (3 %)	383 (15 %)	0 (0 %)	316 (9.2 %)

Liberty noted that at Ameren-CIPS, Division II, only 7 percent of the poles needed animal guards, compared to 22 percent at Ameren-CIPS, Division IV. At Ameren-IP, Division VI, only 4.5 percent needed animal guards, compared to 14 percent at Ameren-IP, Division V. Although most equipment poles had animal guards, Ameren-IP and Ameren-CIPS need to place more emphasis on animal guard installations. The percentage of customer interruptions in 2006 caused by animals was higher for Ameren-IP (13.4 percent) and Ameren-CIPS (11.0 percent) compared to Ameren-CILCO (7.2 percent).[232] Ameren-IL could improve reliability with additional animal protection on distribution circuits.

Application of Lightning Protection

Ameren-IL could not provide data to indicate the percentage of outage events caused by lightning. Ameren-IL reported that its practice was to install arresters on new and refurbished equipment, to install arresters on worst performing circuits, and to replace blown arresters. Ameren-IL's construction standards require that it install lightning arresters on new or re-built lines at the rate of at least four arresters per mile, including those on equipment poles and line switches.

Liberty observed that:

- Some rural circuits did not comply with the four arresters per mile current standard.
- Most arresters installed were the modern metal-oxide-varistor (MOV) type, although some old gap-type arresters were still in service.
- Some line switches did not have arrestor protection, including 5 at Ameren-CILCO, 30 at Ameren-CIPS, and 14 at Ameren-IP.
- Lightning arresters were missing at only one equipment pole, an underground cable riser pole.
- Ameren-CIPS, Division VII was using 10,000-volt arresters, rather than the standard 3,000-volt arrestors on its 4,000-volt equipment.

In summary, Ameren-IL's distribution circuits had lightning protection deficiencies.

[231] Response to Data Request #269. Customer interruptions not including major storms.
[232] Response to Data Request #269. Customer interruptions not including major storms.

Transmission Lines

Liberty conducted an aerial inspection of transmission lines using a helicopter. These lines used steel towers and wood-pole structures. The items that Liberty observed and that needed repair included:

- 6 insulator problems
- 4 static wire problems
- 3 broken or split cross arms
- 3 poles with woodpecker damage
- 2 broken cross-arm braces
- 1 broken anti-gallop spoiler
- 1 pole top with rot
- 1 leaning pole
- 1 split pole
- some missing down guy guards.

Ameren-IL reported that these conditions likely had occurred since the last inspection because it repairs deficiencies when identified by its semi-annual aerial (by airplane) inspections.[233] However, Liberty is doubtful that using an airplane is as effective as using a helicopter for identifying small defects on transmission lines, especially in urban areas. Ameren-Il indicated that it plans to supplement transmission-system airplane inspections with helicopter inspections.[234]

Liberty did not observe any specific systemic condition issues, although many of the transmission poles were aged. The transmission system was in acceptable condition and adequately maintained. Liberty observed locations where Ameren-IL had recently replaced poles, cross arms, braces, and insulators and had recently reinforced some poles.

Substations

Substations contain transformers, circuit breakers, and other equipment that have the primary purposes of changing a higher voltage to a lower voltage and distributing the lower voltage electric power to other substations or to the utilities' customers.

Many pieces of equipment in a substation (*e.g.*, transformers, load tap changers, voltage regulators, oil circuit breakers) contain mineral oil for preventing energized parts from short-circuiting and for cooling. The oil in circuit breakers and reclosers squelches arcing that occurs when those devices interrupt electrical current. Load tap changers may contain hundreds of gallons of oil; transformers and oil circuit breakers may contain many thousands of gallons of oil.

[233] Interview #156, April 4, 2008.
[234] Interview #156, April 4, 2008.

Internal components of high voltage transformers and oil circuit breakers connect to other equipment through oil-filled bushings. Because bushings contain only a small quantity of oil, a short circuit will occur if leakage causes only a small amount of lost oil. Bushings can fail catastrophically, and can damage other equipment when they fail. Because a leak in a bushing can quickly cause the amount of oil in the bushing to become dangerously insufficient, it is necessary to inspect high voltage bushings frequently for oil leaks and oil levels, and to immediately repair or replace leaking bushings.

In most transformers, the space above the oil contains dry nitrogen gas that keeps wet atmosphere out of the transformer. The pressure of the nitrogen gas increases when the oil expands in hot weather and decreases with the oil cools in cold weather. When transformer nitrogen pressure is zero, either the transformer has a nitrogen leak and could be drawing in air, or there was insufficient nitrogen added during hot weather. It is important that a utility maintain a positive transformer nitrogen pressure.

Substation inspections often overlook equipment paint conditions. A protective paint coating prevents rust-through and loss of insulating oil, and, for transformers, is necessary for proper heat transfer to the air. As equipment ages, the thickness of the paint reduces so gradually that inspectors may not notice year-to-year deterioration. It is good utility practice to monitor paint thickness and repaint when necessary to prevent rust-through, particularly on transformer radiators, which often are made of thin steel. Even when the general paint condition is adequate, inspectors should report rust and small defects in paint for maintenance crews to repair.

Inspection and maintenance programs also sometimes overlook general substation appearance. A substation with discolored or rusty equipment and a yard that has weeds and debris discourages pride in substation electricians and can cause the public to think that a utility does not care for its equipment.

When designing its electrical systems, utilities follow guidelines called the National Electrical Safety Code (NESC). For substations, the NESC provide guidelines for fence grounding, and, in particular, for the grounding of the gates in the fence, to minimize the exposure of persons to voltages at the fence when faults occur in the substation or on the lines coming out of the substations.

Liberty performed aerial inspections of 30 Ameren-IL transmission substations. While not a detailed inspection, this review showed that Ameren-IL's substations were generally neat, graveled, void of vegetation, and free of significant oil spills. The only common problem that Liberty identified by the aerial inspections were a few cases where it appeared that the crushed stone just outside of the substation fence was not sufficient to minimize possible electric shock hazards.

Liberty also conducted detailed equipment condition walk-through surveys of 12 aged Ameren-IL substations, including at least one transmission substation and one distribution substation at Ameren-CILCO, Ameren-CIPS, Ameren-CIPS/UE, Ameren-IP-North, and Ameren-IP-South. Liberty selected these areas to cover all legacy companies and the different groups within Ameren-IL that conduct substation inspections.

Liberty purposely inspected only older, large Ameren-IL substations, and expected to find some minor condition issues such as a few small rust spots, a few small oil leaks, and a few weeds and minor debris in substation yards. Although these kinds of issues are unattractive and to some degree reflect on general maintenance practices, they are not significant for older substations. Because Ameren-IL inspects some of its substations with linemen and others with substation electricians, Liberty noted who performed Ameren-IL's inspections at each substation visited. However, Liberty did not observe any appreciable condition differences between substations inspected by distribution linemen compared to those inspected by substation electricians. The table below provides a summary of the items Liberty observed.

Number of Subs.	Inspector[1]	Oil[2]	N_2[3]	Paint[4]	Leaks[5]	Weeds[6]	Noise[7]	Debris[8]
Ameren-CILCO 2	S	1	1	2	0	0	1	1
Ameren-CIPS 4	L	0	0	3	2	1	0	0
Ameren-CIPS/UE 2	L	2	0	2	2	1	0	0
Ameren-IP/North 2	S	0	0	2	0	0	0	0
Ameren-IP/South 2	L	2	1	1	1	0	0	0

Table notes:
[1] "S" substation electricians, "L" line electricians.
[2] Low oil levels in 5 of the 12 substations in a 138,000-volt bushing, two 138,000-volt oil circuit breakers, one load tap changer, and two voltage regulators.
[3] One transformer in each of two substations has zero nitrogen pressure.
[4] Equipment in 10 of the 12 substations had rust and paint needs that ranged from minor spot painting to major equipment painting.
[5] Minor transformer oil leaks in five substations. Some of these might have not been active because oil residue had not been removed.
[6] Excessive dead weeds in the yards of two substations.
[7] A voltage regulator was excessively noisy in one substation.
[8] Broken porcelain under a bus in one substation.

Liberty found some minor condition issues including some rusting on cabinets, small transformer oil leaks, two transformers with zero nitrogen pressure, and some debris and excessive weed issues. These condition issues were typical for aged substations, but, except for the oil leaks, could have been easily corrected.

Liberty also found some major condition issues. These issues were :

- Ameren-CIPS-UE's Mississippi substation: oil had leaked from two 138,000-volt oil-circuit-breaker bushings. The oil level was low in one of the bushings. Catastrophic bushing failure could have occurred.
- Ameren-CIPS-UE's Frey substation: the oil level in a load tap changer was low.
- Ameren-CILCO's Allen substation: the oil level in a 12,000-volt voltage regulator was below minimum level.
- Ameren-IP's Mariknoll substation: the oil level in a 12,000-volt voltage regulator was below the minimum level.
- Ameren-IP's Turkey Hill substation: the oil levels in two 138,000-volt oil circuit breakers were below minimum level.

In addition, three of the four Ameren-IP substations had unacceptable equipment paint conditions. At the North Decatur substation, the paint coatings on two 10-MVA[235] (megavolt-ampere) transformers and most of the other equipment and structural steel was faded through and rust was developing. At the Lathum substation, the paint coatings on its large 445-MVA transformer and on two of its 138,000-volt oil circuit breakers was faded through and some rust was developing. At the Turkey Hill substation, the paint coating was fading through on its 600-MVA transformer.

The following table summarizes Liberty's substation condition evaluations.

Substation	Condition Evaluation and Primary Reason
Ameren-CILCO	
Eastern	Good
Allen	Unacceptable because of low oil in a voltage regulator
Ameren-CIPS	
Canton	Good
Gibson City	Acceptable, but some rust conditions
Ipava	Acceptable, but some major paint needs
Paxton	Acceptable, but some paint needs
Ameren-CIPS-UE	
Frey	Unacceptable because of low oil in load tap changer
Mississippi	Unacceptable because low oil in 138 kV bushing
Ameren-IP/North	
Edwards Street	Unacceptable because of bad paint on nearly all equipment
Latham	Unacceptable because of bad paint on large transformers
Ameren-IP/South	
Mariknoll	Unacceptable because of low oil in a voltage regulator
Turkey Hill	Unacceptable because of low oil in circuit breakers and bad paint condition on major equipment

Liberty found only the Ameren-CIPS substations in good or acceptable condition. One of the Ameren–CILCO substations was in good condition. However, the other Ameren-CILCO substation, and all Ameren-CIPS-UE and Ameren-IP substations inspected were in unacceptable condition because of the paint coatings on substation equipment, oil leaking from 138,000-volt bushings, and oil levels in other equipment below minimum levels. The Ameren-IL substation inspection and repair process was ineffective in maintaining acceptable substation equipment physical conditions.

The number and significance of oil leaks that Liberty observed were minor. However, the management of oil leaks was a concern. Ameren Services reported that when a substation electrician inspector observed an oil leak, he or she may attempt but was not required to stop the leak. Ameren Services expected inspectors to report oil leaks to a substation supervisor, who would then prepare a work order. If it did not know the PCB (polychlorinated biphenyl) content of spilled oil, Ameren Services would test the oil. Ameren Services would notify Ameren's environmental department only if oil leaked outside the substation fence. Ameren Services

[235] MVA is a measure of electrical power that a transformer can change from one voltage to another. It means megavolt-ampere, or 1,000,000 volt-amperes (a volt-ampere is about the same as a watt).

reported that it could not easily determine pending oil-leak repair jobs and that it did not specifically track oil leak repairs.[236]

Section 92E of the National Electrical Safety Code (NESC) requires the grounding of substation fences to limit touch-and-step potential and transferred voltages in accordance with industry practices and that:

1. Fences shall be grounded at each side of a gate or other opening
2. Gates shall be bonded to the grounding conductor, jumper, or fence.

Because substation outages can cause large number of customer interruptions, utilities should protect substations with exposed bus and equipment with lightning masts or shield wires.[237] Animals can also cause substation outages. Utilities should provide adequate protection from these outages.

During its inspections, Liberty verified whether Ameren-IL grounded the posts on both sides of the substation gate and whether it bonded the gates to the pivot post. The table below summarizes the inspection results for this aspect of NESC compliance. It also provides a summary of Liberty's findings related to substation lightning and animal protection.

Substation	Gate Grounding	Lightning Protection	Animal Protection
Ameren-CILCO			
Eastern	No	OK	–
Allen	OK	OK	OK
Ameren-CIPS			
Canton	Note 2	OK	OK
Gibson City	No	OK	–
Ipava	No	OK	–
Paxton	No	OK	OK
Ameren-CIPS/UE			
Frey	OK	No	Note 1
Mississippi	OK	OK	–
Ameren-IP/North			
Edwards Street	No	No	No (note 3)
Latham	No	OK	–
Ameren-IP/South			
Mariknoll	OK	No	OK
Turkey Hill	No	OK	–

Table Notes:
[1] Animal protection typically provided only in substations with exposed 4,000-volt or 12,000-volt equipment. This equipment was enclosed at the Frey substation.
[2] Gate not inspected.
[3] The Decatur Edwards Street substation partially protected with animal guards.

Ameren-IL provided good lightning protection for its transmission substations, but not for its distribution substations. Nine of the twelve substations inspected had lightning masts or

[236] Interview #173, May 5, 2008.
[237] Lightning masts and shield wires are grounded to the substation ground grid and extend above the substation buses and equipment. If appropriately placed at sufficient height, they protect the substation equipment from most lightning strikes.

overhead shield wires. The three substations without masts or shield wires, Frey, Mariknoll, Edwards Street, were distribution substations, and apparently depend on arresters in the substations to provide lightning protection.

Ameren-IL reported that it only installs animal protection on equipment rated less than 15,000 volts. On the substations inspected, Ameren-IL provided adequate animal protection for its distribution substations with exposed 4,000-volt or 12,000-volt equipment, although protection at some was better than others. Two substations had electric animal fences, as well as animal guards. Ameren-IL had installed animal guards on the oil circuit breakers and voltage regulators in the Decatur Edwards Street substation. However, Ameren-IL did not protect the 12,000-volt insulators and transformer bushings.

Liberty evaluated substation outage data.[238] Animal interference caused about one-half of the substation-outage customer interruptions. Animals caused some of the largest outages on 34,500-volt and 69,000-volt equipment, for which Ameren-IL did not install animal protectors.

Insulator and lightning arrester failures (due to lightning, deterioration, or contamination) caused the second largest annual number of customer interruptions related to substation outages. These may be malfunctions, but they may also indicate that Ameren could improve lightning protection either with more shielding, or better lightning arresters. Each of the companies had a few transformer, circuit breaker, and recloser malfunctions and failures. Although much more infrequent than animal-caused outages, these malfunctions and failures resulted in large number of customer interruptions, justifying considerable inspection and maintenance. The failure of an Ameren-CIPS 138,000-volt bushing resulted in the largest number of customers interrupted by a single substation outage in 2007. The inspection and immediate repair of leaking high voltage bushings is an important element of the substation inspection process. To lesser degrees, substation outages involved voltage regulators, switches, fuses, switchgear, and capacitor bank failures or malfunctions. The number of substation equipment malfunctions was not out of line with other utilities.

3. Conclusions

1. With some exceptions, the overall condition of Ameren-IL's electric delivery system was reasonably good.

The improving trend in the overall frequency of customer interruptions and in the contribution to that frequency from equipment malfunctions pointed to improving system conditions. Ameren-IL's division and field personnel believed that the electric delivery system was in acceptable condition. Liberty found no indications of degraded electrical conditions in Ameren-IL's systems. The results of Ameren-IL's inspections indicated that the condition of wood poles was acceptable. Liberty's experience indicated that the number of Ameren-IL transformer failures was not large compared that of other utilities. In its detailed circuit inspections, Liberty did not observe an unusually large number of items needing repair. The number of issues related to compliance with the National Electrical Safety Code was not large or atypical, and Ameren-IL's NESC Corrective Action Plan has defined timelines and reporting requirements to address each

[238] Response to Data Request #649.

item. In other Liberty inspections, the number of condition issues noted on main lines was typical of aged distribution systems. On its transmission system inspections, Liberty did not observe any specific, systemic condition issues and found that Ameren-IL had adequately maintained the system. The minor condition issues Liberty found at Ameren-IL's substations were small in number. Liberty found substation lightning protection good on transmission substations and animal protection adequate on substations with exposed, lower voltage equipment.

2. The condition of distribution and sub-transmission system poles was acceptable. However, Ameren-IL just recently started a regular pole inspection program. Ameren-IL should closely monitor the results of that program. (Recommendation VI-21.)

Ameren-IL has over one million distribution system wood poles. Neither the legacy companies nor Ameren-IL ever adequately inspected these poles. Ameren-IL does not know the age of 73 percent of these poles, many of which could be over 50 old. The results of the limited inspections performed through 2006, and the first-year results from the new inspection program in 2007, indicate that the condition of the poles is acceptable.

3. Ameren-IL did not examine poles to determine the reason they failed. (Recommendation VI-22.)

Ameren-IL did not routinely examine poles that failed. Straightforward examinations could provide information that would lead Ameren-IL to inspect similar poles, inspect poles in the same area, or possibly change design, construction, or maintenance practices. Storms could cause pole failures because the poles were weak or for other reasons such as a tree falling on the pole. Ameren-IL could use pole failure information to improve system reliability and safety.

4. Weaknesses in maintenance practices adversely affected conditions in Ameren-IL's substations. (Recommendations VI-7 in section VI.E above and VI-23 and VI-24 below.)

Low oil levels and bad equipment paint conditions demonstrated that Ameren-IL was not adequately maintaining all of its substations. Ameren-IL may have prevented large transformer failures with more frequent dissolved gas-in-oil testing.

Inadequate oil in substation equipment like bushings can lead to catastrophic failures that damage other substation equipment. Liberty found low oil in a 138,000-volt bushing and in circuit breakers, voltage regulators, and load tap changers.

A protective paint coating on substation equipment prevents rust-through, and, for transformers, is necessary for proper heat transfer to the air. Liberty found unacceptable paint conditions at several Ameren-IL substations.

Oil leaks can be both an environmental and operating issue. Although Ameren Services indicated that it entered all pending repairs into the work management system, substation management did not specifically track pending oil leak repairs and could determine how long oil leaks continued

before repaired, Ameren Services did not have a formal procedures for what inspectors and repair crews were required to do the minimize the affect of oil leaks.

5. Substations had weak protection against outages caused by animals and lightning. (Recommendation VI-25 and VI-26.)

One report from Ameren-IL indicated that animals caused the largest percentage of substation outages. Ameren-IL provided animal protection for its distribution substations with exposed 4,000-volt or 12,000-volt equipment, although Liberty observed that protection at some substations was more complete than the protection at others. Substation animal protection should include equipment rated at sub-transmission voltages because animal contact with 34,500-volt and 69,000-volt equipment caused some of the largest outages.

Ameren-IL provided good lightning protection for its transmission substations. However, Liberty's inspections indicated that Ameren-IL might need more lightning protection on its distribution substations. Ameren-IL's substation outage data did not distinguish lightning-caused outages; some substation outages dealt with arrestors and insulator flashovers, which lighting may have caused. Liberty's inspections found that the substations without lightning masts or shield wires were distribution substations.

6. The condition of Ameren-IL's transmission system poles was acceptable.

Based on the historical practices of the legacy companies and on inspection programs implemented after Ameren's acquisition of each company, the condition of transmission system poles was acceptable. Inspection results yielded a reasonably low pole rejection rate. From 2002 through 2007, the fraction of transmission poles that required replacement or reinforcement was 3.4 percent.

Illinois Power and Ameren-IP have had reasonably good pole inspection practices. In the mid-1990s, Illinois Power fell behind on its planned 10-year cycle but continued to test transmission poles using good techniques. Ameren-IP inspected transmission poles on a 10-year cycle.

CIPS and Ameren-CIPS have had reasonably good pole inspection practices, except that in one of three areas where CIPS and Ameren-CIPS used in-house personnel who did not perform a complete ground-line excavation and inspection. Liberty understands that starting in 2008, a contractor will perform ground-line inspections on all of Ameren-CIPS' transmission poles on a 10-year cycle.

CILCO performed ground-line testing of transmission poles on a regular cycle until it discontinued the program in 1991. Ameren-CILCO does not have many wood poles in the transmission system and it did not inspect transmission poles in 2005-2007. Ameren-IL plans to inspect Ameren-CILCO transmission poles in 2008.

7. The overall condition of branch (or tap) lines off main distribution lines was not good. (Recommendation VI-27.)

Ameren-IL's inspection and repair practices had not maintained the condition of distribution tap lines in consistently good condition. The poles, conductors, and equipment on the tap circuits

were more aged and under-maintained than those found on the mainline circuits. All three companies had a few poles with rotted or split tops, and broken cross arms and braces. Ameren-CIPS-UE's poles and lines were in good condition but it had the most broken pole ground wires. All companies had some broken or slack guy wires. Ameren-CIPS and Ameren-IP had the most blown lightning arresters.

8. There were instances of non-compliance to the National Electrical Safety Code in Ameren-IL's electric delivery system. (Recommendation VI-28.)

Liberty's circuit inspections identified several types of National Electrical Safety Code (NESC) non-compliance issues including the failure to ground or insulate guy wires, and not marking guy wires exposed to pedestrian traffic. The lack of grounds or strain insulators on guy-wires on Ameren-IP lines made up the vast majority of non-compliance issues identified during the Liberty inspections. There were distribution circuits without four grounds per mile (see Conclusion #10 below).

9. Ameren-IL's distribution circuits needed more protection from outages caused by animals. (Recommendation VI-25.)

Ameren-IL reported that animal interference caused over 11 percent of the customer interruptions in 2006. Ameren-IL also reported that it installed animal guards on all new distribution equipment, and its practice was to install animal guards whenever working on equipment poles. It also installed animal guards on its worst performing circuits, where needed. However, even with these efforts, animal interference caused a significant number of service interruptions, particularly in the Ameren-CIPS and Ameren-IP areas.

10. Ameren-IL's distribution circuits had lightning protection and grounding deficiencies. (Recommendations VI-26 and VI-28.)

Grounding and lightning protection on some Ameren-IL rural distribution circuits was not consistent with the National Electrical Safety Code (NESC) requirements and Ameren-IL construction standards. Some rural circuits inspected by Liberty needed additional grounding and lightning protection. The NESC requires that utilities provide grounds on distribution lines at least at four poles within each mile of line. Ameren-IL's construction standards require the installation of lightning arresters at least at four poles within each mile of line. There must be grounds wherever there are arresters.

In addition, except for Ameren-CIPS-UE, the Ameren-IL companies had not installed lightning arresters at some distribution line switches. Liberty observed distribution-line switches without lightning arresters. Arresters are necessary at switches because if lightning strikes a line, a traveling voltage wave could cause a surge voltage at open switches that is twice the surge voltage experienced elsewhere on the line.

11. Service interruption information recorded in the Outage Analysis System is not ideal for Ameren-IL's evaluation of system conditions. (Recommendation VI-29.)

The Outage Analysis System contains accessible, historical information on service interruptions. The information is comprehensive and Ameren can extract data so that engineers can manipulate

the data on personal computers. The usefulness of the data is dependent on the quality of the input from dispatchers and troublemen. Liberty found data inconsistencies, which is typical of other utilities. Ameren-IL does not use specific codes to identify outages caused by lightning. Ameren-IL could make improvements to the outage information that would make it more valuable in assessing system conditions and in pursuing specific equipment problems.

12. Ameren-IL did not have a consistent program for evaluating equipment failures and disseminating information from those evaluations. (Recommendation VI-30.)

Ameren-IL has three different reporting programs for problems encountered on systems in Illinois, one for each of the operating companies. Ameren-IL would benefit from having consistent methods for reporting on incidents and accidents. Analyses of incidents in one area should be available to personnel in other areas and should be in a format that is familiar to them. Ameren-IL reported that it established a team to "Explore simple, practical solutions to establish consistency in procedures, policies, and processes across the Ameren-Illinois operating companies."[239]

13. Ameren-IL did not perform valid root cause analyses of important incidents and accidents. (Recommendation VI-31.)

Ameren-IL makes engineering assessments of equipment failures and problems, and analyzes accidents involving personnel injuries. For most of the typical problems that occur on transmission and distribution systems, Ameren-IL's evaluations are adequate and typical of most electric utilities. However, some significant or unusual incidents warrant a more in-depth investigation. A root cause analysis will determine one of the underlying events, conditions, or factors that created or allowed a defined, undesired outcome. The actual root cause should be specific, something over which management has control, and something for which the analysts can generate effective recommendations.

4. Recommendations

VI-21 Monitor closely the quality of and results from inspections of distribution and sub-transmission wood pole inspections.

The Ameren-IL companies did not inspect regularly and thoroughly distribution and sub-transmission system poles. This would make the condition of these poles suspect. However, the results of the inspections that the companies did perform and the results from Ameren-IL's new inspection program indicate acceptable pole conditions. Ameren-IL should ensure that the new, 12-year cycle inspections are thorough and should closely monitor the results. If the results show a significantly higher pole rejection rate than the 2007 results, Ameren-IL should inspect more aggressively, *i.e.*, reduce the inspection cycle and concentrate on poles that are more likely not to have the required strength. Ameren-IL should have already implemented this recommendation.

In its comments on the draft report, Ameren-IL accepted this recommendation.

[239] Response to Data Request #392.

VI-22 Examine failed poles.

Ameren-IL should implement a program to inspect broken poles. Poles can break for several different reasons. For example, they could have been weak and rotted below ground, they may have broken because they were leaning and high winds caused excessive forces, or a vehicle may have hit an otherwise strong pole. Determining that a pole broke because of deterioration may provide a trigger for distribution engineers to order pole inspections for other poles in the same area or of the same age and type. Liberty recognizes that in a large storm environment, examining poles should not take priority over restoration efforts, and that it is not necessary to examine every failed pole. Nevertheless, pole failure information can help Ameren-IL prioritize maintenance and inspection efforts. Ameren-IL should implement this recommendation within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-23 Correct substation paint deficiencies.

Ameren-IL should repaint major substation equipment that have aged and faded paint coatings. Liberty observed faded paint and rust developing on very large transmission transformers. Appropriate paint coatings are necessary on transformers for optimal heat transfer as well as for preventing rust-through. In addition, there were distribution substation transformers with rust along the top of their radiators and faded paint on some 138,000-volt oil circuit breakers. Ameren-IL should develop a plan for major substation equipment painting within six months of the date of this report. A reasonable plan would include the correction of known deficiencies within five years.

Ameren-IL should also include identifying and correcting minor equipment paint issues in its regular substation maintenance program. Liberty observed some small but severe rust conditions on some cabinets, radiators, and other equipment. Ameren-IL could easily correct these by removing the rust and applying coats of paint on-site, often without equipment outages. Neglecting small rust spots can result rust-through. Rust-through can result in moisture contamination of or oil leakage from equipment components. Ameren-IL should implement the program for correcting minor paint issues within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-24 Improve processes for correcting substation deficiencies.

Ameren-IL should formalize procedures and improve tracking of the repair of substation-equipment oil leaks, low oil levels, zero transformer nitrogen pressure, and other time-sensitive issues.

Oil leaks can have a negative affect on the environment and equipment operation. No nitrogen pressure on transformers could mean that wet air might enter the transformer. Ameren-IL should investigate and correct these types of substation condition issues without undue delay. To accomplish of this, Ameren-IL should:

(1) Implement universal and formal inspector, supervisor, and repair crew procedures, with time limits, for correcting and cleaning up oil leaks, zero nitrogen pressures, and adding oil to equipment. The procedures should include when and how to notify the Ameren environmental organization of oil leaks.
(2) Implement changes to its substation job management system such that it can record and track at least the aforementioned tasks by specific codes or key words from the date of identification to the date of completion.
(3) Assign the responsibility for monitoring pending tasks and the amount of time the tasks were open, and for providing periodic task performance reports to Ameren-IL management for review.
(4) Consider supplementing the substation inspection program with periodic "find and fix" inspections conducted by two-person substation maintenance crews. Direct these crews to conduct detailed substation inspections and to repair, or to initiate the repair of, emergent and standing minor repairs such as oil leaks and oil clean up, zero transformer nitrogen pressures, spot painting, and yard cleanup.

Ameren-IL should implement these procedures within one year from the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-25 Improve animal protection on distribution circuits and at distribution substations.

Ameren-IL's stated practice was to install animal guards on new equipment and when working on poles with equipment. However, Ameren-IL reported that animals caused over 11 percent of customer interruptions and Liberty's inspections revealed that a significant percentage of poles, particularly in the Ameren-CIPS and Ameren-IP areas, did not have animal protection. Outage Analysis System data showed that animals caused most of the outages at substations and that Ameren-IL may need animal protection on equipment operating above 15,000 volts.

Liberty's experience has shown that installing additional animal protection is a cost effective means to improve service reliability. Ameren-IL should evaluate the costs of, and expected reliability improvement gains from, accelerating the addition of animal protection against other reliability improvement efforts and propose an improved animal protection program. Ameren-IL should prepare a written report on this evaluation and on program improvements within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-26 Improve lightning protection on distribution circuits and at distribution substations.

Ameren-IL should develop a lightning protection program that will result in bringing all distribution circuits into compliance with Ameren-IL's current standards. The program should address improving lightning protection at distribution substations. The program should also address lightning protection at distribution line switches, particularly line-tie switches. Retrofitting circuits built to older standards is not a requirement. Therefore, Ameren-IL should

evaluate the costs of, and expected reliability improvement gains from, the addition of more lightning protection against other reliability improvement efforts and propose an improved lightning protection program. Ameren-IL should prepare a written report on this evaluation and on program improvements within one year of the date of this report. It is reasonable to expect that the program will call for completion of improved lightning protection within five years of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-27 Improve the physical condition of distribution-circuit tap lines.

Ameren-IL should include all circuits tapped onto main lines in its routine distribution patrol inspections and make certain that inspectors identify condition issues such as broken ground wires, blown lightning arresters, broken and slack guy wires, rotted and split pole tops and cross arms, broken braces, excessive sag, leaning poles, floating conductors, and broken aerial cable spacers. It should then ensure that it tracks to completion the correction of identified issues. Ameren-IL should implement this effort within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-28 Correct National Electrical Safety Code issues.

Ameren-IL developed a program for correcting NESC compliance issues and submitted it to the Staff of the Illinois Commerce Commission. Ameren-IL should continue the implementation of this committed program. Ameren-IL documented its program and commitments for completing identified NESC compliance issues in letters to the ICC dated October 31, 2007, and April 11, 2008.[240] These documents provide the scope and schedule for implementing this recommendation.

In addition, Ameren-IL should determine where less than four grounds per mile of distribution line exist and make changes as required by NESC code.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-29 Improve the information systems available for evaluating system conditions.

Ameren-IL should take steps that could lead to improved information and analysis of system conditions and equipment problems:

- Add cause codes for lightning. Consider codes for obvious direct lightning strikes and suspected but unverified strikes.
- Use the "equipment malfunction" cause code when equipment did not operate as intended, or broke without external cause. To properly evaluate damage causes and to conveniently identify systemic equipment problems, the equipment malfunction code should not be used if a fallen tree breaks a line or a pole, or lightning damages equipment.

[240] Response to Data Request #683.

- Use tree-related cause codes in such a way to conveniently allow evaluation by the vegetation management and reliability groups for preventable and non-preventable tree contact.
- Train troublemen and dispatchers to apply cause codes with as much accuracy as possible.
- Study the organization of information entered into the Outage Analysis System (OAS). Determine whether there are ways to structure the input and use typical outage scenarios to gain more consistency in data entry.
- Develop methods to use OAS to capture information on particular equipment issues.
- Survey other utilities and information system vendors for the possible replacement of functions now performed by OAS and related to causes of outages.

Ameren-IL should implement this recommendation within one year of the date of this report. If Ameren-IL chooses to replace the Outage Analysis System, then Ameren-IL could extend the implementation to coincide with implementing the new system.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-30 Improve the analysis and reporting of incidents and equipment failures.

Ameren-IL should take better advantage of learning from incidents and equipment problems across its entire Illinois territory. Having one system instead of three for reporting such matters would help in this regard. A common format and content for reporting problems could help distribution engineers and others avoid recurrence of problems that took place in other parts of the Ameren-IL system. Ameren-IL should take the best features and practices from the existing systems to develop the new, comprehensive, and consistent program. It should also establish means for making the information available to those who could benefit from it. Ameren-IL should implement this recommendation within one year of the date of this report.

As an example, Ameren-IL did not evaluate the cause of all substation transformer failures. Age and electrical conditions (excessive loading) apparently were not significant factors in the failures that could have been improper application, design or construction deficiencies, under-maintenance, or inadequate lightning protection and grounding of the lines or the substations. Ameren-IL could benefit from a better understanding of what caused these transformer failures.

In its comments on the draft report, Ameren-IL accepted this recommendation. Ameren-IL interpreted this item as two recommendations. However, Liberty used substation transformer failures as an example of the need for improved analysis of equipment failures.

VI-31 Institute an effective root cause analysis program.

The program should define the type of incidents for which Ameren-IL will perform a root cause analysis and the level of management that can call for a root cause analysis. The program should call for a multi-disciplinary team of personnel to perform the assessment and should make provisions for the team to have time dedicated to the analysis. Procedures should describe the objectives and methods for the team, define the common terms the team should use, and provide a common structure for the reports.

There are companies that provide training for root cause analyses. It has been Liberty's experience that while this training can have value, it often overly complicates the process. Another effective way to produce good root-cause-analysis reports is to conduct questioning reviews of draft reports in sessions with knowledgeable personnel not involved in the work. They can help determine whether the evaluations have been in sufficient depth, whether there remain unanswered questions, whether the team has identified the roots (underlying causes) of the problem, and whether the evaluation addressed preventing recurrence.

Ameren-IL should prepare the program and procedures for root cause analyses within six months of the date of this report and should begin performing them whenever worthy incidents occur thereafter.

In its comments on the draft report, Ameren-IL described a "Post Disturbance Analysis Committee" that it formed to investigate certain electric outage events. Liberty views this as a step in the right direction, but believes that Ameren-IL could benefit from gaining a better understanding of determining root causes, not simply direct causes of incidents.

I. Vegetation Management

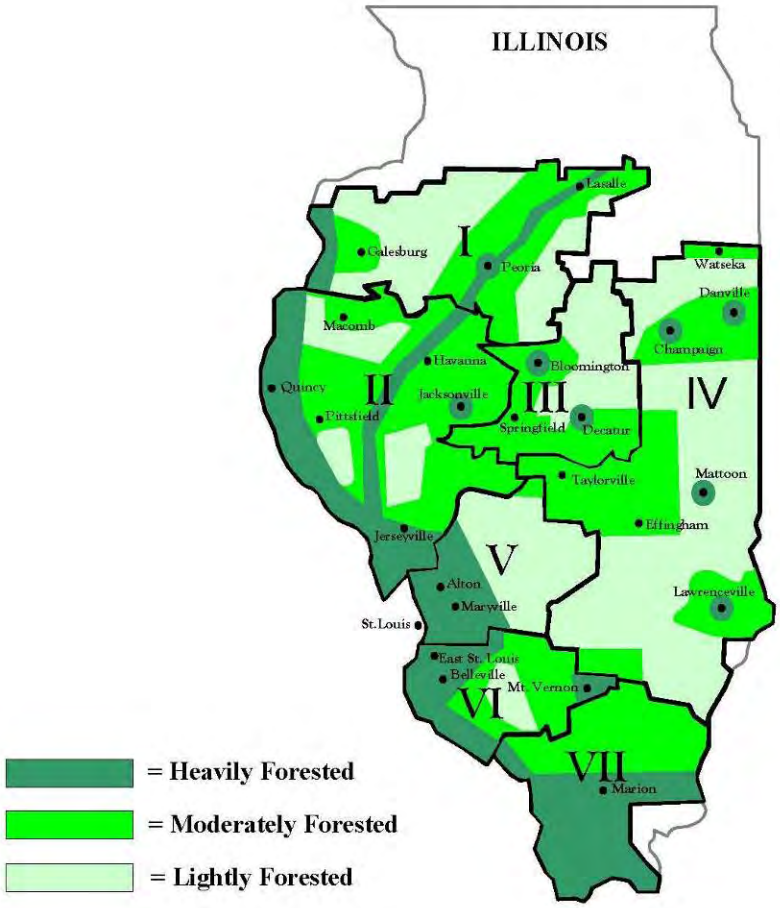
1. Introduction

One of the most important things a utility must do to provide reliable service is to control the vegetation near overhead lines and substation facilities and equipment. Utilities control vegetation in several ways but the single objective is to remove vegetation that could interfere with the reliable and safe operation of the electric delivery system during normal conditions and during storms.

To accomplish this objective, utilities typically use cyclic vegetation management programs for lower voltage portions of the system and right-of-way space in combination with cyclical programs for higher voltage lines. The cycles can be a fixed period or a set number of growing seasons. Some utilities establish different timing of vegetation controls dependent on circuit voltage levels, climate conditions, and vegetation species. Still other utilities have attempted a just-in-time vegetation management program in which the utility monitors vegetation growth and only works on portions that interfere with overhead facilities. Regardless of the methods used, the keys to success in any vegetation management program are consistency of the program, commitment to the program, and program funding.

Ameren-IL's service territory is large, covering the southern three-quarters of Illinois, and diverse with regard to vegetation coverage. The map shown below depicts the general vegetation cover in the Ameren-IL territory.[241]

[241] Response to Data Request #499. The map shows the operating division arrangement as of July 2006.



Ameren-IL's service territory is heavily forested along the Mississippi River on the western portion of the system (Divisions II, V, VI, and VII), along the Illinois River (Divisions I and II), and the southern portion of the system along the Ohio River and in the Shawnee National Forest

(Division VII). Moderate vegetation exists in the central portion of the system and light vegetation is shown in the farming areas of the eastern portion of the system. Ameren-IL must manage a variety of vegetation densities over a large portion of the state.

Section 21, Rule 218 of the National Electrical Safety Code (NESC) requires a utility to address vegetation that is in proximity to its facilities. The Illinois Commerce Commission (ICC) adopted as its rules, portions of the NESC including Section 21 of the 2002 edition of the NESC.[242] Rule 218 says:

> *218. Tree Trimming*
>
> *A. General*
> *1. Trees that may interfere with ungrounded supply conductors should be trimmed or removed.*
> *NOTE: Normal tree growth, the combined movement of trees and conductors under adverse weather conditions, voltage, and sagging of conductors at elevated temperatures are among the factors to be considered in determining the extent of trimming required.*
>
> *2. Where trimming or removal is not practical, the conductor should be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.*
>
> *B. At Line Crossings, Railroad Crossings, and Limited-Access Highway Crossings*
> *The crossing span and the adjoining span on each side of the crossing should be kept free from overhanging or decayed trees or limbs that might otherwise fall into the line.*

The NESC is a standard that covers basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of (1) conductors and equipment in electric supply stations, and (2) overhead and underground electric supply and communications lines.[243] The prime purpose of Rule 218 is therefore personnel safety. However, vegetation is often the leading cause of service interruptions, and vegetation management for service reliability has to be more extensive than that performed only for safety reasons. Therefore, good vegetation management requires a utility to protect the safety of people, protect its equipment from damage, and provide reliable service by balancing service level, cost, proper vegetation care, legal requirements, and the wishes of its customers.

In order to evaluate Ameren-IL's vegetation management, Liberty reviewed the standards, practices, and processes used by Ameren-IL for adequacy, completeness, conformance to the NESC, and technical correctness. Liberty reviewed vegetation management expenditures and the effect that vegetation had on the consequences of the 2006 storms. Finally, Liberty conducted

[242] Title 83, Chapter 1, Subchapter b, Part 305, and Section 305.20.
[243] NESC C2-2002, Abstract.

both aerial and vehicle field inspections of the distribution, sub-transmission, and transmission systems to determine if Ameren-IL implemented the standards as intended.

2. Findings and Analysis

a. Vegetation Management Programs[244]

1. Background

Transmission and some sub-transmission lines are in right-of-ways that allow for a clearance with vegetation. Utilities keep these right-of-ways clear from undergrowth and protect the electric facilities from trees that could interrupt service that are located outside of the right-of-way.[245] A utility may use mechanical mowing, hand clearing, herbicides, or a combination of all three to control vegetation in right-of-ways.

Some sub-transmission and distribution lines are located in proximity to homes and businesses along streets or in a back-lot configuration.[246] Tree trimming programs must deal with fast and slow growing species, vines, health of the trees, aesthetics, and landowners. Utilities control the vegetation in and around these electric facilities along the street using trucks with hydraulic booms. Often in a back-lot configuration, personnel have to climb trees to perform the required pruning. Utilities need landowner permission to trim or cut down vegetation that is not in a public way. In some locations, an easement gives the utility permission to trim on an on-going basis.

2. Transmission System Standards

The Ameren-IL transmission vegetation-management program defines clearances between vegetation and transmission lines. There are two clearances defined in the Ameren-IL transmission vegetation program.

Ameren-IL defines "Clearance 1" as the distance required between vegetation and transmission conductors at the time that vegetation management work is completed. "Clearance 2" is the minimum clearances required at all times. Clearance 2 distances are based upon IEEE (Institute of Electrical and Electronic Engineers) standard 516-2003, specifically section 4.2.4 (*Guide for Maintenance Methods on Energized Power Lines).* This standard is the minimum distance an object can encroach to a certain voltage before a flashover would occur between the line and the object. A flashover has the potential to lead to an outage.

The Ameren-IL program also segments the right-of-way into two zones. These zones are called a "wire" zone and "border" zone. Ameren-IL defines the wire zone as the area occupied by the structures and conductors, which extends 20 feet beyond the outer-most conductor. The border zone extends from the point where the wire zone ends to the edge of the right-of-way. The

[244] Responses to Data Requests #45 and #251, and Interviews #7, October 5, 2007, and #52, October 11, 2007.
[245] Called "danger trees."
[246] A back-lot configuration is where electric lines are in the rear, and along the property lines, of residences of two adjacent streets.

vertical and horizontal clearances required for each clearance condition and each zone varies. The Ameren program mentions height requirements for vegetation within each zone. However, the language is not functional for the vegetation management contractor. An example of this language Ameren's standard follows:[247]

> *Clearance 1 in the wire zone for circuits operated at greater than 200,000 volts requires the following conditions to be achieved upon completion of vegetation management work:*
>
> *1. Vegetation in this zone should be managed to promote the growth of native plant species that have a mature height less than 10 ft. All plant species that normally reach a mature height greater than 10 ft. tall should be removed by mechanical methods or controlled by approved herbicide applications. Exceptions may be permissible for locations where the clearance between the conductor and vegetation is greater than 20 ft.*
>
> *2. If operating conditions cause conductors to sag such that ground to conductor clearance is less than 30 ft., then all vegetation should be maintained for a mature height of less than10 ft. tall.*
>
> *3. If operating conditions cause conductors to sag such that ground to conductor clearance is greater than 30 ft., then all vegetation should be maintained to provide a minimum of 20 ft. clearance.*
>
> *4. No tree growth will be allowed to overhang any conductor, structure or guy line associated with any transmission circuit or structure.*

A transmission line will sag between support structures depending on the load on the line and ambient conditions. Transmission line designers can determine the amount of sag under various conditions, but vegetation contractors cannot. Specifying a clearance between the conductors and vegetation growing up from the ground must take into account all possible conditions needed to set a clearance such as the minimum clearance allowed by the NESC for the particular voltage and use under the line. Ameren-IL needs to develop maximum allowed vegetation heights above ground that consider maximum line sag.

3. Distribution System Standards

Ameren-IL performs vegetation management on all distribution lines on a four-year schedule. More specifically, no circuit can have more than 48 months between vegetation management applications. In addition to the four-year trim cycle, Ameren-IL systematically patrols sub-transmission lines (69,000 volts and 34,500 volts) the year before scheduled maintenance trimming to accomplish work necessary to maintain reliability, including the removal of danger trees.

Ameren-IL's current standard details required clearances. In simplified terms, the standard requires a side clearance of 10 feet between conductors and tree growth. Prior to May 2007,

[247] Response to Data Request #251, 251-A page 10.

Ameren-IL practiced but did not specify a 6- to 8-foot side clearance. If there are secondary conductors present, there should be at least 3 feet clearance with the lowest wire. For softwood trees, the standard requires removal of limbs up to 15 feet above the conductor. The corresponding distance for hardwood trees is 10 feet. The standard requires the removal of dead or dying limbs above the conductor. In addition, Ameren-IL's standard for distribution system overhang includes specific directions concerning the direction of growth of lateral branches and the diameter of limbs that may remain. Any overhang creates the possibility of tree interference, for example, when ice forms on the branches. Ameren-IL's standard attempts to balance reliability against the cost of additional trimming by requiring removal of most overhang and allowing some exceptions based on the type of wood, distance above the conductor, and direction of growth. The direction Ameren-IL gives to contractors in this regard goes beyond the norm for many other utilities and is satisfactory. Ameren-IL removes all overhand for sub-transmission lines, which also have clearances of 10 feet under and to the side of conductors.

Ameren-IL performs a mid-cycle patrol on distribution circuits two years after its scheduled trim. Trained personnel, most of whom are certified arborists, conduct the patrols. If the patrol encounters vegetation that will interfere with circuit operation prior to the next regular ("maintenance") trimming, Ameren-IL performs trimming during this mid-cycle period. None of the Ameren-IL companies had a mid-cycle trim program prior to January 2003. The 34,500-volt sub-transmission system is also subject to the mid-cycle patrol (and to the year-before patrol mentioned above). However, Ameren-IL does not perform mid-cycle patrols on single-phase and two-phase circuit taps that are fused.[248]

Ameren-IL installs the fuses so that a fault on the tap line will not cause an outage on the rest of the circuit. The apparent logic for not performing mid-cycle patrols on fused tap lines is that vegetation there would cause only a limited outage. Ameren-IL estimates that there are approximately 75,000 fused and 13,000 un-fused taps on the system.[249] As it completes the tap-fuse program, it will perform less mid-cycle patrols and trimming. Ameren-IL's approach reduces the value of the mid-cycle program and allows vegetation-caused service interruptions to occur that it could avoid.

The Ameren-IL vegetation management procedures do not specifically address overhead vegetation at road, railroad, and line crossings as required by the NESC Section 218.B. Ameren-IL communicates those requirements to their distribution vegetation management supervisors and the contractor's foremen. Ameren-IL meets the NESC requirement on the transmission system and sub-transmission system in right-of-ways because it removes all overhead vegetation in the normal course of vegetation management.[250] Ameren-IL should specifically include the NESC requirement in its standard.

In certain cases, Ameren-IL's vegetation and pruning standards allow vegetation to remain within the trim zone and in proximity to the conductors. Generally, this is main stems and wood that is in excess of 4 inches in diameter. If it is possible to climb these trees, good utility practice requires extra care for safety. Ameren-IL's vegetation management standards mention the

[248] Interview #109, December 17-21, 2007 and January 7-11, 2008.
[249] Response to Data Request #555.
[250] Interview #52, October 11, 2007.

possibility of children climbing trees but do not have explicit trimming requirements for trees that anyone in the public could climb.[251] Ameren-IL should strengthen its provision in its vegetation management standards that addresses the ability to climb trees with vegetation in the trim zone. As an example, Ameren-IL could specify that if vegetation remains within the trim zone and is within 3 feet of a primary conductor, ensure that nobody can climb the tree by removing all branches 10 feet from the ground level.

While conducting its vegetation management inspections, Liberty observed matters in which Ameren-IL could refine its vegetation management program to improve efficiency, understanding, or processes. Those matters are:

- Evaluate the viability of an enhanced trimming specification for use in urban areas where No. 6 or No. 8 copper wire is in use and vegetation is problematic.
- Evaluate the use of the current GPS system in identifying and tracking, trimming restrictions and refusals, mid-cycle problem trees, and take down trees.
- Prioritize mid-cycle problem trees for take down and danger trees by species, growth rate, tree condition, and tree location on the circuit.
- Provide a requirement that once tree shelves[252] and side clearances have been established, those trees are to be maintained to those locations even if pruning standards would allow some vegetation to remain.
- Include pruning diagrams as examples of what finished vegetation work should look like in relation to the various line configurations and voltages and supply them to contractors along with associated training.
- Provide trimming contractors with more training and information so that they can identify and report non-vegetation corrective maintenance items beyond obvious deficiencies.

b. Program Initiatives[253]

Ameren-IL revised the trimming dimension standards as it acquired the three legacy companies. Ameren-IL also implemented several vegetation program initiatives in recent years. These include the mid-cycle trim program described above and the following.

48-month trim cycle

The ICC required that Ameren-CILCO adopt a 48-month trim cycle by the end of 2002, Ameren-CIPS (UE) by the end of June 2002, and the remainder of Ameren-CIPS by the end of June 2004. Ameren-IP was on a four-year program but defined it as having to start the next trim cycle within 48 months. Ameren-IL subsequently changed the Ameren-IP definition to be consistent (i.e., no more than 48 months between completion of two vegetation management cycles) with the other companies.

[251] Responses to Data Requests #45 and #251.
[252] A horizontal branch of a tree void of vegetation above it.
[253] Response to Data Request #511.

Tree Manager Database

This database allows for the tracking of circuit trimming date data, cost data, productivity information, tree count information, and other information.

Prescriptive Trim Program

Ameren-IL's vegetation management supervisors monitor the cause of feeder outages. If a feeder has more than one tree-related outage in five-year period, it becomes a candidate for prescriptive trimming. Worst performing feeders based on tree-caused customer interruptions also become candidates for prescriptive trimming. Ameren-IL patrols the circuit from the substation to the first protective device and performs required trimming.[254]

Performance Management Agreements with Contractors.

Ameren-IL negotiates annual performance agreements with vegetation contractors. The agreement includes measures of contractor performance in the areas of safety, customer satisfaction, process efficiency, and productivity. The agreements have provisions for incentive payments that depend on meeting specified goals. Ameren-IL indicated that performance also affects the volume of future work assigned to a specific contractor.[255]

Forestry Overhead Damage Report

This report documents overhead equipment damage observed by tree trimming crews in the field. Contractors normally file the reports weekly and should report damage that requires immediate attention to the Ameren-IL vegetation management supervisor on the spot.

Focus on Specific Circuits

Ameren-IL determined that in 2007 field personnel and dispatchers listed the "tree broke" outage cause in 71 percent of the customer interruptions caused by trees. In addition, 75 percent of the customer interruptions caused by trees occurred on only 255 circuits, or approximately 11 percent of Ameren-IL distribution circuits. In 2008, Ameren-IL indicated that it would trim additional overhang, increase removals of trees, implement prescriptive tree trimming, and expand tree replacement programs in those communities.

c. Inspection of Contractor Work

Vegetation management at Ameren is the responsibility of the Manager, Resource Management at Ameren Services. Three superintendents report to this manager, one for Missouri, one for Illinois, and one for transmission in both states. The Illinois superintendent has eight vegetation supervisor reports with at least one in each division. The superintendent for transmission has as direct reports three vegetation supervisors responsible for Illinois.[256]

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[254] Response to Data Request #278.
[255] Interview #109, December 17-21, 2007 and January 7-11, 2008.
[256] Response to Data Request #667, and Interview #7.

The vegetation management workforce for distribution consists of one person per division. This individual is responsible for all crew work activities, crew billings, crew reports, inspection of crew work, and working with towns and customers on tree-related matters. This person has to perform these functions over the entire division. Two individuals perform these functions for the entire transmission system. The Illinois superintendent also has many responsibilities that can interfere with inspection work.[257]

Ameren-IL requires that each vegetation contract crew submit for inspection the documentation of two days of work per crew per month. The contractor may inspect and make corrections to the work that was shown as needing improvement prior to this submission but is required to inform Ameren-IL of the corrections it made. The procedures then require Ameren-IL supervisors to inspect a minimum of 10 percent of the distribution work and a minimum of 20 percent of the transmission work that the contractor submitted. This means that for a 20-day work month, the contractor submits 10 percent, and Ameren-IL may inspect a minimum of 10 percent, or only 1 percent of the total work the contractor performed. However, Ameren-IL typically exceeds the minimum requirements. In 2007, Ameren-IL inspected nearly 40 percent of all contractor distribution work as submitted as part of the normal vegetation-management audit process. (Note that 40 percent of 10 percent means that Ameren-IL inspected only 4 percent of all work.) If Ameren-IL inspections find improvement needed during field inspections, then the contractor general foremen are required to inspect 100 percent of the work performed by this crew on all projects worked, and correct any deficient work at no additional cost to Ameren-IL. Ameren-IL vegetation personnel are also required to do one drive-by inspection per crew per month. This inspection documents observations related to safety, equipment appearance, workers present, and work done to specifications and invoicing.[258] Ameren-IL has no formal inspection program of contractor transmission or distribution work that the contractor does not submit for inspection but has indicated that its vegetation management supervisors do so informally in the normal course of business while traveling. As an example, Ameren-IL transmission supervisors conduct a minimum of one patrol a year on all transmission circuits. During the course of doing these patrols, Ameren-IL transmission vegetation supervisors will view any work that contractors completed prior to the patrol. Circuits greater than 200kV are patrolled twice per year. Therefore, Ameren-IL will informally review a greater percentage of completed work on these transmission circuits.

Liberty concluded that the very small amount of required inspection of contractor work is inadequate, that inspection only of work submitted by the contractor does not represent good auditing practice, and that Ameren-IL cannot conduct additional inspections with its current workforce.

For the transmission system and the years 2004-2006, the contractors identified only one-rework item in the work submitted for Ameren's inspection in the important categories of danger trees, hangers, and clearance issues that could affect reliable operations. Ameren's inspections identified three rework issues in the portion of the system that it inspected. However, for the first nine months of 2007, the contractor's rework items and Ameren's inspection findings increased significantly. If the number of inspection findings for a small percentage of the system reflects

[257] Interviews #67, November 28-29, 2007 and #109, December 17-21, 2007 and January 7-11, 2008.
[258] Responses to Data Requests #251 and #386, and Interviews #7 and #52.

the condition of all the contractors' work, there could be many items requiring rework. Ameren-IL should determine the cause for the increase in transmission vegetation rework in 2007 to prevent unnecessary transmission line operations.

For the distribution system, the first table below shows the number of contractor rework items performed prior to submittal to Ameren-IL for inspections. The second table shows the number of Ameren-IL-identified issues related to danger trees, hangers, and clearance issues. Note that Ameren-IP data are not included until the second quarter of 2005.[259] The 2007 figures are for the year through September.

Contractor Distribution Rework Issues Corrected Prior to Submittal

	2004	2005	2006	2007
Division I	3	13	14	2
Division II	6	6	15	16
Division III	1	0	2	0
Division IV	18	33	17	29
Division V	24	65	100	70
Division VI	0	33	49	14
Division VII	31	26	35	29
Totals	**83**	**176**	**232**	**160**

Ameren Distribution Rework Issues Found on 10 Percent of Submittal

	2004	2005	2006	2007
Division I	0	0	2	0
Division II	0	0	2	1
Division III	0	1	8	6
Division IV	0	0	1	2
Division V	11	23	26	21
Division VI	0	17	27	7
Division VII	14	10	7	10
Totals	**25**	**51**	**73**	**47**

There have been a considerable number of re-work issues identified by the contractor and Ameren-IL vegetation management personnel as part of the Ameren vegetation management QA process. Liberty and Ameren-IL vegetation management personnel identified many re-work issues during distribution inspections conducted during the timeframe of December 17 through December 21, 2007, and January 7 through January 12, 2008. The data in the table above and the locations observed on the distribution inspections indicate that Ameren-IL should inspect more of the vegetation contractor's completed work.

d. Easements

A utility requests an easement from property owners so that it can accomplish routine maintenance trimming and removal of vegetation that could jeopardize reliable system operation.

[259] Response to Data Request #253.

When electric lines are within right-of-ways, the utility has trimming rights contained in the easements.[260] When electric lines are within the roadway, easements may be required depending on the facilities' location relative to private property boundaries. Even when electric facilities are entirely within a roadway, easements could be required to achieve desired side clearances.

The Ameren-IL legacy companies were not diligent in securing easements for facilities entirely or partially located in the roadway. The following table depicts legacy company practices in securing additional trimming easements for distribution, sub-transmission, and transmission lines that are entirely or partially within the roadway.[261]

Company	Distribution	Sub-transmission	Transmission
Ameren-CILCO	Less Than 50 Percent	On Occasion	Always
Ameren-CIPS	None	On Occasion	Always
Ameren-IP	None	Less Than 50 Percent	Always

Ameren-IL is developing a standard easement width requirement for all distribution and sub-transmission lines.[262] However, it is not clear whether the standard easement widths Ameren-IL is developing are applicable to both right-of-ways and roadway applications. In addition, the document proposes a 20-foot easement for 4,000-volt and 12,000-volt facilities. If there is an 8-foot cross arm, there would be only 6 feet of clearance to the edge of the easement, a distance far short of the vegetation trimming side requirements of 10 feet put into effect by Ameren-IL in May 2007.[263] Nevertheless, it does not appear that the lack of additional easements for distribution and sub-transmission facilities created an impediment to perform required trimming, as there were only 97 refusals to perform distribution tree trimming in 2007.[264]

e. Customer Interface and Refusals to Allow Trimming

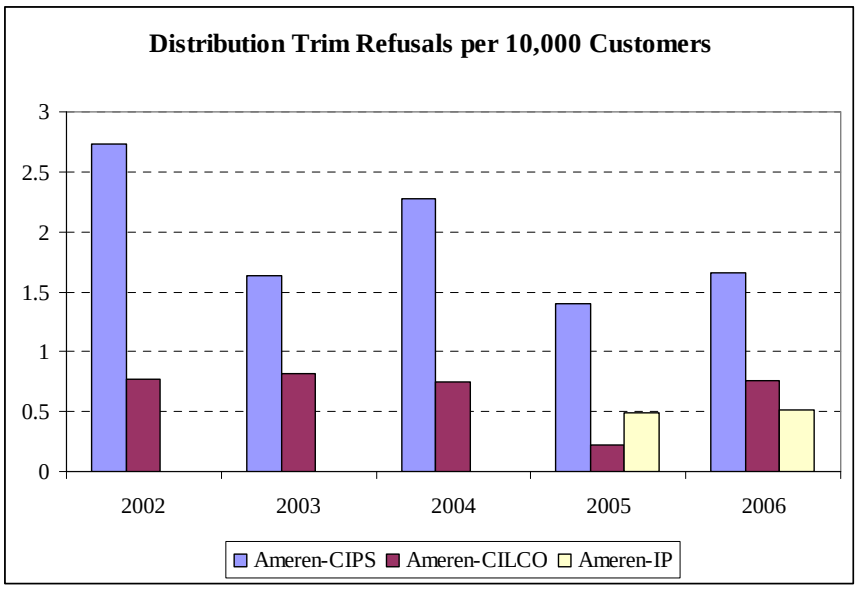
The State of Illinois Public Act 91-0902 requires Ameren-IL to give 21 days advance notice to municipalities and to notify directly affected customers at least 7 days before beginning non-emergency vegetation management activities.[265] Customers receive an automatically generated postcard as notice that Ameren-IL will perform trimming. Ameren-IL instructs contractors to make a courtesy contact at the time of the trimming work. If there is no one at home, the trimming work proceeds. If the contractor receives a refusal, he notes it on the circuit map and forwards the refusal to the Ameren-IL vegetation supervisor who will meet with the customer to reach resolution. Ameren-IL indicated that this meeting typically results in a resolution. However, if there is no resolution, Ameren-IL will trim the amount allowed, tracks locations where customers refuse to allow distribution trimming, but does not subsequently follow up on this location until the next trim cycle.[266] If the contractor receives a transmission-system trimming refusal, he files the refusal in the transmission maintenance log and contacts the

[260] Response to Data Request #583.
[261] Responses to Data Requests, #505, #506, #507, #515, #516, and #517.
[262] Response to Data Request #534.
[263] Responses to Data Requests #510 and #534.
[264] Response to Data Request #56.
[265] http://www.ilga.gov/legislation/legisnet91/sbgroups/sb/910SB1541LV.html.
[266] Interview #52, October 11, 2007.

Ameren-IL transmission vegetation supervisor immediately. Ameren-IL indicated that it makes every effort to come to resolution with the customer.[267]

No communities have expressed objections to Ameren-IL trimming specifications. However, there are locations in several communities in which Ameren-IL has to use special discretion in implementing its standards; these locations generally are the historic districts in those communities. In addition, several communities have very active tree advisory boards. These communities are Bloomington-Normal, Champaign, Urbana, Edwardsville, Quincy, Carbondale, Peoria, Springfield, Centralia, St. Elmo, and Macomb.[268]

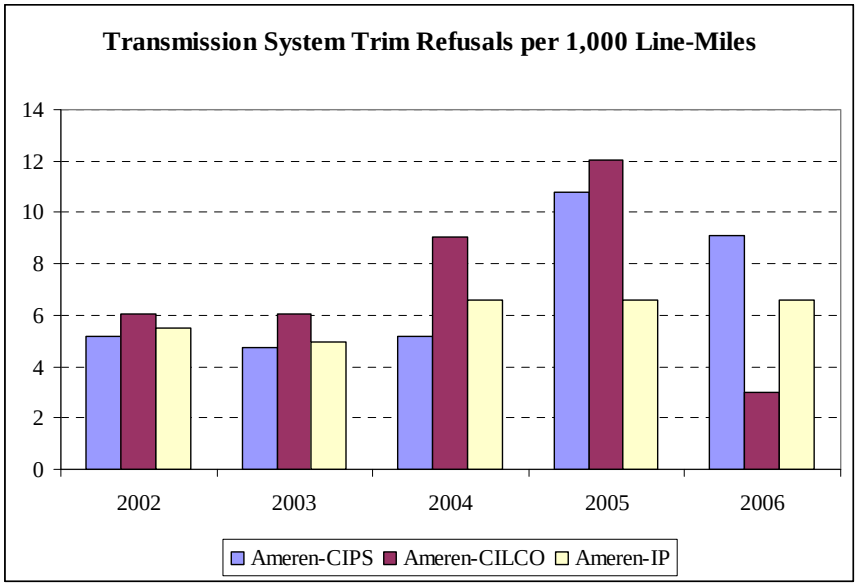
Ameren-IL has received a relatively small number of customer refusals to trim on the distribution system. The total number of such refusals was less than 100 in both 2005 and 2006. The chart below shows the number of distribution refusals per 10,000 customers for each of the Ameren-IL companies.[269]



Despite the small absolute number of refusals, the chart clearly shows that the rate per customer at Ameren-CIPS has been more than twice that at Ameren-CILCO and Ameren-IP. However, when recognizing that Ameren-CIPS has the highest tree density of the three Ameren-IL companies, and the 2006 circuits were the same ones that were trimmed in 2002 on the four-year cycle, the refusal rate per Ameren-CIPS customer shows an improving trend.

There also have been very few transmission system trim refusals. During the period 2002-2006, the highest number was 41 in 2005. The chart below shows the number of such refusals per 1,000 miles of transmission line.[270]

[267] Response to Data Request #58.
[268] Response to Data Request #508.
[269] Responses to Data Requests #6 and #56.
[270] Responses to Data Requests #7 and #280.

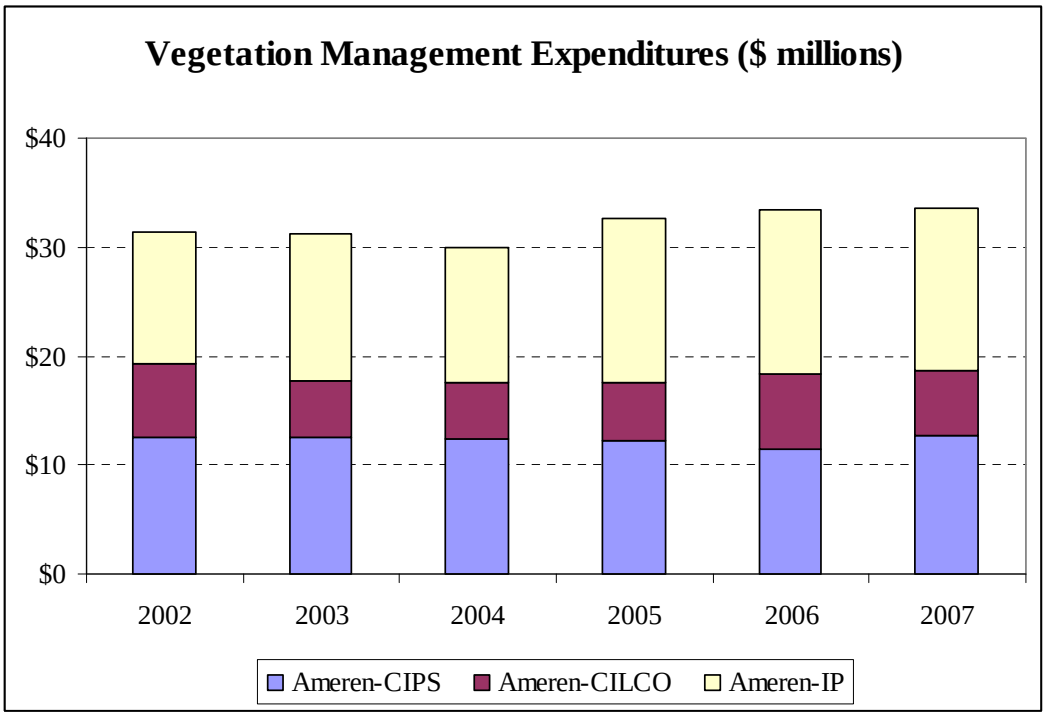


Ameren-CILCO has less than 350 miles of transmission system, and in 2005, the number of refusals it received was only four. However, the chart above shows a step increase in the refusals received on the Ameren-CIPS system in 2005 and 2006 compared to earlier years. Typically, transmission lines have been in place for a long period and have well established right-of-ways. Liberty would not expect to see this type of an increase unless some local event took place such as a new line or a line rebuild that did not have public support or a change in Ameren-IL personnel interfacing with customers.

f. Vegetation Management Expenditures

The success of a vegetation management program depends on consistent and adequate funding. Liberty reviewed the vegetation management funding of the Ameren-IL companies. Data reviewed included expenditures for normal distribution trimming and special expenditures for mid-cycle and "hot spot" trimming, transmission system, and budgeted and actual. The chart below provides a summary of total vegetation management expenditures for the years 2002 through 2006 and the budgeted expenditures for 2007.[271]

[271] Responses to Data Requests #54 and #55.



During the period shown in the chart above, Ameren-IL acquired Ameren-CILCO and Ameren-IP, and implemented new or revised elements of the vegetation management program such as the mid-cycle trim program, trimming distances, and agreements with vegetation management contractors. Total expenditures have remained relatively constant. The 2007 budget is only about 7 percent greater than the non-inflation adjusted expenditure level in 2002 and 2003. Recent increases in fuel costs will affect total expenditures if Ameren-IL maintains the amount of vegetation management work.

g. Liberty's Vegetation Management Inspections

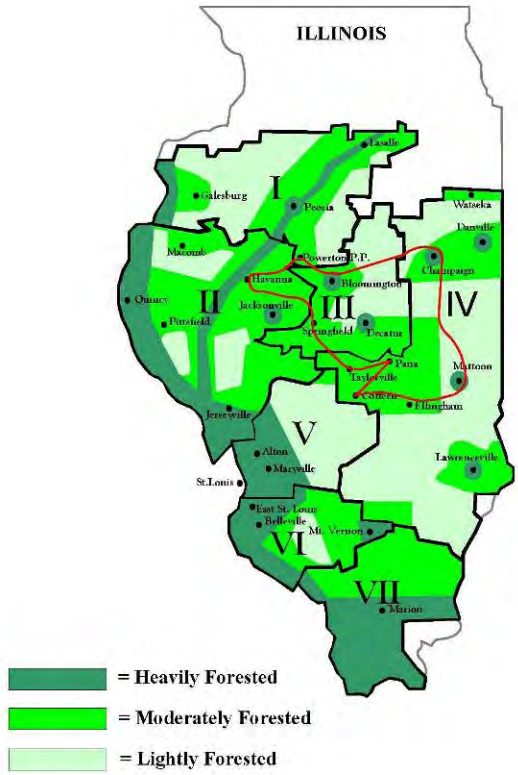
1. Inspection Routes

Liberty based the inspection route on viewing as much of the system as possible during daylight hours, capturing a variety of voltage levels, inspecting areas with the heaviest concentration of vegetation, and inspecting facilities from all three Ameren-IL companies.

Liberty conducted an aerial vegetation inspection of the transmission and sub-transmission system on November 28-29, 2007. The following describes the November 28, 2007, northern aerial route in terms of Ameren-IL substations:

> The inspection began in the Mattoon area and proceeded to Charleston Northeast, Kansas West, Murdock, Sidney, Mira, North Champaign, Leverett, Mahomet, the intersection of the Rising to Rantoul line and then to Rising, Latham to the so called Eiffel tower, Clinton, Brokaw, South Bloomington, Old Danvers, Lilly, Powerton, the intersection of the Tazewell to Mason line, Mason, New Holland, East Springfield, across country to Pawnee, Taylorville South, Pana North, Coffeen, Ramsey East, Holland Northwest, Neoga South, Mattoon West, and Charleston Northeast.

The map below shows the northern aerial route.[272]

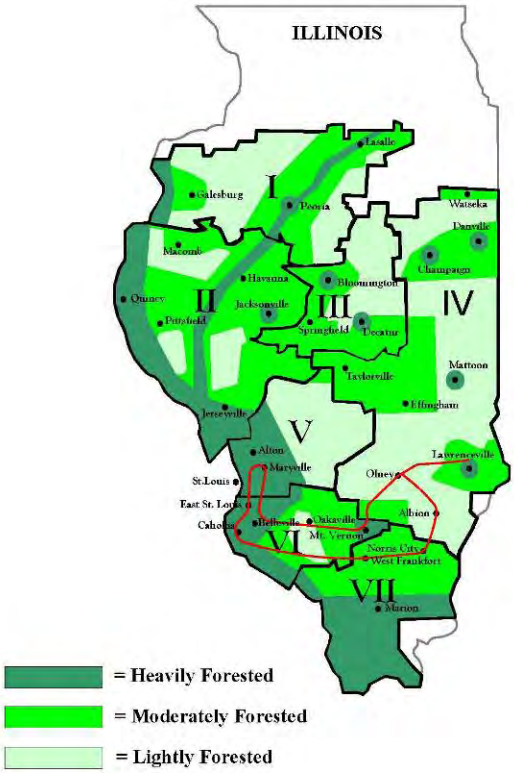


The following describes the November 29, 2007, southern aerial route in terms of Ameren-IL substations:

> Lawrenceville South, Olney North, the intersection of the Xenia to Newton line to Xenia, Mount Vernon West, Ashley, Turkey Hill, East Belleville, Porter Road, Lockman Road, Collinsville, Maryville, the intersection of the Cofeen to Stallings line to Stallings, Granite City, Venice, Cahokia, Coulterville, Pinckneyville, Saint Johns, East Belleville, West Frankfort, West Frankfort East, Norris City North, Crossville West, Albon South, Olney North, and Lawrenceville South.

[272] Response to Data Request #500.

The map below shows the southern aerial route.[273]



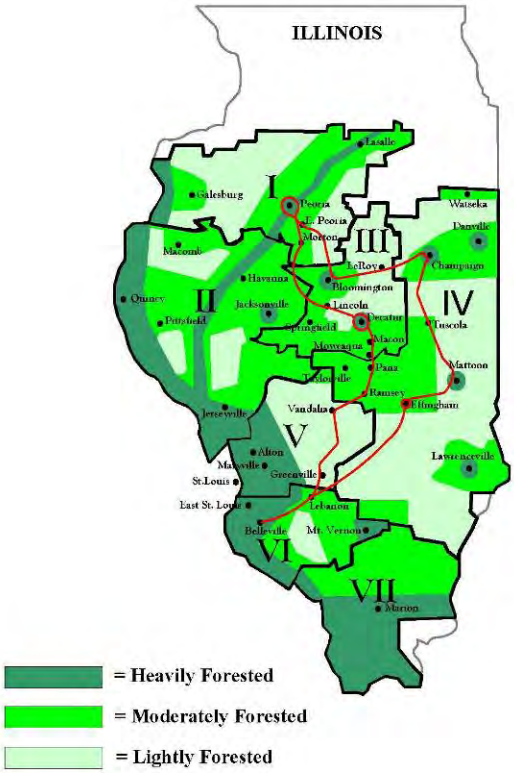
Liberty conducted distribution-system vegetation inspections during the weeks of December 17, 2007, and January 7, 2008.

The first week of inspections covered the eastern portion of Ameren-IL's service territory and the second week the western portion. This report refers to these two inspections as the eastern inspection loop and the western inspection loop, respectively.

The eastern inspection loop began in the town of Swansea and proceeded to Hamel, Litchfield, Springfield, West Springfield, Berlin, New Berlin, Jacksonville, Franklin, Quincy, Barry, Pittsfield, Winchester, White Hall, Carrollton, Jerseyville, Godfrey, Alton, Bethalto, Troy, O'Fallon, Okaville, Mt. Vernon, Marion, Energy, Carbondale, Murphysboro, Chester, and concluded back at Swansea.

[273] Response to Data Request #500.

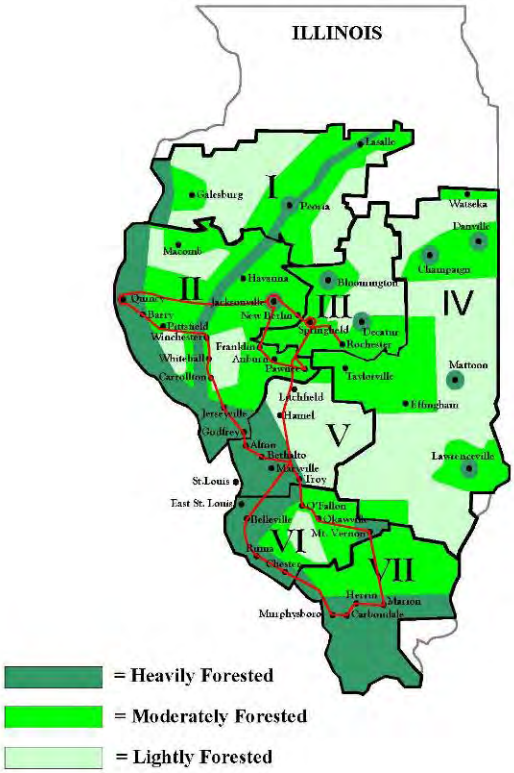
The map below shows the eastern distribution-system inspection route.[274]



The western inspection loop began in the town of Swansea and proceeded to Lebanon, Greenville, Vandalia, Ramsey, Pana, Assumption, Moweaqua, Macon, Decatur, Lincoln, Morton, Peoria, Bloomington, Le Roy, Champaign, Tuscola, Mattoon, Effingham, and concluded back at Swansea.

[274] Response to Data Request #501.

The map below shows the western distribution-system inspection route.[275]



2. *Inspection Results*

Transmission System

Liberty inspected a significant portion of the transmission system, and believes that the inspection results are representative of the entire transmission system. The table below shows the total number of Ameren-IL transmission miles and number of transmission miles Liberty inspected.

[275] Response to Data Request #501.

Transmission Mileage – Mileage and Percent Inspected by Voltage and Legacy Company[276]

Transmission Voltage Level	Ameren-CIPS Total Miles (Inspected)	Ameren-CILCO Total Miles (Inspected)	Ameren-IP Total Miles (Inspected)	Ameren-IL Total Miles (Inspected)	Percent Voltage Level Inspected
138,000-volt	1,737 (177)	284 (12)	1,348 (191)	3,369 (380)	11
161,000-volt	91 (0)	0	0	91 (0)	0
230,000-volt	137 (89)	0	0	137 (89)	65
345,000-volt	350 (116)	48 (0)	472 (172)	910 (288)	32
Totals	2,315 (382)	332 (12)	1,820 (363)	4,467 (757)	17

In addition to the transmission system mileage listed above, Liberty inspected 28 miles of sub-transmission lines that ran parallel to the transmission system and over 40 substations.

Overall, Liberty found that on the transmission system, Ameren-IL had the vegetation under reasonable control and that existing vegetation was the product of a coordinated program. All of the transmission substations were void of vegetation as required by Ameren-IL's substation vegetation-control requirements.[277] Liberty observed some vegetation-management program deficiencies, but none was significant. Liberty observed and documented numerous cases where the contractor should have removed yard trees[278] because of proximity to the transmission line, encroachments including new homes that were within the right-of-way, vegetation over guy wires, and cases where side clearances narrowed inwards towards the transmission line at the end of a wooded stretch.

Distribution System

Liberty inspected a representative and diverse portion of the distribution system, and believes that its observations are representative of the entire system. Liberty inspected over 2,000 miles of distribution (12,000 volts and 4,000 volts) lines and over 500 miles of sub-transmission (34,500 volts and 69,000 volts) lines.[279] Liberty also inspected more than 60 distribution substations for vegetation.

Liberty found that distribution substations were void of vegetation, as required by Ameren-IL's substation vegetation-control requirements.[280] In general and noting that observations differed somewhat by contractor area, Liberty observed that the distribution system had been trimmed according to Ameren-IL vegetation management specifications that existed when the contractor last performed maintenance trimming.[281] Liberty noted vegetation control problems related to the mid-cycle trimming program where trees that contractors should have removed but did not, and cases where the contractors did not perform required mid-cycle trimming. Liberty also observed inadequate back-lot horizontal trimming and trimming that did not comply with Ameren-IL

[276] Response to Data Request #387.
[277] Response to Data Request #284.
[278] A yard tree is a tree that is within the utility easement and is in the residence yard.
[279] Data Requests #530 and #531.
[280] Response to Data Request #285.
[281] Vegetation management specifications varied from two of the legacy company standards to Ameren standards to Ameren's latest standards and from Ameren standards to Ameren's latest standards within the last 48-month vegetation maintenance cycle.

specifications such as skipped areas and insufficient distance between vegetation and conductors.[282]

Ameren-IL's contractors and Ameren-IL vegetation management personnel perform a patrol of distribution circuits midway through the 48-month maintenance trimming cycle. They evaluate vegetation to determine if it will be problematic by the next scheduled tree trimming cycle. If so, they take action to prevent the vegetation interference. Ameren-IL has instructed the contractors that if the cost to remove the tree is less than three times the estimated cost to perform vegetation maintenance and property owner permission can be obtained, then the contractor should remove the tree. Ameren-IL has also instructed contractors to prioritize removals. Ameren-IL vegetation personnel instruct contractors to prioritize removals based upon the location of the tree with regard to construction type of 3-phase, 2-phase or single-phase. A higher priority is placed on trees located under 3-phase lines that typically provide service to a greater number of customers than single-phase or 2- phase sections of circuits. This guideline has been in use for some time and does not reflect recent economic shifts. The guideline also has a limited factor for reliability improvement captured in the evaluation. Improper evaluation may result in trees remaining that contractors should remove if the property owner gives permission.

Ameren-IL requires the vegetation contractors' general foreman to maintain a copy of a master circuit map for each circuit that has work in progress. The intent of this process is to ensure each general foreman tracks all completed work and notes any locations where work may have to be deferred because of traffic control or the need for high reach equipment, or rework. During its inspection of the distribution system, Liberty asked one of the general foremen if he had a copy of his master map for projects his crews were currently working. In this instance, the general foreman did not have his copy of the master map with him, but indicated he had left it in his office. Ameren-IL vegetation management should reinforce with contract supervision the need to have master circuit maps with them in the field to ensure timely up dates of completed and deferred work and documentation for any rework issues.

3. Conclusions

1. Transmission conductor-to-vegetation clearance requirements are improper and not functional for the vegetation management contractor. (Recommendation VI-32)

Ameren defines clearances between vegetation and the conductors of transmission lines. Transmission vegetation-management contractors do not have the capability to determine operating conditions of the transmission line on which they are working. Therefore, vegetation-management clearance requirements based on the operating condition of the line are not functional to the contractor and may lead to errors in permitted vegetation heights that could in turn result in an outage.

[282] Back lot construction is where the electrical facilities normally constructed on the street in front of residences are in the rear and is usually on the property line of two residences of adjoining streets. According to the response to Data Request #512, the trimming specifications for back lot construction are the same as on street facilities.

2. The mid-cycle trim program is in tension with the reliability improvement program to fuse all circuit taps. (Recommendation VI-33)

The mid-cycle patrol does not include fused single-phase and two-phase taps. As Ameren-IL completes its tap fusing program, it will conduct less mid-cycle trimming. This practice could permit outages to occur (even though affecting a smaller number of customers) that otherwise it would have prevented.

3. Vegetation management standards do not incorporate NESC Section 218.B requirements for infrastructure crossings. (Recommendation VI-34)

The NESC requires specific trimming requirements at line crossings, railroad crossings, and limited-access highway crossings. These requirements are stricter than most of Ameren-IL's vegetation management standards and are not included in the standards. Insufficient trimming at infrastructure crossings could result.

4. Vegetation management standards need a stronger climbing safety standard. (Recommendation VI-35)

Vegetation management standards and pruning standards allow some vegetation to remain within the trim zone and in proximity to the conductors. The vegetation that remains is generally main stem and wood that is in excess of 4 inches in diameter. If people could climb these trees, good utility practice requires extra safety measures. Ameren-IL's vegetation management standards do not address this issue completely.

5. Vegetation management standards and practices are fundamentally sound, but there are improvements that Ameren-IL can make. (Recommendation VI-36)

While conducting its vegetation management inspections, Liberty observed matters for which Ameren-IL could refine its vegetation management program to improve efficiency, understanding, or processes.

6. Ameren-IL has undertaken several initiatives to improve the vegetation management program.

It is apparent that Ameren-IL continues to make improvements to its vegetation management program and practices.

7. Ameren-IL's distribution vegetation-management workforce is not adequate to conduct a reasonable amount of inspections of contractor work. (Recommendation VI-37)

Liberty's inspections revealed that some contractor work is unsatisfactory. Ameren-IL is required under its program to inspect a minimum of 1 percent of the contractor work but typically inspects more. Good utility practice requires that Ameren-IL evaluate and track the various contractors and crews to prevent workmanship issues from causing unnecessary customer outages.

8. A sharp increase in transmission vegetation rework for reliability-based items occurred in 2007. (Recommendation VI-38)

The number of contractor and Ameren-IL rework for reliability-based items on the transmission system for the first nine months of 2007 was four times the number of the rework items for the previous three years combined.

9. Distribution vegetation-management contractor rework is excessive and not being corrected. (Recommendations VI-37 and VI-39)

The distribution vegetation-management contractors are required to submit 10 percent of their work for audit and can perform rework before doing so. The number of contractor-rework items before submittal reflects on the completeness of their work. Ameren-IL inspects a minimum of 10 percent of the work submitted and finds that significant additional rework is required. This indicates that the contractors are not addressing required rework on the system.

10. Ameren-IL has acquired little additional trimming easements for distribution and sub-transmission facilities located entirely or partially in the roadway. (Recommendations VI-40 and VI-41)

Ameren-IL legacy companies did not put a priority on trimming easements for distribution and sub-transmission facilities located partially or entirely in the roadway. Although Ameren-IL has to date met its trimming requirements in most instances, the establishment of new vegetation side clearance requirements may result in increased refusals and less than desired clearance to vegetation leading to outages.

11. Ameren-IL has received a relatively small number of customer refusals to trim. However, the distribution refusal rate at Ameren-CIPS is much higher than at the other two companies. Transmission refusals also increased at Ameren-CIPS in 2005 and 2006. (Recommendation VI-42)

Customer refusal rates for distribution trimming have been higher at Ameren-CIPS. In addition, the transmission refusals at Ameren-CIPS doubled in 2005 and 2006 compared to earlier years. Finally, after an initial meeting, Ameren-IL does not revisit customers who refused trimming prior to the next trim cycle.

12. Vegetation management at all Ameren-IL substations is adequate.

Liberty inspected over 100 Ameren-IL transmission, sub-transmission, and distribution substations for vegetation conditions while performing its transmission and distribution vegetation management inspections. Liberty found essentially no vegetation problems at substations.

13. Contractors are not fully implementing transmission right-of-way vegetation-management standards in the field. (Recommendations VI-43 and VI-44)

During its transmission vegetation management inspection, Liberty observed that Ameren-IL needs to be alert for and address problems related to right-of-way side clearances, vegetation on

transmission-structure guy wires, yard trees, and encroachments. These matters could affect the reliable operation of the transmission system.

14. Ameren-IL is not fully implementing distribution vegetation-management standards. (Recommendations VI-45 and VI-46)

Liberty's inspections found evidence in some locations that Ameren-IL's contractors are not trimming away enough vegetation in back-lot locations to comply with Ameren-IL's horizontal trimming specifications. Ameren-IL's back-lot trimming specifications are the same as those for facilities that are located on the street. Not trimming to specifications increases customer outages.

Liberty found that contractors did not remove or trim all trees that should have been part of the mid-cycle trimming program. Ameren-IL's removal guidelines may not have been followed during mid-cycle trimming. The economic guideline for tree removal provided by Ameren-IL is not up to date and does not reflect current economic conditions, but provides limited consideration for reliability improvement into the removal evaluation. Not trimming these trees as part of the mid-cycle program may cause additional customer outages.

There was evidence during distribution circuit inspections that contractors may not be maintaining information on master copies of circuit maps as Ameren-IL requires. A contractor generally cannot start at one end of a circuit and trim it to completion. Many things such as traffic control, need for high reach equipment, and the daily work times can fragment the flow of work. Ameren-IL requires a contractor to keep master circuit maps updated to ensure that it trims the total circuit. Not keeping track of daily work causes skipped sections of a circuit, interference with power lines by trees, and this results in unnecessary outages.

4. Recommendations

VI-32 Develop allowed transmission vegetation heights from the ground.

Operating conditions of a transmission line can be different for each line depending when it was constructed, and can vary on the same line during the day during normal operating conditions. Furthermore, the line could sag to its minimum allowed NESC conductor clearance limit during system contingency events. Ameren-IL should develop allowed vegetation heights measured from the ground and take into consideration all sag variables. Ameren-IL should implement this recommendation within six months of the date of this report.

VI-33 Include all taps in the mid-cycle patrol and trimming program.

When Ameren-IL adds fuses to a distribution tap line, it removes the line from the mid-cycle patrol. This could allow vegetation-caused outages to occur that otherwise it would have prevented. Ameren-IL should change its mid-cycle patrol requirements to include all taps within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-34 Add Section 218.B of the NESC to all voltage levels of the vegetation management standards that allow overhang.

Ameren-IL's standards allow some vegetation overhang of conductors at the lower voltage levels. Section 218.B of the NESC does not allow vegetation overhang at infrastructure crossings and one span on each side of crossings. Ameren-IL should include this requirement in its vegetation management standards. Ameren-IL should implement this recommendation within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-35 Strengthen tree-climbing requirement to vegetation management standards.

Ameren-IL should strengthen the provision in its vegetation management standards that addresses the ability of the public to climb trees with vegetation within the trim zone. An example would be that if vegetation remains within the trim zone and is within 3 feet of a primary conductor, ensure that tree climbing is not possible by removing all branches 10 feet from the ground level. Ameren-IL should implement this recommendation within three months of the date of this report.

VI-36 Evaluate for merit several possible refinements to the vegetation management program to improve efficiency, understanding, or processes.

Ameren-IL should evaluate the items listed below for potential refinements to its vegetation management program. Ameren-IL should document its evaluation and any implementation plans for each item within nine months of the date of this report.

- Evaluate the viability of an enhanced trimming specification for use in urban areas where No. 6 or No. 8 copper wire is in use and vegetation is problematic.
- Evaluate the use of the current GPS system in identifying and tracking trimming restrictions and refusals, mid-cycle problem trees, and take down trees.
- Prioritize mid-cycle problem trees for take down and danger trees by species, growth rate, tree condition, and tree location on the circuit.
- Provide a requirement that once tree shelves and side clearances have been established, those trees are to be maintained to those locations even if pruning standards would allow some vegetation to remain.
- Include pruning diagrams as examples of what finished vegetation work should look like in relation to the various line configurations and voltages and supply them to contractors along with associated training.
- Provide trimming contractors with more training and information so that they can identify and report non-vegetation corrective maintenance items beyond obvious deficiencies.

VI-37 Increase vegetation management staffing to permit inspection 100 percent of contractor work.

Ameren-IL should add personnel to allow for complete inspection of all contractor distribution work and management oversight of both contractors and Ameren-IL inspectors. To accomplish this, Liberty recommends that Ameren-IL add one person to each division in the distribution area

and one person attached to the vegetation management superintendent in Illinois. Ameren-IL should propose a staffing increase plan within six months of the date of this report and complete implementation of this recommendation within two years of the date of this report.

VI-38 Determine and correct the cause for the increase in transmission vegetation rework in 2007.

If the increase in transmission vegetation rework identified by the audit process is indicative of the 2007 work performed by the contractors, something has fundamentally changed from the prior years. Ameren-IL should determine the cause for the increase in transmission vegetation rework and take the appropriate corrective actions to prevent unnecessary transmission line operations. Ameren-IL should complete this evaluation within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-39 Inspect 100 percent of distribution system vegetation-management contractor's work.

Ameren-IL finds rework on the contractor submitted work that it audits. This rework is in addition to the rework performed by the contractor prior to submitting its work for audit. If representative of all work performed, the inspections suggest that a significant number of vegetation issues remain on the system. Only inspecting work submitted by the contractor does not represent good auditing practice. Ameren-IL should inspect 100 percent of the distribution vegetation-management contractors' work with Ameren-IL trained personnel. Ameren-IL should begin increasing the percentage inspected within six months of the date of this report and complete implementation consistent with Recommendation VI-37 above.

In its comments on the draft report, Ameren-IL proposed inspecting more of the completed work. Ameren-IL will likely not have the staff to begin inspecting 100 percent of the contractor work within six months, and therefore inspecting more percent of all contractor work is a step in the right direction.

VI-40 Continue to pursue standard easement widths for distribution and sub-transmission voltage levels for facilities in and out of the roadway.

Ameren-IL has drafted standard easement widths. It is not clear if the proposed widths are applicable to facilities that are in the roadway. The proposed easement widths do not always align with the new vegetation side-clearance requirements put into effect in May 2007. Ameren-IL should continue to pursue standard easement widths for distribution and sub-transmission facilities that are consistent with Ameren-IL's vegetation side-clearance requirements and applicable facilities located on or off the roadway. Ameren-IL should complete this work within six months of the date of this report.

VI-41 Acquire required trimming easements for distribution and sub-transmission facilities on a forward going basis.

Ameren-IL has not had a large problem with attaining permission to perform required trimming. Ameren-IL also increased its 6- 8-foot side trimming requirements to 10 feet in May 2007, which may increase customer refusals in the future. For new lines and on a going forward basis, Ameren-IL should secure adequate easements when possible that allow for trimming in accordance with its vegetation management standards for facilities where the easement would extend entirely or partially off the roadway. Ameren-IL should implement this practice within six months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-42 Improve customer trim refusal practices.

Ameren-IL should take the following measures related to customer trim refusals:

1. Increase customer awareness of importance of tree trimming at Ameren-CIPS. In addition to its normal identification and customer relations program, Ameren-IL should increase efforts to alleviate customer concerns with tree trimming at Ameren-CIPS.

2. Revisit distribution customer refusals prior to the next trim cycle at all Ameren-IL companies. Ameren-IL (and not the contractor) should revisit distribution-trimming refusals prior to the next trim cycle to gain a better understanding of customers' concerns and to at least perform trimming in the public way.

3. Determine cause(s) for the increase in transmission trimming refusals at Ameren-CIPS and take appropriate actions.

Ameren-IL should complete the implementation of this recommendation within one year of the date of this report.

VI-43 Reinforce Ameren-IL vegetation standards with transmission vegetation contractors.

Contractors remove vegetation from the rights-of-way with a variety of methods to meet Ameren-IL standards. One of those standards is that vegetation above transmission structure guy wires is to be removed to prevent line damage should the vegetation fall. Liberty noted many instances where this removal practice was not followed.

Right-of-way side clearances were also noted to flare inward at the end of a wooded stretch. This vegetation can quickly grow to interfere with lines that are in Ameren-IL's narrow rights-of-ways in a short period.

Ameren-IL should demonstrate that it has reinforced correction of these issues with its transmission vegetation contractors within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-44 Remove and prevent right-of-way obstacles from occurring.

Liberty inspections noted many instances of yard trees and customer encroachments that could interfere with reliable operation of transmission facilities. Vegetation management personnel are responsible for identifying and correcting these conditions where possible. Ameren-IL should identify, record, track, and correct all such conditions and easement violations. This should be an ongoing process to capture new conditions. Ameren-IL personnel should conduct this process because they are better equipped to make business decisions and decisions that affect system reliability. Ameren-IL should begin this process within three months of the date of this report and complete corrective actions within three years.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-45 Trim back-lot facilities to vegetation management horizontal specifications.

Back-lot facilities had insufficient horizontal trimming that did not meet Ameren-IL's specifications. The nature of back-lot construction generates considerable customer issues with regard to trimming because the vegetation to be removed is often property boundaries providing customer privacy. Not maintaining horizontal specifications increases customer outages. Outages on these facilities are also usually longer due to their inaccessibility. Ameren-IL should begin horizontal trimming back-lot construction to their specification within three months of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-46 Revaluate the removal of mid-cycle trees requiring trimming.

Ameren-IL vegetation supervisors and contractors are responsible for identifying mid-cycle problem trees and evaluating the possible need of removing these trees. Ameren-IL should re-evaluate its current guidelines taking into consideration the current economic considerations and the value of prevention of customer outages. Ameren-IL personnel and the contractor should work in a collaborative effort to make the tree removal evaluations. Ameren-IL should reinforce with contractors that removal evaluations will be made based on sound business reasons as well as potential for improvement to the reliability of the system. Ameren-IL should begin this process within three months of the date of this report and continue it on an ongoing basis.

VI-47 Enforce contractor record keeping requirements.

There was evidence during distribution inspections that some contractor supervision may not be keeping master copies of circuit maps updated in a timely manner. A contractor cannot keep track of completed work, deferred work because of traffic control or the need for high reach equipment, or rework without these documents. Skipped areas of trimming can result in unnecessary customer outages. Ameren-IL should take steps to ensure that contractors keep required daily work records within three months of the date of this report and continue it on an ongoing basis.

In its comments on the draft report, Ameren-IL accepted this recommendation.

J. The Effects of Maintenance and Inspections on the 2006 Storms

1. Introduction

This section addresses the question of whether Ameren-IL's maintenance and inspection practices or system conditions contributed to the negative effects of the 2006 storms. More specifically, this section addresses whether the omissions or weaknesses in Ameren-IL's maintenance and inspection practices, or deteriorated system conditions, identified in the above sections of this chapter made worse the consequences of the 2006 storms. This section uses information about the storms reported in Chapter II of this report, and supplements the findings in Chapter V, section C.5, regarding the effects of planning, design, construction, and protection on the 2006 storms.

Bad weather like that which occurred in Ameren-IL's service territory in 2006 will cause interruptions to customers' electric service even on the best-maintained electric delivery systems. Trees can break or become uprooted and fall on electric lines and poles. Good vegetation management programs do not include the removal of all trees that could affect overhead electric systems. Loadings from wind and ice can exceed even conservative design criteria. Equipment malfunctions can occur even when tests and inspections show that the equipment is operable.

It is also clear, however, that weaknesses in maintenance and inspection practices can make a storm's service interruptions more extensive and can lengthen restoration times. Poles can rot or become infested, lose strength, and easily fall because of only moderate wind, ice, or tree limbs. Tree trimming can fall behind schedule or not be sufficient to prevent limbs from falling on electric lines. Inadequate or no equipment testing and protection can mask inoperable equipment. Poor conditions such as broken cross-arms may not be a problem in good weather but cause outages during severe weather. Poor preventive maintenance such as the failure to lubricate moving parts or test the settings on protective relays has the potential to exacerbate the effects of storms.

2. Findings and Analysis

a. Transmission System

Transmission system outages did not contribute materially to customer interruptions during the 2006 storms.[283]

Liberty found weaknesses in Ameren-IL's transmission-line inspection practices.[284] These weaknesses dealt with the lack of periodic maintenance on transmission line switches, the method used for aerial inspections, and record keeping. Regarding the first of these, Liberty found no evidence that the lack of maintenance on transmission line switches caused problems during the storms.

[283] Refer to Chapter II, and Chapter V section V.C.5.c.
[284] Refer to section VI.E above.

During the July 2006 storms, broken shield wires falling onto energized conductors caused two of the 138,000-volt line outages. During the November-December 2006 storm, Ameren-IL experienced sustained outages on nine 138,000-volt transmission lines and one 345,000-volt line. Broken shield wires or shield-wire hardware caused five of the 138,000-volt line outages and the one 345,000-volt line outage. Ameren Services' use of an airplane, rather than a helicopter, for its periodic transmission line inspections may have prevented inspectors from observing the small, but critical, burn marks and other defects on shield wires and hardware that resulted in these eight transmission line outages. In 2008, Ameren Services reported that it would use helicopters to supplement the inspections of transmission lines conducted from an airplane.[285]

Ameren Services also reported that it determined that small lightning burns caused shield wires to corrode, to break, and to fall into energized conductors. Ameren Services is developing a method to detect the burned spots, and will develop a program to repair or replace damaged shield wire.[286]

The criticism of transmission-line inspection record keeping dealt with Ameren-IL's failure to maintain records of completed aerial inspections and repairs. However, an administrative error with pole inspection records resulted in two broken poles on an H-frame structure causing one of the 138,000-volt line outages during the July 2006 storm. Ameren-IL should have replaced these poles in 2004 because inspectors identified them as "priority-reject" poles in April 2004 by Illinois Power's pole inspectors, prior to its merger with Ameren-IL.[287] During Illinois Power's transition to Ameren-IL, personnel overlooked the replacement of these two poles on this transmission line.[288]

Despite this isolated problem, Liberty found that Ameren Services conducted transmission-line pole inspections consistent with its program and good utility practices. A contractor performed ground-line transmission pole inspections on a cycle of 10 percent per year for aged poles. Liberty concluded that the condition of Ameren-IL's transmission system poles was acceptable.

Liberty conducted an aerial inspection of transmission lines using a helicopter.[289] Liberty did not observe any specific systemic condition issues, although many of the transmission poles were aged. The transmission system was in acceptable condition and adequately maintained.

Liberty found no indication that trees caused any of the transmission system outages during the 2006 storms. Moreover, Liberty's inspections determined that Ameren-IL's transmission system had vegetation that was under reasonable control and that appeared to be the product of a coordinated program. The vegetation program deficiencies observed by Liberty were the type of deficiencies one would expect to find in a reasonably maintained power system and no evidence of serious vegetation-management plan deficiencies.

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[285] Interview #156, April 4, 2008.
[286] Interview #156, April 4, 2008.
[287] Response to Data Request #176.
[288] Interview #156, April 4, 2008.
[289] Liberty inspections, November 28-29, 2007.

In the fall of 2006, Ameren-IL implemented a program for replacing structure cross-arm braces on two of its 345,000-volt lines. Some of the braces on these lines failed in the past. Ameren-IL planned to complete this program in 2008.[290] Although these braces did not contribute to the damage resulting to the 2006 storms, replacing the braces will likely reduce transmission outages caused by cross arm brace failures on these lines if storms expose these lines to severe wind or ice loads in the future.

In summary, Ameren failed to detect shield-wire problems and to replace two weak transmission system poles. However, transmission system outages did not contribute materially to customer interruptions, and Liberty found that Ameren-IL's transmission system maintenance and inspection practices and the condition of the transmission system did not contribute to the effects of the 2006 storms.

b. Sub-Transmission System

As noted in Chapter II of this report, outages on the sub-transmission system caused more customer interruptions than did outages on the transmission system, but not nearly as many as the interruptions caused by damage to the distribution system. For example, by the end of the day on July 19, 2006, the storm had interrupted 225,000 Ameren-IL customers, and approximately 53,000 customer interruptions were attributable to sub-transmission facilities.[291]

Liberty concluded that Ameren-IL's vegetation management practices on the sub-transmission system were sound, but that narrow right-of-ways made maintaining sufficient clearance to trees difficult.[292] The lines on right-of-ways have much less side clearance to vegetation than transmission lines.[293] In addition, many sub-transmission lines are not on right-of-ways, but rather on city streets in close proximity to vegetation. Liberty found that vegetation might have caused about 60 percent of the 48 sub-transmission outages during the July storm, and over 50 percent of the 68 sub-transmission outages in the November/December 2006 storm.[294]

Ameren-IP and Ameren-CILCO had good sub-transmission ground-line pole-inspection methods, while Ameren-CIPS did not have good methods. However, for all of the companies, the number of poles inspected on the sub-transmission system was reasonable and the condition of sub-transmission system poles was acceptable.[295] While its accuracy is suspect, Outage Analysis System (OAS) data contained only four sub-transmission system pole-replacement jobs in each of the two major storms in 2006.[296]

Liberty concluded that weaknesses or omissions unique to Ameren-IL's sub-transmission system maintenance and inspection practices and the condition of the sub-transmission system, aside from the proximity to vegetation, did not contribute materially to the effects of the 2006 storms.

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[290] Response to Data Request #553.
[291] Response to Data Request #265.
[292] Refer to section VI.I above.
[293] Response to Data Request #45.
[294] Refer to Chapter V, section V.C.5.c.
[295] Refer to section VI.H.3 above.
[296] Response to DR #138.

Liberty discusses aspects of the sub-transmission system that it could not separate from the distribution system in the section immediately below.

c. Distribution System

Damage to the distribution system, including service lines to customers, caused most of the interruptions during the 2006 storms.[297]

To assess whether and how the distribution system maintenance and inspection practices or the condition of the distribution system contributed to the effects of the storms, Liberty determined whether there were correlations between weaknesses or omissions in those practices with storm damage and reported outage causes. The weaknesses most likely to show such correlations were:

- Ameren-IL did not regularly inspect distribution poles
- Ameren-IL did not retain records to show that it had repaired deficiencies found in circuit patrol inspections
- The condition of tap (or branch) distribution lines was not acceptable
- Tree trimming in "back lot" areas did not always meet vegetation management standards
- Some distribution circuits lacked adequate lightning protection.

Several factors contributed to making these correlations difficult. As examples, Ameren-IL did not examine poles that failed during the storms and the Outage Analysis System (OAS) did not include a specific code for lightning nor did it uniformly include specific explanations when personnel used the "equipment malfunction" cause code. One-third of the pole and wire replacement jobs for the July storms, and one-quarter for the November-December storm, were either not cause-coded, or coded as unknown.[298] Up to one-quarter of the cause codes for wire replacement jobs during the storms were "equipment malfunctions."[299] Liberty could not discern from the OAS if a wire broke, or "malfunctioned," because a tree fell on it or failed for some other reason. More generally, the outage cause codes entered in the OAS during these major storms are suspect because some personnel were not sufficiently familiar with the system, and all personnel had a higher priority on restoring power rather than investigating and making sure that cause-codes were correct.

Ameren-IL replaced many poles in the storm restorations. It replaced 848 poles resulting from the July storms and 1,359 poles resulting from the November-December storm. Uprooted or broken trees that fall onto poles can easily bring down or damage poles to the extent that they require replacement. The Outage Analysis System (OAS) cause codes for pole replacement jobs indicated that between one-quarter and one-third related to trees.[300] Liberty determined that the environmental conditions during the July storms might have exceeded design criteria in some locations, but that in the winter storm, environmental conditions did not exceed design criteria.[301]

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[297] Refer to Chapter II.
[298] Responses to Data Requests #8, #123, #137, and #138.
[299] Responses to Data Requests #8, #123, #137, and #138.
[300] Responses to Data Requests #8, #123, #137, and #138.
[301] Refer to Chapter V section V.C.5.

While unavoidable tree uprooting caused some of the pole failures, it is likely that vegetation management deficiencies caused others.[302] Ameren-IL linemen, who had been involved with repairs conducted during and after the storms, indicated that trees, particularly trees and limbs from above and outside the trim zone, caused a lot of the pole damage.[303]

However, Liberty concluded that many of the pole failures were likely the result of distribution poles that were below National Electrical Safety Code (NESC) strength requirements. As reported in section VI.E above, none of the Ameren-IL companies regularly inspected distribution poles. The number of these poles inspected in recent years was a very small percentage of the total. It is a known fact that some poles will rot, decay, or become damaged over time. Therefore, high winds, loading from ice, and downed small trees or limbs can bring down these weakened poles in a storm. There is no good way to estimate the number of such failures because Ameren-IL did not have inspection records and did not perform any forensic examination of failed poles.

Service wires[304] broken or pulled from houses by fallen trees and limbs severely affected the number of interruptions and restoration of customers during the July and the November-December storms. This result was largely because Ameren-IL's vegetation management practices for the distribution system focuses on circuit primaries and secondaries located along the streets or in right-of-ways in the rear of customer's property. Ameren typically does not perform vegetation trimming along service drop lines.[305] Liberty found this Ameren-IL practice to be appropriate. Utilities typically do not trim, and are not responsible for trimming, along service drop lines.

Liberty inspected Ameren-IL's distribution system in late 2007. There is no way to know for certain the physical condition of the system at the time of the storms because Ameren-IL did not retain records to show that it had repaired deficiencies found in circuit patrol inspections. However, aside from the major repairs performed after the storms, the condition at the time of the storm was likely similar to that which Liberty found. As discussed in section VI.H above, Liberty found that the overall condition of Ameren-IL's system was reasonably good, but that the condition of branch (or tap) lines off main distribution lines was not good. This included vegetation management problems, decayed or split pole tops, blown lightning arresters, and broken cross arms or braces. Liberty concluded that it is likely that such conditions contributed to the effects of the storms, but existing information does not permit making a reasonable estimate of that contribution.

The July storms came with significant lightning activity.[306] The Outage Analysis System contained a prevalent weather description of thunderstorms for the July storms but did not record lightning specifically. However, as reported in section VI.H above, Liberty's inspections found weaknesses in the lightning protection Ameren-IL provided to the distribution system.

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[302] Refer to section VI.I, Vegetation Management, above.
[303] Interviews Nos. 30 through 36, October 30, 2007 through December 5, 2007.
[304] Service wires are the overhead wires from Ameren-IL transformer poles to house-mounted meter bases.
[305] Responses to Data Requests #251 and #522. Utilities typically do not trim, and are not responsible for trimming, along service drop lines.
[306] Refer to Chapter II section II.D.1.

Liberty concluded that Ameren-IL's failure to inspect distribution poles, the physical condition of distribution-system tap lines, vegetation management on parts of the distribution system, and the lack of lightning protection on the distribution system all contributed to the consequences of the 2006 storms.

d. Substations

During the July storms, substation outages caused about 7 percent of the total customer interruptions, while in the November-December storm, substation outages caused less than 1 percent of all customer interruptions.[307]

Problems at substations caused three significant transmission-line outages during the 2006 storms.[308] In July, a lightning-damaged 138,000-volt switch at one substation caused the outage of a municipal electric company and a 4,000-volt regulator at another substation failed causing a sustained customer outage. In December, during the ice storm, a 34,500-volt circuit breaker failed to open, causing a sub-transmission transformer failure and backup protection to de-energize a 138,000-volt transmission line, resulting in an outage for a rural electric company. This was the only substation equipment malfunction reported for the November-December storm. Ameren-IL could not report the degree to which substation equipment malfunctions and failures contributed to the outages during the July storms.[309] However, a significant number of substation equipment malfunctions or failures occurred during the July wind and lightning storm, including:[310]

- 1 transmission circuit breaker
- 5 sub-transmission circuit breakers
- 10 distribution circuit breakers or circuit reclosers
- 1 transmission switch
- 1 transmission, 2 sub-transmission, and 1 distribution lightning arrester
- 1 sub-transmission potential transformer
- 2 distribution voltage regulators
- 1 transformer that supplied substation control power

Trees and limbs blown into substations during the July storms damaged one power transformer and one transformer that provided power for other substation equipment.

Tripping and closing component malfunctions caused most of the circuit breaker problems. The many circuit breaker malfunctions or failures that occurred during the storms suggest weaknesses in Ameren-IL's substation circuit breaker maintenance practices. Except for the tree-caused damage, Ameren-IL did not know the causes of the other equipment failures. Liberty believes that lightning was likely the cause of many. These failures point to the need for improved lightning protection.

[307] Responses to Data Requests #265 and #266.
[308] Response to Data Request #139.
[309] Response to Data Request #794.
[310] Response to Data Request #794.

Liberty found that Ameren-IL's substation maintenance programs were appropriate, but that its substation inspections were inconsistent, that its substation repair and maintenance recordkeeping were not complete, and that some poor substation conditions existed. Other than the need for more lightning protection on some distribution substations, the substation deficiencies observed during Liberty's inspections (*e.g.*, low oil levels, oil leaks, and poor paint conditions) would not have caused the storm effects to be more severe. However, the circuit breaker malfunctions or failures occurring during the storms point to deficiencies in Ameren-IL's circuit breaker maintenance practices. These deficiencies could be inadequate lubrication, operation verification tests, or trip timing tests. This number of circuit breaker malfunctions should not have occurred if circuit breaker maintenance practices had been consistent with the programs.

3. Conclusions

1. Ameren-IL's transmission system maintenance and inspection practices and the condition of the transmission system did not contribute to the effects of the 2006 storms. (Recommendation VI-48)

Transmission system outages did not contribute materially to customer interruptions during the 2006 storms. Moreover, Liberty found that, with some exceptions, Ameren-IL's maintenance and inspections of the transmission system were reasonable. Detailed aerial inspections may have detected shield wire deficiencies that caused some problems during the storms.

2. Weaknesses or omissions unique to Ameren-IL's sub-transmission system maintenance and inspection practices and the condition of the sub-transmission system did not contribute materially to the effects of the 2006 storms.

Ameren-IL had reasonable sub-transmission pole-inspection practices and the number of recorded sub-transmission pole-replacement jobs was small. Vegetation caused most of the sub-transmission outages, and Liberty observed limited vegetation clearances on some sub-transmission lines.

3. Ameren-IL's failure to test the strength of, and replace as necessary, distribution system poles contributed to the negative effects of the 2006 storms. (See Recommendation VI-10 in section VI.E above.)

In its review of distribution maintenance, Liberty concluded that the Ameren-IL companies did not have good distribution-pole inspection programs. Although tree interference caused many of the problems, the significant number of broken distribution poles indicated that weak distribution poles contributed to the storm damage.

4. The physical condition of distribution-system tap lines contributed to the negative effects of the 2006 storms. (See Recommendation VI-27 in section VI.H above)

During inspections conducted in 2007, Liberty found that some distribution tap lines were susceptible to vegetation interference and that some tap lines were under-maintained. Therefore,

it is likely that the physical condition of distribution-system tap lines contributed to the negative effects of the 2006 storms.

5. Inadequate lightning protection on the distribution system contributed to the negative effects of the July 2006 storm. (See Recommendations VI-26 and VI-29 in section VI.H above)

Ameren-IL did not include lightning as a cause-code for distribution outages. This prevented quantification of lightning-caused interruptions and damage. However, based on Liberty's finding that Ameren-IL's distribution circuits had lightning deficiencies and because thunderstorms were the indicated weather code for numerous July storm repair jobs, it is likely that inadequate lightning protection contributed to the interruptions.

6. Inadequate maintenance of substation circuit breakers contributed to the negative effects of the 2006 storms. (Recommendation VI-49)

Substation circuit breaker problems contributed to the negative affects of the storms. One transmission, six sub-transmission, and ten distribution circuit breakers or reclosers failed or malfunctioned during the storms, and some relay schemes malfunctioned because some circuit breakers tripped too slowly. These malfunctions should not have occurred if Ameren-IL had inspected, tested, lubricated, adjusted, and relay-operated circuit breakers within timeframes outlined in Ameren-IL's substation and relay maintenance programs. Ameren-IL's maintenance programs for circuit breakers were acceptable, but records did not show that Ameren-IL actually completed the inspections and tests on the schedules outlined in those programs.

4. Recommendations

VI-48 Develop a program to identify and repair or replace lightning-damaged shield wire.

Ameren-IL should assure that its program to identify and repair or replace lightning-caused damage to its aged, Copperweld® shield wire on its transmission lines would effectively minimize outages caused by breakage during storms. Shield wire breakage is a common cause of electric utility transmission outages. Ameren reported that it determined that small lightning burns caused shield wires to corrode, to break, and to fall into energized conductors. It reported that it is developing a method to detect the burned spots, and will develop a program to repair or replace damaged shield wire. Within three months of the date of this report, Ameren-IL should document its method and program for identifying burn spots and repairing or replacing transmission shield wires. The program should define a schedule for repairs.

In its comments on the draft report, Ameren-IL accepted this recommendation.

VI-49 Intensify substation circuit breaker maintenance.

Ameren-IL should ensure that its substation circuit-breaker maintenance practices meet scope and cycle-lengths in its written programs. Those programs cover all transmission, sub-transmission, and distribution circuit breakers. Although the maintenance varies depending on breaker type, typical 2- and 4-year maintenance includes inspecting, lubricating, testing, and

operating the breakers from relays. Ameren-IL should document that it complied with recommendation within one year of the date of this report.

In its comments on the draft report, Ameren-IL accepted this recommendation, noting however that it may require additional staffing.