ATTACHMENT B

EPRI

Power Delivery Reliability Initiative

Distribution Program

Commonwealth Edison Summary Report

AG 0001102

Power Delivery Reliability Initiative

Distribution Program

Commonwealth Edison Summary Report

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AG 0001105

FORWARD

The information contained in this report reflects the condition of the Commonwealth Edison Company ("ComEd") system at the time of the Illinois Commerce Commission ("ICC") report investigation. It should be noted that ComEd has taken substantial steps since this time to revamp its management, engineering and maintenance practices to significantly improve the reliability of its power deliver system and avoid similar problems in the future.

Significant changes in staffing, practices and processes have been implemented to promote increased accountability and ComEd has shifted from central to regional management. In addition, ComEd has reorganized its distribution group to sharpen its focus on customer service, energy services and public affairs.

Since launching a comprehensive improvement plan in mid-August 1999, ComEd has:

- Completed over 33,000 pole inspections;
- Repaired over 700 of its worst-performing circuits;
- Performed extensive maintenance of protective relays and controls;
- Inspected 5,700 manholes;
- Installed nearly six million feet of new cable;
- Increased pole installation and replacement by 20 percent;
- Installed state-of-the-art protection and monitoring equipment for five 34kVswitches within the City of Chicago;
- *Exceeded its schedule for achieving a four-year tree-trimming cycle;*
- *Developed a comprehensive two-year inspection and repair program of the nearly 4,800 feeders in its system ;*
- *Identified over 700 system reinforcement projects of which a large portion are planned to be complete before this summer*

ComEd has appointed new vice presidents for regional distribution operations, supply chain management, projects and contracts as well as new senior managers for vegetation management, substation management and distribution dispatch management since last summer.

CONTENTS

Section 1 - Introduction

This report has been prepared as part of EPRI's industry wide reliability initiative. The purpose of this initiative is to assess the reliability of both the transmission and distribution systems in the United States. This report is the first in a series of reports pertaining to the distribution portion of this initiative.

It would be difficult to perform a reliability analysis of all distribution systems in the United States. Rather, for this effort, a "cross-section" of five different representative distribution systems has been chosen. The systems types are:

- Urban Radial, largely underground
- Urban Network, largely underground
- Urban Radial, largely overhead
- Suburban, combined overhead and underground
- Rural

The review for these systems will cover the following:

- Review and analysis of load forecast data
- Review of equipment condition
- Evaluation of human factor performance (organization effectiveness, follow through)
- Analysis of root causes leading to recent outages
- Review of maintenance techniques
- Review of contingency criteria and design compliance

As part of the written synopsis, EPRI will summarize the project results and combine them for the purpose of highlighting general causes leading to a reduced level of reliability in distribution systems. These conclusions will be generalized to cover as broad a base of utilities as possible. In addition, a self-assessment guide will be prepared which will facilitate the effective and efficient deployment of single utility self-evaluations. The guide will include benchmarks of best utility practices in areas covered by the assessment.

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Section 1 – Introduction (con't)

In August of 1999, Commonwealth Edison Company (ComEd) in Chicago launched a massive internal effort to assess their system in response to concerns raised by the Mayor's office and the Illinois Commerce Commission (ICC). ComEd asked EPRI to work along-side ComEd engineering and management staff to perform this assessment. EPRI provided 23 technical experts who participated in an intensive examination of ComEd's system and organization in the following areas:

- System Planning
- Component Assessment
- System Inspection and Maintenance
- System Operations
- Engineering and Construction
- Investment Optimization
- Business Process Review

The teams worked continuously for over three weeks and delivered elements of a report which ComEd prepared for the Illinois Commerce Commission (ICC). ComEd has agreed to allow the material developed in this examination to be used as part of EPRI's reliability initiative. Specifically, the information gathered at ComEd covers the *Urban Radial, largely underground* distribution system of the EPRI initiative.

This report summarizes the ComEd results and has been drawn from the EPRI team observations and the ComEd ICC report. The purpose of this document is to focus on "common denominators." That is, lessons learned at ComEd that can be applied to other utility organizations. As such, this summary report intentionally avoids detailed technical descriptions of problems or systems -- which vary from utility to utility. Rather the focus is on overall processes and process improvements that may be applied across a broader cross-section of utility organizations.

Process Overview

The following paragraphs summarize the different aspects of the entire EPRI Reliability Initiative Distribution Program. Many portions of the ComEd review are similar to the process outlined below; however, because the ComEd investigation took place prior to the launch of the EPRI initiative, there are aspects of the ComEd work which deviate from the general outline. It should also be noted in these descriptions that the investigative process is dynamic. That is, as this effort continues to progress, the scope will be modified to permit intensive effort where needed.

Contingency Planning

EPRI reviewed and evaluated the peak loads projected by the utility and how effectively this is utilized in practice. The normal and emergency substation and distribution circuitry ratings were examined to determine their adequacy for meeting the normal and emergency loads.

Substation Design

EPRI reviewed the utility's substation designs to determine how a bus, transformer, or circuit fault will affect or cause other substation components to fail and recommended improvements or changes if needed.

Assessing Condition and Maintenance of Cables and Overhead Feeders

EPRI assessed the condition and the maintenance of overhead feeders and cables. In particular, the following was reviewed:

- Type of inspections and tests
- Equipment inspected
- Intervals between inspections
- Responsibility for inspection, chain of command and accountability
- Documentation of findings, corrective actions
- Time to corrective action
- Maintenance of a reliability centered or similar data base

EPRI conducted on-site inspections to clarify, verify and document maintenance procedures. The topics listed below were evaluated from technical, management, and operational standpoints. Therefore, not only was the collection and evaluation of the data investigated, but the appropriate organizational response to this data was also evaluated.

- Evaluation of operations, maintenance and training programs
- Investigation of new and improved monitoring and diagnostics for the lines and cables.

Assessment of Maintenance Programs for Distribution Electrical Equipment and Feeder Connections at Substations

To assess the utility's maintenance and inspection program for the network distribution equipment (other than lines and cables), the following was reviewed:

- Type of inspections and equipment types inspected
- Intervals between inspections
- Responsibility for inspections, i.e., chain of command and accountability for the inspection process
- Time to corrective action
- Documentation of findings and corrective actions
- Maintenance of a reliability centered or similar data base

EPRI, where applicable, conducted on-site inspections to properly clarify and document maintenance procedures.

Although this section is concerned mainly with maintenance, equipment design and installation was considered and examined especially where it affects the maintenance or reliable and safe operation of the equipment.

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Analysis of Utility Load Relief Procedures

EPRI evaluated Utility Load Relief Procedures, examining how such loading values are determined and how frequently they are updated. EPRI also examined whether such load readings have any weak points or limitations that may prevent the operators from acting quickly and judiciously to relieve effected feeders, transformers, or substations.

An analysis of written load relief procedures alone may not prove sufficient for uncovering problem areas to ensure that the utility is ready for peak loads. Hence, in the performance of this task, EPRI has:

- Assessed current emergency load relief (ELR) procedures and practices
- Examined the form of load data going into the ELR
- Interviewed distribution system operators and assessed how they implement these procedures in emergency conditions, i.e., who has the final say, and who throws the switches and opens the breakers
- If needed, make recommendations to improve operational switching flexibility and contingency relief procedures for feeder and station equipment
- Worked with operating personnel to assess the risk to the system posed by potentially overloaded feeders and small substations

Load Forecasting

EPRI audited the utility's load forecasting methods and practices. In particular, the following was investigated as part of this effort:

- Forecasting methodologies and the use of different forecasting tools in different departments and small-area load forecasting
- Methodologies and approaches for anticipating extreme weather conditions
- The use of alternative forecasting tools, if current tools are found deficient, to improve the accuracy and timeliness of load forecasts
- The inclusion in the utility's planning criteria of demand-side technologies, *which may have an adverse effect on the utility's forecasting and service reliability*

The review included an assessment of how the forecasting and planning data is being used and disseminated. EPRI reported on any deficiencies uncovered and made recommendations to remedy them.

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Procedure Audit

A study of maintenance programs, system design, and planning may not be sufficient to uncover system reliability problems. EPRI has encountered organizations that have had acceptable policies and programs "on the books" in all of these areas — and still have had substantial reliability issues.

This occurs when field staff fail to follow published polices and procedures. Poor communication, poor training, too many task "hand-offs," or an organization structure with no clear lines of responsibility can cause this break down. To be complete, a reliability study *must* include an audit of how effectively published policies and procedures are being followed.

EPRI interviewed selected Utility field, engineering, and management staff to identify any gaps between published methods and field practices. This included an assessment of field training and communications, along with an examination of roles and responsibilities within the maintenance and operations staff. EPRI reported on any gaps found and made recommendations designed to close these gaps.

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Section 2 – Commonwealth Edison Event History

ComEd's intensive internal assessment was triggered by a series of outages occurring throughout the late summer of 1999. The catalyst for these outages was an extended period of unusually hot weather. In fact, the first major event, on July 30, took place during the fourth hottest week of the century (according to the Chicago Tribune). The following section summarizes events that took place on the ComEd system immediately prior to the launch of the assessment.

Cortland / Northwest:

Early in the morning on Friday July 30, a 12 kV cable connected to one of three Cortland substation transformers faulted, causing this transformer to be put out of service. Customers affected by this were switched to one of the two remaining in-service transformers at the station.

At 11:24 am feeder (5348) connected to a second Cortland transformer failed. This failure removed this transformer from service and put the remaining Cortland transformer in an overloaded state. Within a few minutes this last transformer was also off line. The loss of the Cortland station left approximately 10,000 customers without power.

The fault in cable 5348 was repaired and returned to service, but faulted in a second location causing two transformers at the Northwest substation to trip off line at approximately 4:30 p.m. This event raised the number of customers without power to roughly 100,000.

On August 9 and 10, ComEd experienced manhole fires at Cortland Avenue, which left 8,200 customers without power.

Jefferson:

Further south in the system, at the Jefferson substation (on August 5) ComEd removed one of four transformers because field personnel observed an over temperature condition. . On August 11, at 7:45 p.m. a 69 kV feeder cable leaving the station failed at a splice, removing the second transformer from service. At 9:40 the morning of the 12th, another 69 kV feeder faulted at a splice, removing the third Jefferson transformer from service.

At this point in time, ComEd began water spraying (to help cool) the remaining energized Jefferson transformer, and asked businesses in the area to curtail energy use. In addition, load was transferred to a new spare transformer at the LaSalle substation. This new LaSalle transformer experienced a cooling system problem and began to overheat.

Section 2 – Commonwealth Edison Event History (con't)

ComEd decided to remove the LaSalle spare from service to repair the cooling system. Businesses affected by this action were given 45 minute notice and power was cut at 1:45 p.m. and then restored at 3:00 p.m. The 2300 customers affected by this outage were located in Chicago's largely commercial south loop area. Customers included the Chicago Options Board, the University of Illinois at Chicago, the Dirksen Federal Building (with FBI and U.S. Attorney offices along with a number of federal courtrooms) and several major financial institutions.

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Section 3 - Commonwealth Edison/Illinois Commerce Commission Report

While the charter of most of the ComEd teams revolved around technical issues, a "filtering" of team results aimed at extracting common denominators – which can be applied across the industry – produced primarily organizational or management related items. This is apparent in the ComEd ICC final report. The report's executive summary lists the following findings:

Maintenance:

- *Management Systems - ComEd's maintenance program is hampered by incomplete definition, lack of focus, historic budget swings, suboptimal work planning and inconsistent supervision.*

- *Equipment Monitoring and Capacity Management - Too much of ComEd's maintenance work is reactive rather than preventive, driven by actual or pending equipment failures, because of insufficient monitoring and inadequate capacity (monitoring and capacity are discussed separately below).*

- *Program Execution - ComEd's maintenance program has been hindered because of gaps in equipment condition monitoring, inconsistent training and work practices, and unclear priorities.*

- *Recordkeeping and Documentation - ComEd maintenance efforts are often made more difficult by incomplete operating histories of components due to gaps in data capture, inattention to detail, and lack of workforce discipline.*

Equipment Protection and Monitoring:

- *Maintenance Program Ownership - It was not always clear who was responsible for specific elements of ComEd's protection and monitoring program. Even when the responsible party was clearly identified, he or she was not always held accountable for the performance of those elements.*

- *Calibration Maintenance - ComEd has not kept pace with the necessary relay calibrations, and its efforts to do so are hampered by the same types of issues described above with respect to other types of systems maintenance.*

- *Root Cause Analysis - ComEd has not effectively tracked and analyzed information about relay failures, and thus cannot analyze or address the root causes of those failures.*

- *Equipment Condition Monitoring - ComEd has not implemented a consistent program of equipment monitoring across its system, thus limiting its ability to detect incipient failures.*

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T&D Load and Capacity:

- *Substation Capacity - Upon initial review, it appears that almost a third of ComEd's large substations (approximately 73) operate above capacity at times of peak demand, and that 27 of those substations require expedited corrective actions. Three of those 27 substations are located in the City of Chicago (Crosby at 1180 North Crosby, Lakeview at 1141 West Diversey, and Northwest at 3501 North California), and 24 are located outside the City.*

- *Distribution Feeder Capacity - Upon initial review, it appears that almost one fifth of ComEd's small substations and feeders (approximately 880) operate above capacity at times of peak demand; 185 of those small substations and feeders are located in the City.*

T&D System Optimization:

- *System Design - ComEd's downtown distribution system lacks some of the features which provide high reliability and flexibility in other US and European designs.*

- *Delivery Capacity - Additional power delivery capacity is needed to provide the operating flexibility and contingency management capability needed to ensure highly reliable service.*

- *System Operation - Traditional contingency planning criteria applied to this system will not provide the requisite reliability for such an important area.*

EPRI has observed, that the items listed in the first two categories, '*Maintenance and Equipment Protection and Monitoring*', **do** pertain to many participants in the United States utility industry. The items listed under "*T&D Load and Capacity*" and "*T&D System Optimization*" are specific to the ComEd system. The following sections discuss these and related observations in detail.

Again, it is very important to note, in the case of Commonwealth Edison, most major distribution reliability issues can be traced back to management or organizational issues. In most cases, problems or concerns that originally appear to be technical in nature often are rooted in problems with management or company organization issues.

Section 4 - Common Denominators

Cost Savings

In today's utility environment, where most organizations have been making a transition from a regulated to some form of competitive environment, substantial pressure is being applied to reduce cost. Because the market currently views electricity as a "generic" commodity, the need to keep costs as low as possible will be with the industry through the foreseeable future.

Costs can be reduced through intelligent use of limited funds -- or through the blind application of budget reductions across an entire organization. Common sense dictates that intelligent allocation of funds works best. However, at ComEd, and in other organizations with which EPRI has worked, the general trend has been across the board budget reductions.

In today's environment, it is vital that limited financial resources be applied where they can be most effective. System reliability performance can be used to establish priorities. The following is a subset of questions which, surprisingly enough, frequently do *not* get asked when decisions are being made:

- What part of the network is most vital to overall network health?
- Where are the most sensitive / significant customers?
- Which part of the system can the utility least afford to lose?
- Within each substation, which are the most vital components?
- What are the most important equipment functions that must be preserved?

Answering these and other similar questions will help an organization determine which substations and which equipment within those substations deserve attention and maintenance dollars -- and which can have their maintenance budget reduced.

The same is true for individual pieces of equipment, and *within* a piece of equipment. For example, proper operation of a given circuit breaker may be essential in one station, on one part of the network, and less important in another station; hence, the important breaker should get increased maintenance attention, and the other less. The "open" (de-energize) function for a circuit breaker is generally much more vital than the "close" (energize) function. Depending on the breaker design, this may dictate more money be spent on those components playing a role in the "open" operation, and less on those which only come into play for "close."

EPRI and others provide the industry with a set of tools designed to facilitate this kind of prioritization. For the maintenance environment, Reliability Centered Maintenance (RCM) is the name given to a set of tools specifically designed for this purpose.

Cost Savings (con't)

Maintenance prioritization must also take into consideration future costs resulting from the discontinuation of routine programs. In ComEd's case, discontinuing routine inspections of transformers and cables may have resulted in a number of the failures which contributed to their string of outages. *Calculation of future costs must include catastrophic failures and lost revenue.* Failure to include these costs in the maintenance prioritization process guarantees that vital routine maintenance tasks will be underprioritized, setting the system up for major -- costly -- incidents.

The cost of public reaction must also be taken into consideration. As a consequence of this past summer's incidents and as part of agreements with the City of Chicago and the state legislature, ComEd has agreed to spend *$3.1billion on reliability improvements.*

Management

A number of the problems witnessed at ComEd and elsewhere appear at first glance to be technical in nature, but upon closer scrutiny have their root cause in management or organizational failures.

Paying Attention:

Today the electric power industry is in a continuous state of flux. It is very easy for utility management at all levels to be distracted by the changes taking place, *losing site of day-to-day operation.* Moving into competitive markets, "functional unbundling" of utility organizations, mergers, reorganizations and so forth demand a substantial amount of attention and energy. It is easy to fall into a trap where the "normal" job of keeping the system in operation defaults to a low priority.

This problem is exacerbated by organizational changes which often put new management in a role where they may not understand the idiosyncrasies or complexity of the area for which they have become responsible. Functioning in a new role, management may not know where to focus their attention or the attention of their staff because they lack the background and experience to make this judgment.

Management which has "risen through the ranks" -- carrying with it substantial experience -- can fall into a different trap. Someone in this category may assume that operating or maintenance procedures that were in place while they were in a more junior position are still being followed. With all of the current changes in a typical utility organization, this is a bad assumption.

By "walking the system" -- that is, going to a substation, walking through shops and offices -- both the experienced and the inexperienced manager can uncover and fix problems. The experienced manager should be able to determine -- quickly -- if processes are running the way he or she assumed they were. The inexperienced manager can gain familiarity with their new "territory" and ask questions which will lead to discovering breakdowns in procedures. For both types of managers, inconsistencies or glaring problems can be immediately identified. At ComEd and in other organizations where reliability problems have surfaced, obvious signs (non-operating cooling systems, major oil leaks, unusual noises or vibrations, triggered alarms, messy environments) existed -- all of which pointed to more serious underlying problems. Management could have spotted any of these obvious signs *had they walked around the system.* Organizations that receive unusually high marks for reliability have management -- all the way up to the senior VP level -- who make a point of going out into the field and looking at the system from time to time.

Management (con't)

Authority and Accountability

With all of the confusion brought about by industry changes, it is very important for authority and accountability to be clearly assigned for all key systems. Within ComEd, the ICC report reveals that for some key systems and processes no clear ownership was defined. Without this definition, it is impossible to make necessary decisions in an organized way. In general, with no authority and accountability assigned, *no* decisions will be made. Only during emergencies will these "unassigned" systems attract attention -- and it will be because they have failed.

Goals and Reliability

Employee and management goals must include reliability measures. EPRI has encountered, both at ComEd and elsewhere, situations where budget related goals have completely eclipsed reliability measures. While cost cutting and efficient performance are vital in today's utility world, a balance must be struck between goals that encourage cost cutting and reliability requirements. It is possible to build reliability into a cost savings goal *if the projected cost of failed equipment and outage consequences are taken into consideration.* In many of today's utility organizations, the cost of catastrophic failures and the public impact are *not* considered when calculating the cost / benefit ration for a given maintenance program or technology.

Spending Decisions

Pushing budget responsibility too far down in the organization also results in a skewed spending decision process. Usually, someone who only has budget responsibility for a *piece* of the organization makes spending decisions regarding new technologies or system changes - aimed at improving reliability. So, for example, a manager responsible for transformer maintenance may balance the cost of a new transformer monitor against potential future savings *to their budget.* This budget may not be impacted by lost revenue, capital required to replace a failed transformer, and so forth. Given that this manager only sees part of the "big picture", it is likely he or she will be led to make an incorrect decision.

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Communication

Shooting the Messenger

Most utility systems have historically been conservatively designed and conservatively operated. Spending cuts, several years ago, may not have had a measurable impact on reliability. Because these cuts did not initially affect reliability, the budget cut cycle has -- in many organizations -- been repeated a number of times. Clearly, this cycle cannot continue forever. However, employees who have flagged pending problems have often been criticized for being "out of touch" with the new business environment (i.e., too conservative). Conversely, employees who have accepted the reductions -- and assured management they will cause no problems, have been rewarded.

This has created an environment where staff becomes leery of reporting serious concerns. All internal communications (in this environment) are forced to be positive. This is a major communication failure, and can lull management at all levels into a false feeling of security.

Head in the Sand

In a disturbing number of cases, organizations or individuals within organizations have consciously decided not to gather information that could point to system problems. This happens when staff fears they have serious problems that they do not have the resources to fix in a timely manner. The belief is that documenting the problem and *then* having a failure before the problem can be fixed is worse (results in more punitive consequences) than having a "surprise" failure. Organizations also fear increased liability if system failures are traced back to known -- but unfixed -- problems.

Generally, these "feared consequences" are not encountered if a utility has a well-documented method for finding and addressing problems rapidly once uncovered.

Technology Deployment

ComEd was at the forefront of technology development in a number of key areas that could have helped mitigate their problems. However, these technologies were not implemented widely enough to be useful. In fact, information about the availability of these tools never made it to some departments which could have benefited.

ComEd's very "compartmentalized" structure insured that communication between departments -- necessary to insure proper deployment of new tools -- did not exist.

When new tools have been introduced and judged to be valuable, it is essential that management facilitate their widespread use. Individuals with enough authority and *adequate resources* must be assigned to make this happen. Frequently, the resources required to implement a new tool or technology are seriously underestimated -- resulting in incomplete roll out and, consequently, disappointing results.

Technology Training

Because of recent organization changes, EPRI has seen frequent situations where new or reassigned staff is not familiar with tools and technologies presently in place and in operation. Data from these systems (which is flagging an incipient problem) may be ignored or filed without interpretation. Utilities must insure that reassigned staff is properly trained in the interpretation of data they receive and the tools they use in the course of performing their job.

The Big Trap

Operating the system during peak load is always a concern. In this condition all safety margins are at their minimum. If the system has been properly maintained it is possible to operate equipment beyond its rating. If the system has not been properly maintained equipment *may not even be capable of operating at nominal ratings.* In today's environment it is likely that (for all of the reasons given above) equipment maintenance has suffered. It is also likely that -- due to today's cost and investment recovery concerns -- expenditures on system improvements or expansion have been minimal. This places many utilities in a situation where they attempt to operate an under maintained system at or near maximum rating (or into overload). This is problematic.

Many of the components which failed on ComEd's system -- leading to the system failures of last summer -- failed at well below their rating. In a number of cases, the inability of these components to operate as designed and rated can be directly traced to inadequate maintenance.

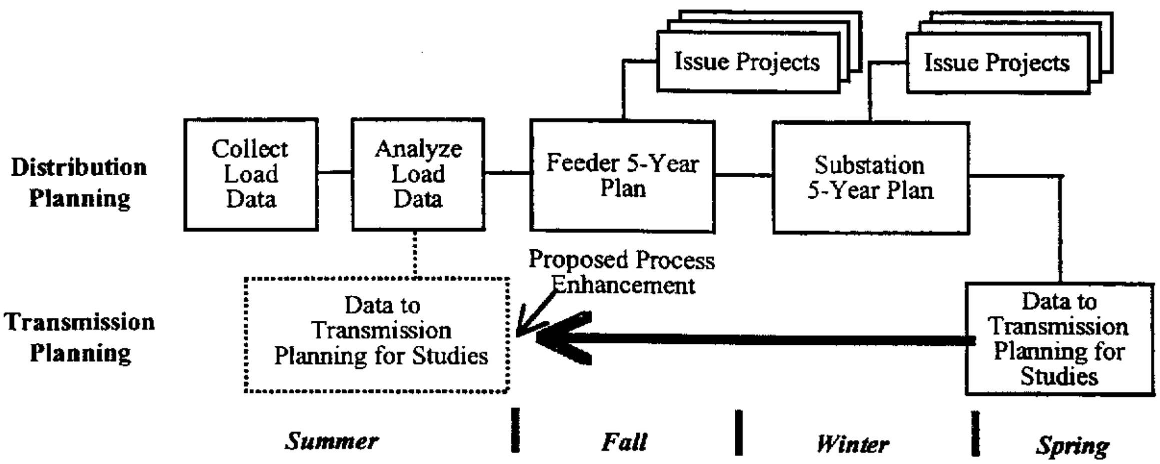
Section 5 - Technical Findings

The following sections have been extracted and condensed from the technical findings of the ICC report. As explained earlier in this document, most of the technical information contained in the ICC report is specific to ComEd – and thus not of interest to the industry as a whole. The items listed below are those that apply more broadly (across the industry) or serve to illustrate points made earlier in this document.

System Planning

ComEd's T&D planners need timely data to improve forecasts and reinforce the infrastructure. For instance, the study found that transmission planners receive load data approximately seven months after the distribution planners. Currently, in a given year, distribution planners obtain load data, conduct analyses, prepare five-year feeder plans, then prepare substation five-year plans. It is typically spring of the next year before the transmission planners have prior year data to conduct their studies.

System Planning Current Process



Transmission planners receive load data approximately seven months after the Distribution planners.

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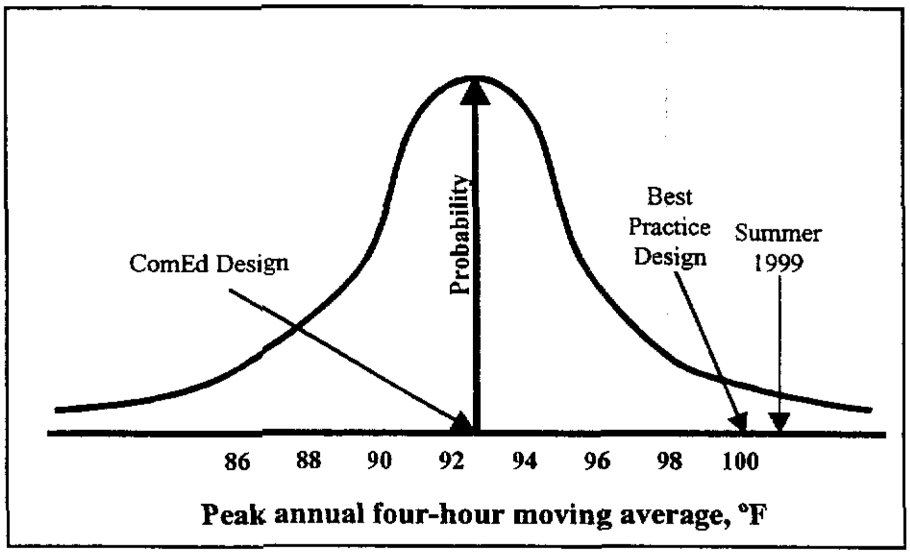
Further, the current practice of averaging weather data over a 15-year period does not aid in planning for extreme weather conditions. Therefore, to improve the accuracy of load forecasts, planners should incorporate data on extreme weather.



Currently, ComEd forecasts load by using a 15-year average of normalized weather data. Extreme weather increases system loading, resulting in more equipment overloads and extended outage restoration times. Conclusion: Incorporating extreme weather into forecasting processes should help to mitigate the impact of these conditions.

The study also found that:

- The use of "contingencies" in system design may not be adequate. As such, all planning and design criteria should be reviewed (for some areas) and updated if necessary to reflect a possible increase to third contingency.
- Inconsistencies between equipment ratings and actual operating conditions can raise the risk of outages. The application of dynamic ratings should be considered as a possible remedy.
- Community expectations must also be addressed in the planning process, i.e., planning criteria must be clearly defined and communicated to constituents.

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Capacity Planning

Because operating margins in ComEd's distribution system may not be sufficient to withstand a contingency or for a peak load significantly greater than that forecast, the utility must inspect and maintain all substations and other equipment identified as stressed or at risk of overloading and ensure components meet planning criteria.

Total Peak Load of Large Distribution Substations (MW)

Year	Chicago	Northeast	Northwest	South	Total
1995	4,931	6,489	3,043	3,904	18,367
1996	4,644	6,447	2,946	3,821	17,858
1997	4,688	6,340	2,963	3,826	17,817
1998	4,857	6,501	3,083	3,871	18,312
1999	5,293	7,084	3,438	4,297	20,112
1998-1999 Increase	9.0%	9.0%	11.5%	11.0%	9.8%
1995-1999 Compound Rate	1.8%	2.2%	3.1%	2.4%	2.3%

ComEd experienced significant substation load increases in 1999.

The utility must also ensure that its maintenance plans include up-to-date equipment operation data. In addition, to improve service reliability and optimize performance, the utility must model system design, perform sensitivity studies, and evaluate alternative designs.

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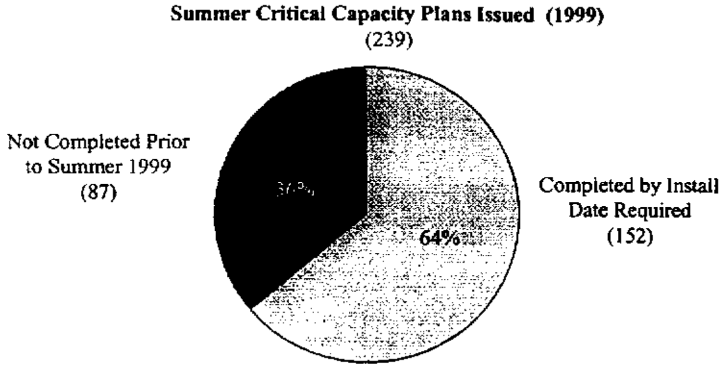
Engineering & Design Practices

The study found that ComEd could better protect the primary/secondary distribution systems from operating stresses and customer demands. As such, the utility must evaluate and improve engineering and design practices. For instance, the utility must determine whether the planning cycle provides adequate lead time for capacity expansion.



Although capacity additions are planned far in advance, plans to complete capacity additions are issued to be completed in the calendar year of the expected problem. As a result, in 1999 approximately one-third of the summer-critical jobs were not completed by the date required.

ComEd must also:

- Assess the adequacy of its contingency plans for the secondary network,
- Determine whether planners know which customers are connected to which transformers,
- Determine whether outage mitigation efforts are both applied consistently and adequate for expected severe summer weather.
- Determine whether protection schemes for underground and overhead lines are compatible and whether distribution circuit sectionalizing can limit outages.
- Confirm that the power quality needs and expectations of its customers are understood throughout the organization. The utility should identify "critical" customers" or "areas" and develop separate design criteria.

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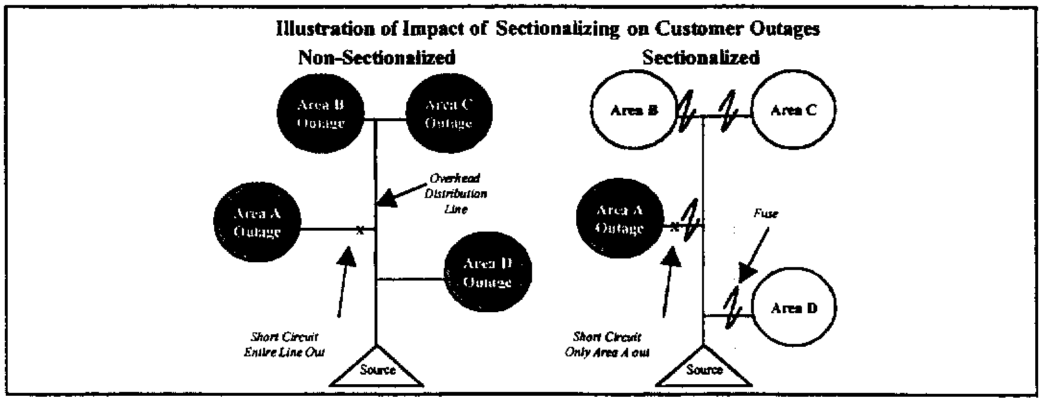
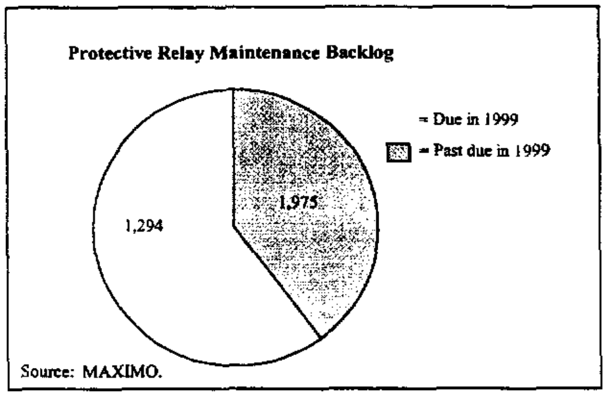


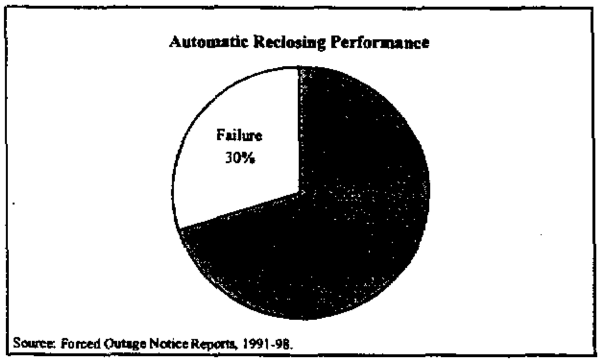
Improving distribution circuit sectionalizing could reduce the number of customers interrupted.

Protective Relays and Equipment Monitoring

If the protection system is to operate as designed, ComEd must perform regular maintenance, i.e., the maintenance backlog must be reduced, and substation equipment-monitoring and control systems and protective relays must be fully integrated.



The relay preventive maintenance program has a large backlog of work, and known failures are not used effectively to adjust maintenance procedures.



Incomplete data suggests only 70% success rate for automatic reclosing on transmission system. Anecdotal data suggests similar success rate for the distribution system.

The remedy could include the installation of new intelligent devices that allow monitoring of device deterioration across a number of parameters. However, key monitoring data should be widely accessible from an integrated software interface.

In addition, protective relay system communication lines must be highly reliable, and lines not owned by ComEd, i.e., leased lines, must be monitored closely. Distribution center transformers must have fusing on the high side, since relays in substations may be unable to identify all faults. This will reduce the chance of equipment damage. Non –utility –owned DC batteries in substations must also be monitored closely.

Components

The study found that although equipment ratings depend heavily on the proper operating condition of auxiliary components, ComEd did not perform recommissioning tests after repair or maintenance work was completed, nor did the utility perform failure analysis on failed distribution cables, joints, or termination's. As such, the report recommended that all engineering and design components, such as large power transformers, circuit breakers, protective relays, towers, switches, wire and cable, be specified according to design operating conditions and operated properly according to those specifications. In

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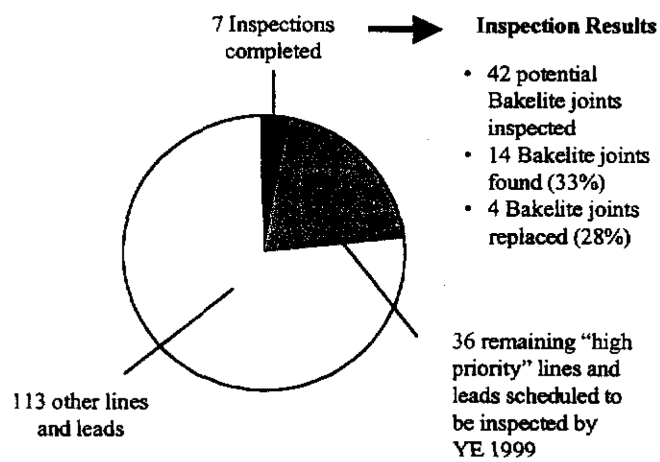
addition, such components must be tested whenever repair and maintenance work is completed. Likewise, after a failure these components must also be inspected to gain knowledge that may help in avoiding future failures.

Underground Maintenance

The study found that maintenance performed on ComEd's underground transmission and distribution system is inconsistent. Indeed, underground transmission lines have not been inspected in many years, and diagnostic testing is not performed on either underground transmission lines or underground distribution PILC cables.

A comprehensive underground transmission inspection and maintenance program is critical to improving reliability, and to be effective, such a program must be both integrated and system-wide. At a minimum such programs should include diagnostic testing and assessment of the condition of critical feeders. Of course, all inspections and maintenance must be tracked and documented.

Inspection status: Underground Components [1]



[1] 156 total transmission lines and transformer leads
Source: Transmission Underground Inspection Team

Underground transmission lines have not been inspected systematically since 1989, as a result certain elements of the system are in poor physical condition. Fluid leaks, defective reservoirs and unsupported cables have been identified in the recent triage inspection effort. If left unresolved, this could result in the deterioration of electrical insulation and equipment failure.

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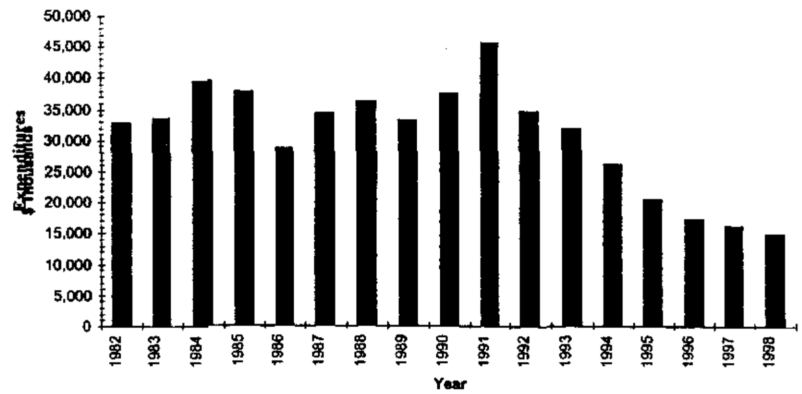
Substation Maintenance

The study found that some high-priority substation maintenance programs were incomplete and could contribute to system interruptions. To ensure the reliable operation of substation components, the study recommended that ComEd undertake a proper maintenance program, based on a Reliability Centered Maintenance philosophy (RCM).. Such a program should address – but not be limited to – short-term, high-priority repairs, work process management and tracking, and worker training.

Substation Maintenance Expenditures 1982-1998[1]



[1]In 1999 dollars.
Source: General ledger, ARMS (Applied Resource Management System), CBMS (Competitive Business Management System)

Emphasis on capital work has resulted in fewer resources being allocated for maintenance work. As such there needs to be an increased focus on maintenance and determination of appropriate resource levels. In addition, the utility should establish an organization with accountability and ownership for equipment/system performance.

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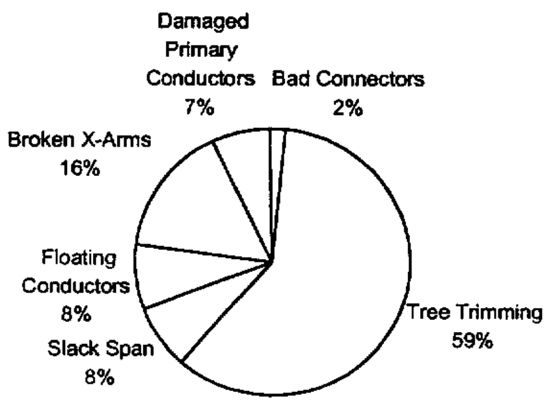
Overhead Maintenance

The study found a large number of unidentified problems affecting the reliability o the distribution system and disjointed and unsynchronized maintenance programs. It recommended that ComEd adopt a state-of-the-art maintenance (inspection and repair) program for overhead T&D conductors and equipment and underground residential distribution facilities that includes preventive maintenance. The study further recommended that ComEd synchronize the work to avoid rework and to ensure prioritization of repairs, i.e., high-impact vs. low-impact repair items. Such a program should include long-term analysis of optimal feeder design and should be managed so that a "big picture" of maintenance is developed for analysis and prioritization of work.

Inspection Status[1]

- 167 feeders inspected to date (27% of 626 top priority feeders)
- 2,401 repair items identified/327 (14%) repaired to date
- Feeder inspection in progress for 109 feeders (17%)

Inspection Results: Breakdown of Identified Problems

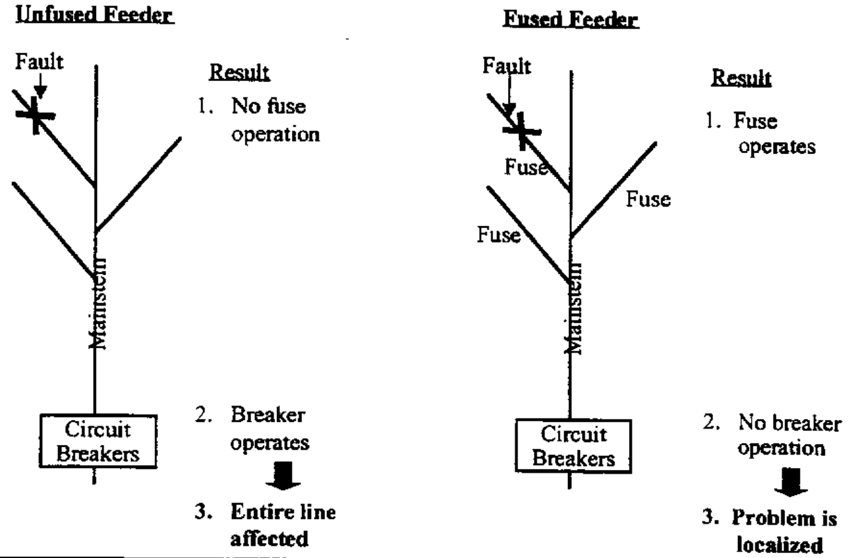


[1] As of 9/7/99

Source: 626 feeder inspection program.

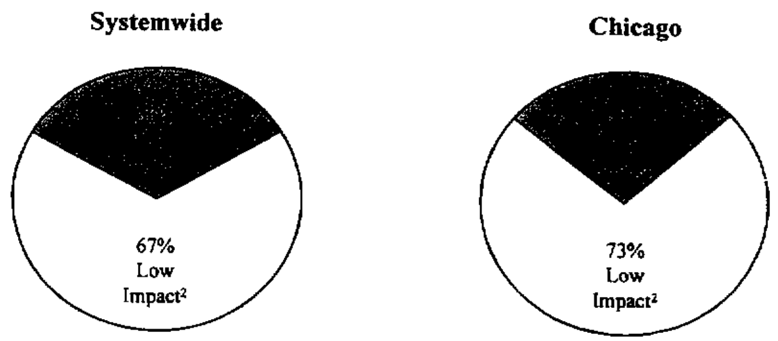
Overhead maintenance should improve knowledge of the physical condition of the distribution network.

Diagram of Feeder Fusing Impact



Inspections will determine whether the application of existing fusing standards has been inconsistent, as ComEd discovered.

Breakdown of Existing Maintenance Plans



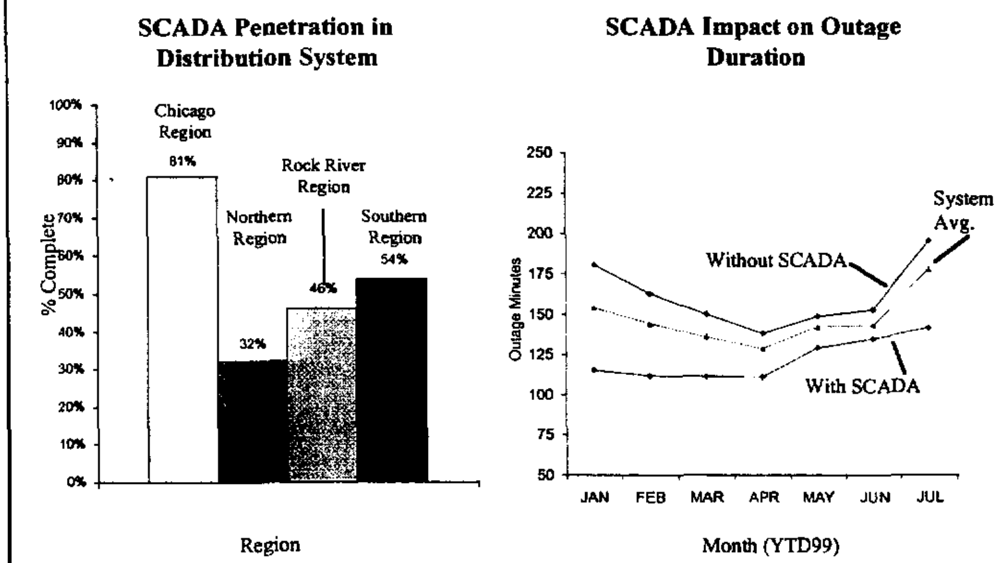
[1]High Impact = Broken cross-arm, blown arresters
[2]Low Impact = Pole steps, missing guy markers
Source: Present C-1 Maintenance Items List

Repair of high-impact items has not been prioritized.

System Operations (Including Emergency Response Management)

The study found that ComEd's emergency load relief procedures were inadequate for Chicago, that this hinders emergency load shedding in the downtown area, and that much of the distribution system is not monitored by the SCADA system. It recommended that system operations at ComEd be revised to include up-to-date load relief procedures and that such procedures must be reviewed on a regular basis to ensure that they meet operating objectives. To be acceptable:

- There must be clear procedures and lines of authority for load shedding.
- The distribution system should be monitored or controlled by SCADA.
- Facility maps must be up to date.
- Distribution management tools must be up to date and integrated.
- Existing emergency storm processes be augmented to shorten duration of interruptions.



Source: SCADA Database.

Source: IRS Database.

A large percentage of ComEd's distribution system is not monitored or controlled by the Supervisory Control And Data Acquisition (SCADA) system.

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Information Systems/Information Technology

The study found that with 91 different work management systems, ComEd's IS/IT lacks organization, leadership, and direction, which hinders its transition to a more integrated and systematic operating model. In order for ComEd to ensure proper coordination and planning throughout its T&D system, the study said, ComEd must determine whether its T&D organizations use a common IS platform, and whether that platform is suitable to specific T&D needs. For an IS system to be considered adequate, for instance, the outage management system/trouble call portion of the system must meet customer and government expectations regarding responsiveness and reliability as well as managing trouble and field crews. In addition, ComEd should implement a geographic information system that is effective in displaying/recording position of all T&D facilities.

Resource Optimization

The study found that a misallocation of ComEd's T&D investment resources has restricted some needed work. To optimize the performance of its overall T&D system, ComEd must examine its T&D investment plans to determine whether those plans emphasize risk-mitigation projects. That is, do T&D investment plans focus on delivering value to stakeholder groups, such as adding capacity, avoiding interruptions, restoring outages, improving asset condition, and managing risk.

Perceived Value Drivers

Old	Stakeholders	New
• ASIFI • ASIDI	← *Customers* →	• Asset condition • Extreme weather capacity • Quality of power • Avoiding interruptions • Outage restoration • Outage communication
• Regulatory performance • Cost of service • Open access implementation	← *Regulators & Government* →	• Customer satisfaction • Meeting commitments • Regulatory performance
• Shareholder value added • Budget performance • Work plan completion	← *Shareholders* →	• Shareholder value added • Risk management • Good will

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