PUBLIC VERSION

Patoka Area 69 kV Subtransmission Study

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Executive Summary

This study examined the 69 kV system in the Patoka area to determine if any system changes would be required to ensure reliable operation during normal and contingency conditions. The scope of the study was limited to the following three items.

1. A five year Patoka system study for the years 2009 through 2013.
2. A horizon study for the years 2014 through 2018 including a system sensitivity analysis.
3. A study to determine the impact of adding a large load to the area.

The analysis showed the following:

1. No voltage or loading violations were identified in the five year study.
2. No voltage or loading violations were identified in the period from 2014 through 2018 using existing forecasted loads. In addition to using the existing forecast, various bulk loads were added to the area to test the robustness of the system. The results showed that no system improvements would be required for an additional load of 3 MVA or less. However, additional loads between 3 and 8 MVA will require approximately $6 million in system upgrades and $8 million in system improvements are required when the load is increased to greater than 8 MVA.
3. Major reinforcement of the system would be required to support adding a 29 MVA load to Line 6651. The recommended option would require a new 138kV/69kV substation as shown in Option #4 on page C-6 of Attachment C.

Section
1

Introduction

1.1 Purpose of Study

The purpose of this study is to examine the 69 kV system in the Patoka area using the current load forecast and to recommend system changes to maintain acceptable service during normal and single contingency outage conditions for the years 2009 through 2013. Since the Patoka area is a strategic location for pipelines and there is likelihood of future development a horizon strategy will also be evaluated and various bulk loads added to the Patoka area to test the area for sensitivity to load changes. In addition, due to a recent customer request this study will determine the impact of adding a new pumping station load on the electrical system in this area and examine various configurations to accommodate the new load.

1.2 Scope of Study

The scope of this study includes the following:

- Analysis of the Ameren 69 kV system in the Patoka area for the years 2009 through 2013, for both normal and contingency peak load conditions. Identification of any equipment overloads on the Ameren system requiring changes due to forecasted load growth.
- Horizon strategies for the Patoka area for the years 2014 through 2018. In addition, bulk loads will be added to the area to test the robustness of the system and determine required system changes to maintain acceptable service.
- Determine system impact of adding a pumping station load of approximately 29 MVA to Line 6651. Examine various configurations to accommodate the new pumping station.

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Section
2

Study Assumptions and Inputs

2.1 Assumptions

- The 2004 summer NERC MMWG series case was used to build a model for expected years 2009, 2013 and 2018 summer conditions. Any scheduled and planned reinforcements of the transmission and distribution systems in Hillsboro, Mt Vernon and nearby areas were included in the models.
- Power Technologies Inc's (PTI) Power system simulator for Engineering (PSS/E) program was used to simulate the transmission and Ameren subtransmission system. Steady state simulations were performed for the projected peak loading conditions. System operation was evaluated for normal and first contingency system configurations.
- The Patoka area to be studied is defined in Attachment A and consist of both customer and distribution loads served off of Line 6651.

2.2 Initial Conditions

- The study area is the Patoka 69 kV area which is a portion of the Hillsboro and Mt. Vernon areas served by the South 69 kV system.
- 69 kV Line 6651 feeds the Patoka area.
- The general location of the study area is shown on a diagram in Attachment A.
- The study area is currently fed by the following bulk supply transformers:

Substation	Nameplate MVA Rating	Voltage (kV)
Aviston #2	93.3	138 / 69
Bluff City	83.1	138 / 69
Midway	41.7	138 / 69 / 34
S. Centralia #1	66.7	138 / 69
S. Centralia #3	74.7	138 / 69
W. Salem #1	112	138 / 69
W. Salem #2	112	138 / 69

- There are several system capacitor banks in the South 69 kV load area as given below:

Location	Voltage (kV)	Connected kVAR
Aviston	69	7200
Beckmeyer	69	10800
Bluff City	69	10800
Duquoin	69	10800
Ferrin	69	10800
Geary St.	69	10800
Nashville	69	10800
N. Nashville	69	10800
Patoka	69	10800
Patoka	69	7200
Salem	69	6000
Texas	69	10800
Trenton	69	10800
Vandalia	34	4500
Waltenville	69	18000

Section

3

System Analysis and Results

3.1 Steady-State Load Flow Results

Steady state simulations were performed for the projected 2009 through 2013 peak loading conditions. Load flow results on the 69 kV Patoka area for the summer peak period during normal and contingency conditions are listed below. Planning Criteria, listed in Appendix F, were used to determine voltage problems and overloads.

Normal System Conditions:
No steady state voltage or equipment loading violations were identified for the Patoka area for the time period of 2009 through 2013.

First Contingency Outages
No steady state voltage or equipment loading violations were identified for the Patoka area for the time period of 2009 through 2013.

3.2 Recommendations

No steady state voltage or equipment loading violations were identified in this analysis. The MVA difference between the Line 6651 rating and the calculated loading under normal and first contingency conditions is given as the available capacity and is shown in Appendix E. The two worst case contingencies for the loading of Line 6651 are the loss of Line and the loss of Line

Section
4

Area Load Sensitivity Analysis

4.1 Horizon Strategies

While the state of the Patoka subtransmission system in the five year horizon period of 2014 through 2018 will likely differ from the current forecast, this study was extended to include those years in order to make note of possible conditions which could have a significant effect on the system or require sizeable investment of resources. Load flow results on the 69 kV Patoka area for the forecasted summer peak period during normal and contingency conditions are listed below. Planning Criteria, listed in Appendix F, were used to determine voltage problems and overloads.

Normal System Conditions
No steady state voltage or equipment loading violations were identified for the Patoka area for the time period of 2014 through 2018.

First Contingency Outages
No steady state voltage or equipment loading violations were identified for the Patoka area for the time period of 2014 through 2018.

4.2 Sensitivity Analysis

A sensitivity analysis was performed to evaluate the system impact in the Patoka area due to additional loading greater than that evaluated in sections 3.1 and 4.1 of the study. The analysis used summer peak load models for the year 2008 and added bulk loads to the area to test the robustness of the system.

As the years progress the known area load growth is only about 0.3% as shown in Attachment D. This 2008 modeled load of approximately 35.3 MVA is served from the north out of the Vandalia substation and from the south out the Sandoval Switching Station and the West Salem substation. In 2018 this modeled load only increases to 36.9 MVA. This small percentage increase is due to a large portion of the load being known customer load that is not increasing. However, there is a possibility that this area could see new additional customer load in the near future that we do not know about. In order to study the impact that such additional load would have on the area three different load scenarios were simulated at the Patoka Substation. The results of these three load scenarios are summarized below and illustrated in Appendix B.

- **Scenario 1 – Loads less than 3 MVA**

  Required System Reinforcements

  1. Capacity Related
     - Normal – none
     - Contingency – none
  2. Voltage Related
     - Normal – none
     - Contingency – none

  Costs

  Planning estimate = $0

- **Scenario 2 – Loads between 3 and 8 MVA**

  Required System Reinforcements

  1. Capacity Related
     - Normal – none
     - Contingency – HTO 22.1 mi and reconductor 7.3 mi of Line 6651
  2. Voltage Related
     - Normal – none
     - Contingency – Increase cap bank at Patoka to 10.8 MVAR

  Costs

  Planning estimate = $6 million

- **Scenario 3 – Loads greater than 8 MVA**

  Required System Reinforcements

  1. Capacity Related
     - Normal – none
     - Contingency – Build new 138/69 kV substation and 5.5 mi of new line from new substation to Patoka
  2. Voltage Related
     - Normal – none
     - Contingency – Build new 138/69 kV substation and 5.5 mi of new line from new substation to Patoka

  Costs

  Planning estimate = $8 million

4.3 Summary

No voltage or loading violations were identified in the period from 2014 through 2018 using existing forecasted loads. In addition, various bulk loads were added to the area to test the robustness of the system. The results showed that no system improvements would be required for an additional load of 3 MVA or less. However, additional loads between 3 and 8 MVA will require approximately $6 million in system upgrades, and $8 million in system improvements are required when the load is increased to greater than roughly 8 MVA.

Section

5

New Large Customer Analysis

5.1 Plans Considered

This section of the study determined the system impact of adding a large load to Line 6651. Due to a recent customer request a new pumping station load of approximately 29 MVA on the electrical system in the Patoka area was examined and various configurations to accommodate the new load were investigated. While performing this analysis various configurations were considered. Different connecting sources, number of lines and tap points as well as switchyard bus configuration are some of the variations that were considered. Configurations were judged on cost, reliability and flexibility. The different options evaluated are summarized below and shown in Attachment C.

- **Customer Requirements**
  1. Main load is hp motors and is expected to run 24/7.
  2.
  3. 20 / 26.7 / 33.3 MVA Customer Owned Transformer
  4. Dual Utility supply feeder will be required
  5. Motors will have a VFD installed to provide soft start capability, but they still want to have the option of starting across the line.
  6. Site is located at the following GPS Coordinates:

- **Option #1 – Dual Feed from 69 kV Line 6651**

  Required System Reinforcements
  1. Capacity Related
     Normal – none
     Contingency - Need to reconductor 29 miles of Line 6651 and HTO 2.5 miles of Line 6676
  2. Voltage Related
     Normal – none
     Contingency – Can NOT add enough capacitance
  3. Relaying concerns - none
  4. Across the line motor starting capability – No

Costs

Planning estimate = $13.5 million

Option #1 summary

This option looked at providing dual service at the 69 kV level to the new load. However, due to the high cost and voltage concerns during contingencies and across the line motor starting it is not considered a valid option.

- **Option #2 – Feed radially from West Salem with Line 6651 backup**

Required System Reinforcements

1. Capacity Related
   Normal – none
   Contingency - none
2. Voltage Related
   Normal – none
   Contingency – Capacitors required to increase the .93 pu voltage at Patoka
3. Relaying concerns - none
4. Across the line motor starting capability – Yes from normal source

Costs

Planning estimate = $7 million

Option #2 summary

This option looked at providing service from an existing West Salem138/69 kV source and using a 69 kV alternate supply to feed to the new load. The alternate feed would not be able to be operated closed through to the West Salem source as this would create a four terminal line. The high cost is mainly due to the 13 mi of new 69 kV line required.

- **Option #3 – Feed radially from new 138/69 kV substation**

Required System Reinforcements

1. Capacity Related
   Normal – none
   Contingency – none
2. Voltage Related
   Normal – none
   Contingency – none
3. Relaying concerns - none
4. Across the line motor starting capability – Yes

Costs

Planning estimate = $6 million

Option #3 summary

This option looked at providing 69 kV service from a new 138 kV source. This option only provides a radial feed and does not meet the customer's need for a dual source. The high cost is mainly due to the new 138/69 kV substation.

- **Option #4 – Feed from new 138/69 kV substation with 69 kV backup**

  Required System Reinforcements

  1. Capacity Related
     Normal – none
     Contingency – none
  2. Voltage Related
     Normal – none
     Contingency – none
  3. Relaying concerns - none
  4. Across the line motor starting capability – Yes, from normal source

  Costs

  Planning estimate = $8 million

  Option #4 summary

  This option looked at providing service from a new 138/69 kV source and using a 69 kV source as an alternate feed. This option meets all of the customer's requirements including the need for a dual source. The high cost is mainly due to the new 138/69 kV substation bus and the need for breakers at Patoka.

- **Option #5 – New bulk substation with two transformers tied into the 69 kV system**

  Required System Reinforcements

  1. Capacity Related
     Normal – none
     Contingency – none
  2. Voltage Related
     Normal – none
     Contingency – none
  3. Relaying concerns - none
  4. Across the line motor starting capability – Yes from new substation

  Costs

  Planning estimate = $11 million

  Option # summary

  This option looked at providing service from a new bulk substation with two transformers tied into the 69 kV system. This configuration is viewed as an ultimate configuration. This option might be used with option #4 when additional load is added to the area. If constructed upfront then the cost could be shared with the customer.

5.2 Summary

Major reinforcement of the system would be required to support adding a 29 MVA load to Line 6651. The recommended option will require a new 138kV/69kV substation as shown in Option #4 on page C-6 of Attachment C. Option #4 is preferred over Option #2 because of the better reliability and system expandability.

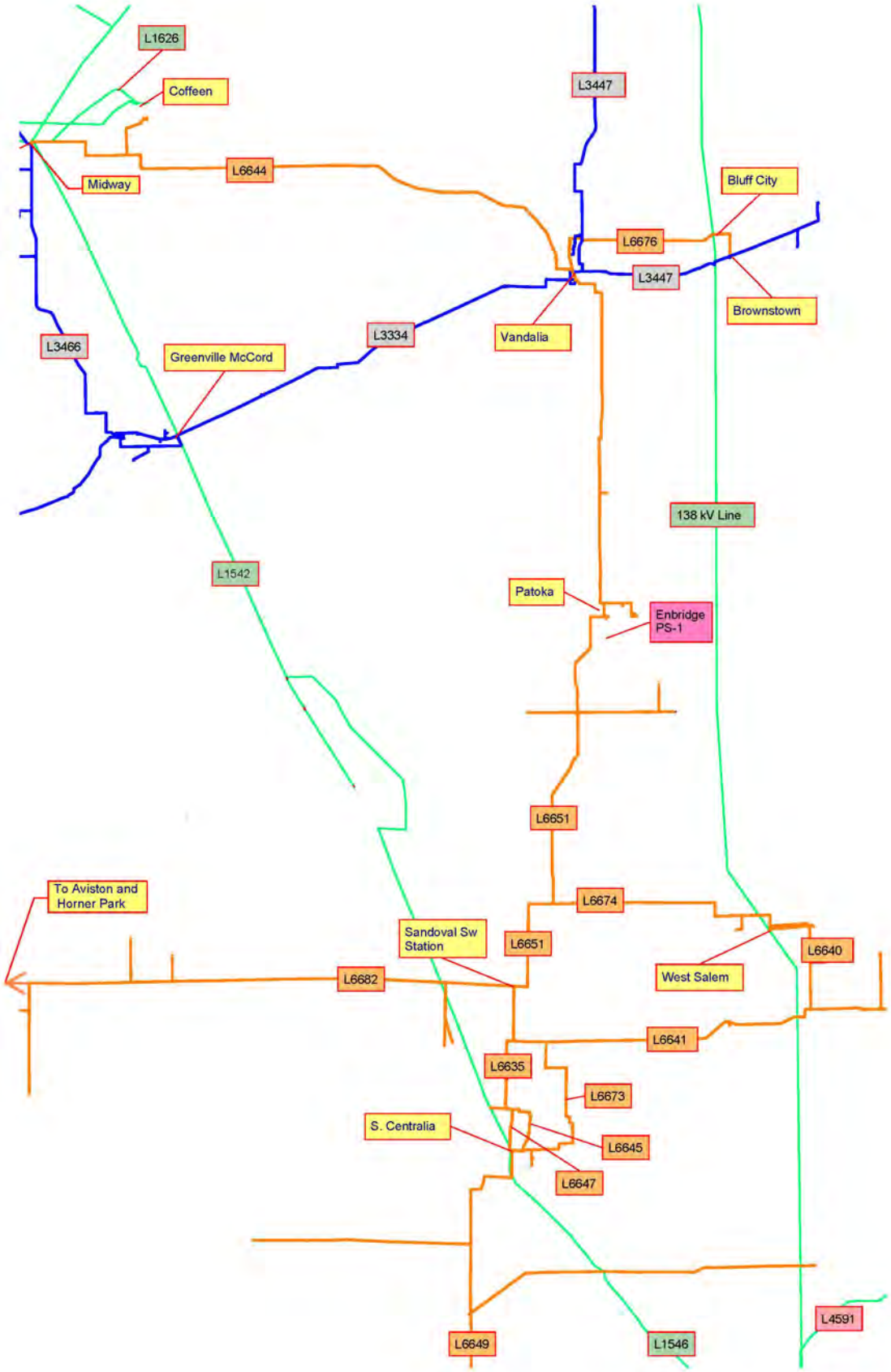
Appendix

A

System Configuration Diagrams

The following two diagrams show the general location of the Patoka area as well as a one-line of the existing Patoka area.

General Location



Appendix

B

Area Load Sensitivity Options

The following three diagrams show the sensitivity to load additions in the area. In addition, system changes to adjust for the additional load are shown.

Attachment

C

New Customer Requirements and Options

s presently considering installing a new pumping station for their pipeline in the Patoka area. The approximate location and their requirements are shown on page C-2 of this Attachment.

Also shown in this attachment are five alternatives considered as possible system connection options if were to want to connect to the AmerenIP system with the load as described on page C-2.

Appendix

D

Patoka Area Loads

Forecasted Load (MVA)						
Bus #	**Load Name**	**2008**	**2009**	**2011**	**2013**	**2018**
96424		1.6	1.7	1.8	1.9	2.1
94209		8.6	8.6	8.6	8.6	8.6
94208		1.9	1.9	1.9	1.9	1.9
96501		4.2	4.2	4.2	4.2	4.2
94207		7.4	7.4	7.4	7.4	7.4
94206		2.1	2.1	2.1	2.1	2.1
91405		2.9	2.9	2.9	2.9	2.9
94056		0.1	0.1	0.1	0.1	0.1
96298		1.4	1.4	1.4	1.4	1.4
91410		2.2	2.2	2.2	2.2	2.2
96771		9.5	9.5	9.7	9.9	10.3
Total		**41.9**	**42.0**	**42.3**	**42.6**	**43.2**

Modeled Flow Into the Area (MVA)						
Bus #	**Load Name**	**2008**	**2009**	**2011**	**2013**	**2018**
96423	Vandalia	16.4	17.2	17.2	17.6	18.0
96769	Sandoval Tap	18.9	18.0	18.3	18.5	18.9
Total		**35.3**	**35.2**	**35.5**	**36.1**	**36.9**

Appendix

E

Line 6651 Available Capacity

Year 2008

Line Section	From Bus		To Bus		Normal Available Capacity	Contingency Available Capacity
MV L6651a	VANDALIA	69.0	SHOBOREA	69.0		

Year 2013

Line Section	From Bus		To Bus		Normal Available Capacity	Contingency Available Capacity
MV L6651a	VANDALIA	69.0	SHOBOREA	69.0		

Appendix

F

Planning Criteria

F.1 Subtransmission Voltage Criteria

The planning criteria for AmerenIP require that the voltage limits at the low voltage bus of distribution and customer substations will be maintained as follows:

	% of Nominal Voltage					
			First-Contingency Outages			
	Normal System		Short-Term		Long-Term	
System	Max	Min	Max	Min	Max	Min
Dist. Sub with ± 10% Regs.*	108	96	108	96	108	96
Dist. Sub with ± 5% Regs.	108	101	108	101	108	101
Dist. Sub with no Regs.	106	103.5	106	103.5	106	103.5
Cust. Subs 12.47, 4.16 &0.48 kV	106	90	106	90	106	90
Cust. With 34.5, 69 or 138 kV delivery	106	90	106	90	106	90

*With capacitors within the substation that can be switched off to reduce the voltage to the 108 level, voltage may reach 110% of normal voltage.

F.2 Subtransmission Contingency Outage Planning Criteria

The subtransmission system will have the capability of supplying total projected peak load in the event of a first-contingency outage such as the loss of any bulk supply transformer or by the loss of any single subtransmission line. Loads less than 40 MVA supplied by a radial subtransmission line will be dropped in the event of an outage of that line.

This Patoka Area Study did not assess the subtransmission system using the recently proposed criteria (i.e. bus outage and double contingencies at reduced load levels).