Prairie State Generation Campus Joint Study Report

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I. Background

A. Interconnection Request

Peabody Energy submitted their original request to Illinois Power to perform a facility study for a 1,500 coal fired power plant on July 3, 2001. Additional information was supplied on July 16, 2001. A revised request was submitted on July 25, 2001.

B. Illinois Power Facility Study

Illinois Power completed the facility study entitled "Washington County 2 Facility Study" for Peabody Energy on October 16, 2001 (See Attachment 1). The following upgrades were needed to remove all of the constraints identified by the load flow analysis.

1) Replace terminal conductor on Line 4511 at Baldwin Power Station and replace nine 345 kV breakers capable of 3000 amps for an estimated cost of $8,433,000.

2) Clear 4.5 miles of conductor in Line 1472 (Turkey Hill Substation to East Belleville Substation) for high temperature (125 C) operation (five H-frame structures would need to be replaced to provide adequate clearance) for an estimated cost of $156,000.

3) Install a new 345 kV line from Baldwin Power Station to Ameren's Rush Island Power Station. This line would be approximately 26 miles long and require a river crossing for an estimated cost of $22,000,000.

4) Install one 345 kV breaker in one of the new 345 kV bays at the Baldwin Power Station being added for the Applicants interconnection for an estimated cost of $843,000.

5) Install 345 kV terminal equipment at the Ameren Rush Island Power Station. This cost estimate would need to be obtained from Ameren.

6) Reconductor two miles of Line 1386 between the Sidney Substation and the tap to Mira Substation for an estimated cost of $463,000.

7) Clear the section of Line 6651 for High Temperature Operation for an estimated cost of $934,000.

8) Replace the Steelville 69/34.5 kV transformer with a 20/37 MVA transformer for an estimated cost of $710,000.

9) Replace the South Belleville 138/34.5 kV transformer #1 with a 60/112 MVA transformer for an estimated cost of $ 1,620,000.

10) Clear the section of Line 3311 for High Temperature Operation for an estimated cost of $1,060,000.

The fault study identified no Illinois Power equipment that exceeded its interrupting rating as a result of the Applicant's new generation.

The stability study identified the following upgrades:

1) A new 345 kV line from the Baldwin Power Station to the Rush Island Power Station (Ameren) is required to stay stable during critical contingencies.

2) Breaker 4556 in Baldwin Power station must be replaced with a 2 cycle breaker in order to shorten clearing times. This cost is has already been captured in the breaker replacement at Baldwin in the Load Flow Analysis section.

3) Replace the relays on breakers 4556, 4572, 4576, 4584 and 4588 to allow faster clearing time for an estimated cost of $131,000.

C. Peabody Interconnection Agreement

On August 9, 2002, Peabody Energy's Prairie State Generating Company and Illinois Power entered into an Interconnection and Operating Agreement (IA). Appendix A of this IA contains the details of the facilities to be constructed and which party would be responsible for building and maintaining those facilities.

Illinois Power would own or control, and operate the following Illinois Power Interconnection Facilities for the purpose of providing Interconnection Service under the IA:

1) The two 345 kV line terminal structures to connect the new plant's 345 kV transmission lines to the Baldwin Switchyard.

2) Relays, meters and associated equipment for the new equipment to be installed within the Baldwin Switchyard.

3) Four 4-345 kV SF6 breakers, structures, rigid and strain bus work, rock, fence, grounding, foundations, cabling, disconnect switches and other associated equipment within the Baldwin Switchyard.

4) The tuning requirements for the generator stability system.

Illinois Power would own or control, construct and operate the following System Upgrades for the purpose of providing interconnection service under the Agreement:

1) Clear 4.5 miles of conductor in Line 1472 from Turkey Hill Substation to East Belleville Substation for high temperature operation (125 C). (System Upgrade to the Transmission System.)

2) Install approximately 26 miles of a new 345 kV transmission line from Baldwin Power Station to Ameren's Rush Island Power Station. (System Upgrade to the Transmission System.)

3) Install one 345 kV breaker in one of the new 345 kV bays at the Baldwin Power Station. (System Upgrade to the Transmission System.)

4) Reconductor two miles of 138 kV transmission line in Line 1386 between Sidney Substation and the tap to Mira Substation. (System Upgrade to the Transmission System.)

5) Clear the section of Line 6651 line from Texaco-Mobil Substation to Line 6651B Tap for high temperature operation. (System Upgrade to Illinois Power distribution system.)

6) Replace terminal conductor on Line 4511 at Baldwin Power Station and replace ten 345 kV breakers capable of 3000 amps. (System Upgrade to the Transmission System.)

Prairie State Generating Company would own or control, install (or cause to be installed) and operate the following interconnection facilities and other equipment for the purpose of receiving interconnection service under the Agreement:

1) Generator step-up transformers for two generators (part of the Generator Interconnection Facilities).

2) Two generator breakers used for synchronization (part of the Generator Interconnection Facilities).

3) Bus, cable, structures, foundations, jumpers, and terminal connectors to connect the Facility to the Facility's step-up transformers (part of the Generator Interconnection Facilities).

4) Two 345 kV Transmission lines approximately 10 miles long, including structures, foundations, jumpers, and terminal connectors to

connect the Facility step-up transformers to the Baldwin Switchyard (part of the Generator Interconnection Facilities).

5) A generator power stabilizer (part of the Facility).

D. Ameren Generation Impact Study

Ameren's generation impact study included two scenarios. The first scenario excluded the transmission upgrades identified by Illinois Power in the Washington County 2 facility study. Under this scenario, Ameren identified several limiting elements on their system including the Cahokia to Campbell Tap 345 kV line, the Sioux to Roxford 345 kV line, the Sioux to Huster 1 138 kV line and the Sioux to Huster 3 138 kV line. No system reinforcements were proposed to relieve the constraints identified under Scenario 1.

Scenario 2 included the proposed Baldwin to Rush Island 345 kV line, historical operational limits on the Rush Island to St. Francois 1 345 kV line and an evaluation of losses. Under this scenario, Ameren identified several limiting elements on their system including the Lutesville to St. Francois 1 345 kV line, the Makanda to Ordill 138 kV line, the Ordill to Marion South 138 kV line, the Kelso to Miner 161 kV line, the St. Francois Esther section of St. Francois to Rivermines 2 138 kV line, the St. Francois to Rivermines 1 138 kV line, the Rivermines to Fredericktown section of the Rivermines to Cape 1 138 kV line and the Avena Tap to Ramsey 138 kV line. They estimated the cost to remove these limits to be $35 million.

E. Joint Study

The IA between Prairie State and Illinois Power requires a new Illinois Power/Ameren interconnection point via the Baldwin to Rush Island 345 kV line. In their report, Ameren expressed concerns about the impacts this interconnection would have on their system. Given the highly integrated nature of the Illinois Power and Ameren systems, it was decided that a joint study with Ameren, Illinois Power and Peabody would be the best way to develop a reinforcement plan that would best serve both the users and owners of the transmission system.

II. Study Progression

A. MOU

A memorandum of understanding (MOU) was entered into by Illinois Power, Ameren and Prairie State Generating Company in August of 2002

to perform a joint study. The intent of the study is described in section 2 of the MOU was as follows:

1) Incorporate data provided by Prairie State;

2) Evaluate the applicability of the previous studies results;

3) Include power flow, fault conditions and system stability analyses;

4) Identify impacts on the combined electric delivery systems of Illinois Power and Ameren and on the Prairie State Facility;

5) Investigate the merits, justification, estimated costs and adequacy of all Optimal Options;

6) Develop a schedule of major upgrade activities for the Optimal Options; and

7) Include a listing of the authorizations and approvals required for the Optimal Option.

B. Meetings and Conference Calls

Beginning on June 14, 2002, several meetings and conference calls occurred over the next ten months to study the connection of the new plant and develop the preferred configuration. These efforts included:

- Discussion of the MOU and initial studies performed by Ameren and Illinois Power
- Verification of the generator data to be used for the studies
- Development of six configurations to be screened in Phase 1 of the study
- Development of a tentative schedule for the study
- Agreement on deliverables from the study
- Narrowing the configurations to proceed to Phase 2 of the study
- Inclusion of the Midwest Independent System Operator in the study process
- Analysis of load flows, fault studies and stabilities studies
- Analysis of cost estimates, reliability and operational advantages to determine an optimal configuration

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III. Phase I Study

A. Plan Development

A joint study group consisting of Ameren, Illinois Power and Prairie State was formed to explore potential solutions to the constraints that the Prairie State generation would place on the transmission system. The study group developed six potential plans to be evaluated in Phase I of the Joint Study. Plans 1-5 are based upon the original interconnection configuration proposed by Prairie State (See Figure 1). In this configuration, two 345 kV lines would be constructed from Prairie State to the Baldwin Substation. The alternate configuration would consist of splitting two 345 kV lines and building a new substation near PSCG (See Figure 2). The plans are described below:

1) Plan 1 is the Baldwin-Rush Island 345 kV line. Twenty six miles of 345 kV line would be built from the Baldwin Substation to the Rush Island Substation. Ameren would own the line section in Missouri and Illinois Power would own the line section in Illinois. . This was the original solution proposed by Illinois Power and included in the IA with Prairie State (See Figure 3).

2) Plan 2 is the Baldwin-Dupo Ferry 345 kV line. Twenty eight miles of 345 kV line would be built from the Baldwin Substation to the Dupo Ferry Substation. The success of Plan 2 depends heavily upon a new 345 kV line planned by Ameren from their Cahokia Substation to the Dupo Ferry Substation (See Figure 4).

3) Plan 3 is the Baldwin-Stallings 345 kV line. Forty seven miles of 345 kV line would be built from the Baldwin Substation to the Stallings Substation (See Figure 5).

4) Plan 4 is the Baldwin-Turkey Hill-Cahokia 345 kV line. Twenty one miles of 345 kV line would be built from the Baldwin Substation to the Turkey Hill Substation. An existing 138 kV line from Turkey Hill to Cahokia would be upgraded to a 345 kV line (See Figure 6).

5) Plan 5 is the Baldwin-Mt Vernon 345 kV line. Fifty miles of 345 kV line would build from the Baldwin Substation to the Mt Vernon Substation (See Figure 7).

6) Plan 6 is an alternate interconnection configuration that would tap the Baldwin to Mt Vernon and Baldwin Stallings 345 kV lines. The existing 345 kV line between the Baldwin Substation and the Stallings

Substation would be cut and brought into the new substation near the Prairie State plant to form two separate lines. The existing 345 kV line between the Baldwin Substation and the Mt Vernon Substation would be cut and brought into the new substation near the Prairie State plant to form two separate lines (See Figure 8).

B. Stability Analysis

The stability base case is an updated version of the North American Electric Reliability (NERC) Multi-Regional Modeling Working Group (MMWG) summer 2001 base case. It models most of the Eastern US interconnection. The Ameren data was replaced with data that was developed for the MAIN FSSG 2004 base case. Illinois Power data was updated with changes submitted for the MMWG 2002 version of the 2004 summer base case. Both utilities used the same base case for this analysis.

Ameren and Illinois Power agreed to perform a limited stability analysis to ensure that each of the proposed plans would result in a stable system under selected fault scenarios. Several severe faults were simulated for each plan in the Phase I analysis.

For the base configuration, an additional 345 kV line is need out of the Baldwin Substation in order for the Baldwin and Prairie State generating units to remain stable. In the alternate configuration, no additional lines are needed to maintain stability.

C. Load Flow Analysis

The base case for the load flow analysis was the 2007 summer MMWG case (2001 series). It was updated to incorporate the latest Ameren and Illinois Power changes and planned reinforcements.

Using the load flow base case Illinois Power tested each plan with each of the following three dispatch scenarios:

1) Illinois Power generation units were dispatched based on the most current economic dispatch information.

2) Wood River and Stallings power plants were fully dispatched.

3) Wood River and Stallings power plants were fully dispatched. In addition, Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched.

Using the load flow base case Ameren tested each plan with each of the following six dispatch scenarios:

1) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched.

2) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched. Prairie State generation was dispatched assuming 50% would be transferred to Northern Illinois and 50% would be transferred to TVA.

3) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched. Prairie State generation was dispatched assuming 50% would be transferred to Entergy and 50% would be transferred to TVA.

4) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched. Loads in control areas north and generation in control areas south of the Ameren system were reduced to simulate a high north-south bias condition flowing across the Midwest.

5) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched. Loads in control areas north and generation in control areas south of the Ameren system were reduced to simulate a high north-south bias condition flowing across the Midwest. Prairie State generation was dispatched assuming 50% would be transferred to Northern Illinois and 50% would be transferred to TVA.

6) Ameren's Callaway, Labadie, Rush Island, Coffeen and Newton power plants were fully dispatched. Loads in control areas north and generation in control areas south of the Ameren system were reduced to simulate a high north-south bias condition flowing across the Midwest. Prairie State generation was dispatched assuming 50% would be transferred to Entergy and 50% would be transferred to TVA.

Each utility evaluated the plans using their own planning criteria. For each constraint identified upgrades were found that would relieve the overload.

D. System Upgrades

Constraints were identified for each plan based on planning criteria. The required upgrades are listed below for each plan.

1) Plan 1 requires three 345 kV breakers and the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. No upgrades were required on the Ameren system.

2) Plan 2 requires the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. Ameren would need a second 345/138 kV transformer from their 345 line from Cahokia near Dupo Ferry.

3) Plan 3 requires three 345 kV breakers and the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. A new 345/138 transformer would be needed at the Stallings Substation in addition to the upgrade of 345 kV terminal equipment and a breaker to 3000 amp capability. Seven miles of the Stallings to Madison Industrial 138 kV line would require reconductoring. No upgrades were required on the Ameren system.

4) Plan 4 requires three 345 kV breakers and the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. Five miles of the Porter Road to Highland 138 kV line would require reconductoring. A switch and wave trap would need to be replaced at the East Belleville Substation. On the Ameren system the Effingham to Newton 138 kV line would require reconductoring and the Cahokia 345/138 Transformer #8 would have to be upgraded from 560 to 700 MVA.

5) Plan 5 requires three 345 kV breakers and the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. A second 345 kV line from the Turkey Hill Substation to the Stallings Substation is required. Line terminals for the Baldwin to Turkey Hill 345 kV line need to be upgraded to 3000 amp capability at both the Baldwin and Turkey Hill Substation. The line breaker at Baldwin should also be upgraded to 3000 amps. A new 345/138 transformer and three new 345 kV breakers would be needed at the Stallings Substation in addition to the upgrade of 345 kV terminal equipment and a breaker to 3000 amp capability. Five miles of the Stallings to Line 1452A Tap 138 kV line would require reconductoring.

6) Plan 6 requires three 345 kV breakers and the Baldwin to Cahokia 345 kV line terminal be upgraded to 3000 amp capability at the Baldwin Substation. A 345 kV line from the Turkey Hill Substation to the Stallings Substation is required. Line terminals for the Baldwin to Turkey Hill 345 kV line need to be upgraded to 3000 amp capability at both the Baldwin and Turkey Hill Substation. The line

breaker at Baldwin should also be upgraded to 3000 amps. A new 345/138 transformer and three new 345 kV breakers would be needed at the Stallings Substation in addition to the upgrade of 345 kV terminal equipment and a breaker to 3000 amp capability. Five miles of the Stallings to Line 1452A Tap 138 kV line would require reconductoring.

E. Cost Comparisons

Preliminary cost estimates for screening were developed and analyzed by Peabody Energy, Ameren and Illinois Power for the interconnection costs and system upgrades.

Plan 5 was clearly the most unfavorable plan. The Baldwin to Mt Vernon 345 kV line was not heavily loaded in the load flows indicating the flow of power was not toward the east. This plan would require construction of two 345 kV lines resulting in the need to acquire right-of-way and construct of over 70 miles of 345 kV line. Due to the high cost this plan was eliminated from further consideration.

Plan 3 would require right-of-way and construction of 47 miles of 345 kV line. The routing of this line would be separated from the existing Baldwin to Stallings line to reduce the possibility of losing both lines due to a common event. Obtaining right-of-way along this route is expected to be very difficult. Substantial upgrades at the Stallings substation increased the cost of the plan. This plan was not cost effective compared to the other remaining plans and thus it was eliminated from further consideration.

Plan 4 would require right-of-way and construction of 21 miles of 345 kV line. It would also require the conversion of an existing 138 kV line to 345 kV. The loss the 138 kV line would degrade the reliability of the 138 kV system in this area. Ameren also express concerns about the impact of this plan on their 138 kV system. Due to the higher comparative cost and negative impact on reliability this plan was eliminated from further consideration.

Plan 6 was the only plan based on the alternate interconnection configuration. At the time of the plan development, no additional line was associated with this plan since a new line was not needed to maintain stability. Based on the load flow analysis, the need for a new line was identified. A new 345 kV line from the Turkey Hill Substation to the Stallings Substation was chosen to meet this requirement. This upgrade resulted in this plan having a higher total cost than plans 1, 2 and 4.

During the plan evaluation stage, it was decided to revaluate Plan 6 with the Baldwin to Rush Island 345 kV line since it appeared that this might be a lower cost plan. From the initial screening, the alternate configuration also appeared to be most favorable from a stability perspective. Plan 6 provided the Prairie State plant with four 345 kV outlets versus two with the other plans. Plan 6 was therefore modified and revaluated. The total cost for the modified Plan 6 was $57,550,000.

These cost estimates are provided below for each plan:

1) Plan 1 : $ 54,800,000

2) Plan 2 : $ 64,680,500

3) Plan 3 : $ 89,100,000

4) Plan 4 : $ 68,580,000

5) Plan 5 : $113,800,000

6) Plan 6 : $ 74,420,000

7) Modified Plan 6 : $ 57,500,000

Plans 1, 2 and modified 6 were retained for further evaluation.

IV. Phase II Study

A. Assumptions

The 2002 MMWG series of load flows were released during the middle of the Phase I analysis. For the second phase of the study, the group decided to use the more recent 2009 summer and winter load flow cases. The stability studies would continue to use the same base case since none of the 2002 series models had been thoroughly tested for dynamic studies. Each company would use their own short circuit models. Presently these models include only equivalents for systems beyond a company's border. Additional sensitivities would be based on each company's specific planning criteria and internal models.

B. Load Flow Analysis

The Illinois Power detailed load flow analysis with modified Plan 6 implemented revealed only one transmission constraint for outlet purposes. Illinois Power performed an outlet evaluation for Prairie State

by transferring the power proportionately to all surrounding regions. This evaluation found that the Baldwin to Cahokia 345 KV line terminal at the Baldwin Substation would constrain output from the plant. This upgrade was actually implemented for other reasons while the Phase II analysis was in progress, and thus it was not included in the cost estimates.

The Ameren detailed load flow analysis with modified Plan 6 implemented identified the need for three system upgrades as follows:

1) Reconductor the AmerenCIPS Newton to Effingham 138 kV line and upgrade the line terminals.

2) Replacement of the AmerenUE Cahokia 345/138 kV Transformer #8.

3) Increase the ground clearance on the AmerenUE Cahokia to North Coulterville 230 kV line.

All three of these upgrades were include in the final cost estimates for Plan 1 and modified Plan 6.

C. Stability Analysis

Fifty scenarios were evaluated to satisfy the Illinois Power planning criteria. The first twenty-seven scenarios pertain to existing facilities. Of these faults, ten are permanent three-phase faults, fifteen are double-line-to-ground faults with breaker failures and two are single-line-to-ground faults for the same phase of both circuits on a double circuit tower. The last twenty-three scenarios pertain to new facilities. Of these faults, seven are permanent three-phase faults, fourteen are double-line-to-ground faults with breaker failures and two are single-line-to-ground faults for the same phase of both circuits on a double circuit tower.
None of the 3-phase or single-phase faults simulated resulted in any of the Baldwin or Peabody generating units losing synchronism with the system. One of the double-line-to-ground fault scenarios did cause Baldwin 2 to become unstable and loose synchronism with the system. This scenario was modified by reducing the clearing time of Breaker 4556 one cycle. With this modification all Baldwin and Peabody units remained stable.

Ameren's review of stability found transient stability to be acceptable. Their small-signal stability analysis indicated that power system stabilizers would be required on all units at the Prairie State plant and Baldwin.

D. Fault Analysis

Illinois Power's detail fault study found that all the 345 kV breakers in the Baldwin Substation will need to be replaced based on fault duty. Due to

the large amount of local generation, the breakers are overdutied both thermally and dielectrically due to the high rate of rise of the transient recovery voltage. TRV control capacitors will be required on the breaker terminals to resolve this concern. Additional equipment that must be replaced includes the 345 kV circuit switcher, all breaker disconnect switches, generator unit disconnect switches, the grounding system and the 345 kV wave traps.

Relays upgrades will be required for the two 345 kV lines that will be used to supply the new substation at Prairie State according to modified Plan 6. These upgrades impact both the Baldwin to Mt Vernon 345 kV line and the Baldwin to Stallings 345 kV line.

Ameren short circuit study identified that two AmerenUE Labadie 345 kV circuit breakers as being overstressed and need to be replaced.

E. Cost Comparison

Total costs for Plan 1 is $77,449,500 compared with $72,622,000 for modified Plan 6. These costs do not include gross-up for taxes. Ameren's costs would be the same for both plans. Since the new line and upgrades are identical, the interconnection configuration drives the cost differential.

V. Conclusions

Based on the final cost comparison and robustness, the group agreed that modified Plan 6 was the optimal plan. The group agreed that this was the best plan to move forward with. The IA will be modified to incorporate the final cost estimates and schedules associated with this plan. The joint study represents a tremendous accomplishment that could not have been completed without the cooperation of all parties involved. This same spirit of cooperation must now be carried forward to the regulatory bodies responsible for granting the approvals necessary to implement this plan.