

TRANSMISSION SYSTEM REVIEW
VOLUME I

KENTUCKY PIONEER ENERGY
CASE NO. 2002-00312

Prepared for:

**Kentucky State Board
on Electric Generation
and Transmission Siting**

Prepared by:

CAI Commonwealth Associates, Inc.
engineers • consultants • construction managers



March 3, 2003

Mr. Robert A. Amato, P.E.
Director, Division of Engineering
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, KY 40602

**SUBJECT: TRANSMISSION SYSTEM REVIEW,
KENTUCKY PIONEER ENERGY PROJECT
CASE NO. 2002-00312**

Dear Mr. Amato:

The enclosed report provides a summary of our review and analysis of the impacts of the Kentucky Pioneer Energy (KPE) Project on the reliability of the transmission grid; specifically with regard to impact on the reliability of service to retail customers.

Our review is based on the following:

1. Information submitted in the KPE application and responses.
2. Our own independent power flow analysis.
3. A review meeting held with East Kentucky Power Cooperative (EKPC).

Study conclusions are as follows:

1. Based on transmission studies completed to-date by EKPC and by our own independent power flow analysis, the proposed KPE plant with its associated transmission system additions and upgrades will not decrease the reliability of service to retail customers.
2. Our review and discussions with EKPC indicate that additional transmission studies will be performed to further define and evaluate transmission system conditions as the in-service date of the KPE project is established relative to other future power plant or transmission projects by EKPC and its neighboring utilities. Future studies will include short circuit and transient stability analysis, which are not available at this time.

Since additional transmission studies will be required, we recommend that the Kentucky Siting Board provide conditional approval of the project at this time and request that the Board be provided with the final transmission studies for review prior to project commencement.

Sincerely,

David A. Shafer, P.E.
Manager, Electrical Systems
Kentucky License No. 22509

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At the offices of
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P.O. Box 1124
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March 3, 2003

Approved for submittal:



David A. Shafer, P.E.
Manager, Electrical Systems

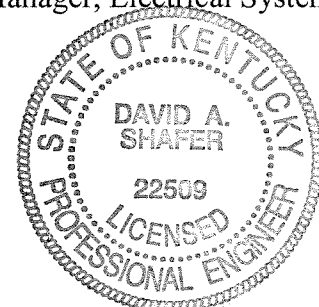


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- Case 300s04 – CT’s 4, 5, and EA Gilbert, internal dispatch
- Case 310s04 – CT’s 4, 5, and EA Gilbert, external dispatch
- Case 410s04 – CT’s 4, 5, EA Gilbert, and KPE, external dispatch

INTRODUCTION

The General Assembly of the Commonwealth of Kentucky, in May 2002, enacted legislation (SB257) to create the Kentucky State Board on Electric Generation and Transmission Siting (Board). The Board is responsible for issue of construction certificates for merchant electric generating facilities.

Obtaining a construction certificate for a merchant electric generating facility requires that an application be filed with the Board. The requirements of the application and the criteria for evaluation are provided in the statute.

Kentucky Pioneer Energy, LLC (KPE) is developing a 540 MW merchant power plant in Clark County, Kentucky, near Trapp, and has submitted an application to the Board in compliance with the statute.

While the requirements of the application are broad, this report evaluates only one aspect of those requirements, namely, the impact of the merchant power plant on the electric transmission system. According to SB257, Section 6, Paragraph 1.f., the completed application is required to include, “An analysis of the proposed facility’s projected effect on the electricity transmission system in Kentucky.”

The evaluation criterion to be used by the Board is provided in SB257, Section 6, Paragraph 1.f., “Whether the additional load imposed upon the electricity transmission system by use of the merchant electric generating facility will adversely affect the reliability of service for retail customers of electric utilities regulated by the (Kentucky) Public Service Commission.”

Commonwealth Associates, Inc. (CAI), an engineering consulting firm that specializes in the analysis and design of high voltage power transmission systems, has been retained by the Board to assist in the evaluation of the affect of the proposed power plant on the electric transmission grid.

BACKGROUND

The project description, as provided in the application for construction by KPE, follows:

“Kentucky Pioneer Energy, LLC (KPE) intends to construct and operate a base-load 540 megawatt Integrated Gasification Combined Cycle (IGCC) electrical generating facility in Clark County, Kentucky, approximately two miles west of Trapp Elementary School and one mile from Highway 89. The plant would be fueled by synthetic gas produced on-site from Kentucky coal and Refuse Derived Fuel (RDF) pellets. The power plant will be located at an existing generating facility, on a 300-acre parcel leased from East Kentucky Power Cooperative (EKPC) fully within their approximate 3200-acre J. K. Smith site. The facility will jointly utilize existing buildings, roads, rail facilities, and other infrastructure. The power plant will receive water from EKPC under its Withdrawal Authorization using the existing large capacity pipeline originally installed by EKPC. KPE will install a new intake structure at the Kentucky River to support the

volume requirements of both KPE and EKPC. EKPC will meter the flow to KPE. Any wastewater will be treated by KPE and discharged to the Kentucky River under a Discharge Permit via the existing large capacity discharge line installed by EKPC.

The power plant will consist of two gas turbine driven generator sets, each with a heat recovery steam generator (HRSG). Steam from the two HRSG units will operate a steam turbine-driven generator set. The power will be delivered to the wholesale customer at the Interconnect Point, located at the facilities generator step up transformers.

East Kentucky Power Cooperative is the wholesale customer for 100% of the power, for use by its own Cooperative Members and their own Kentucky customer needs. EKPC will receive the power at the Interconnect Points and be responsible for all transmission requirements.”

EKPC Transmission Study

East Kentucky Power Cooperative (EKPC) will install two combustion turbine generators at the J. K. Smith generating station (CT #4 and CT #5) prior to the completion of the Kentucky Pioneer project. If the Kentucky Pioneer project could not be completed, future generating units were being planned for installation at the J. K. Smith and H. L. Spurlock generating stations. The future generation would include four additional CT’s at J. K. Smith and E. A. Gilbert Unit 3 at Spurlock.

EKPC conducted three transmission system studies; one for the addition of CT’s 4 and 5 at JK Smith (with Phase I transmission), the second for CT’s 4 and 5 plus the KPE generators (with Phase II transmission), and the third for CT’s 4 through 9 at JK Smith and the EA Gilbert unit at Spurlock. The transmission facilities listed in Table I below were identified by EKPC for these projects. A transmission system map of the area around the KPE plant, Exhibit 1, depicts the proposed new transmission facilities for these projects. Interconnection of the EA Gilbert unit would include some of the same facilities shown in Table I below, marked with an asterisk, but also requires the existing Zimmer (Cinergy) to Stuart (Dayton Power and Light) transmission line be looped-in to Spurlock.

One-line drawing, Exhibit 2, also depicts the proposed transmission system facilities. Detailed impedances and power ratings of the facilities that were modeled for Phase I, Phase II, and the EA Gilbert project are shown in the Appendix.

TABLE I

Phase I Facilities for CT #4 and CT #5 (Case 101)

Item Number	Location	Voltage (kV)	Normal Rating (MVA)	Conductor Type	Distance (Miles)
1.1	Second Fawkes EKPC – LGEE Tie	138	259	Identical to circuit 1	
1.2	JK Smith – Lake Reba Tap	138	251	954 MCM ACSR	12.0
1.3	Lake Reba Transformer	161/138	202		
1.4	Reconductor Dale – Boonesboro Tap	138	252	2-477 MCM ACSR	2.8

Phase II Facilities for CT #4, CT #5, and KPE (Cases 200 and 210)

Item Number	Location	Voltage (kV)	Normal Rating (MVA)	Conductor Type	Distance (Miles)
2.1, 3.1	*JK Smith Transformer	345/138	434		
2.2	KPE – JK Smith Circuits #1, 2	138	425	2-954 MCM ACSR	0.8 each
2.3, 3.3	*JK Smith – Spencer Road	138	251	954 MCM ACSR	17.0
2.4, 3.4	*JK Smith – Avon	345	717	2-954 MCM ACSR	17.0
2.6	Spencer Road Transformer	138/69	72		
2.7	Farmers Transformer	138/69	40		
2.8	Reconductor Clark County – Parker Seal	69	112	795 MCM ACSR	0.8

Additional Facilities for EA Gilbert Unit 3 (Cases 300, 310, and 410)

Item Number	Location	Voltage (kV)	Rating (MVA)	Conductor Type	Distance (Miles)
3.5	Loop-in *Spurlock to Zimmer – Stuart Line	345	1195	2-954 MCM ACSR	Added 8.9

Items denoted with an asterisk are transmission facilities identified by EKPC for the addition of six CT's at JK Smith and the EA Gilbert unit at Spurlock.

EKPC also noted that upgrades would be made to terminal facilities at Dale Substation (JK Smith line) to 2000-Ampere. The Spencer Road transformer will be replaced with the unit from the LG&E Energy (LGEE) Boonesboro North Substation, and the Farmers Substation transformer will be replaced with the unit from the Spencer Road Substation.

From the Phase I and Phase II studies, EKPC determined that the KPE generators will help provide increased transmission system reliability and voltage support for a contingency where the two Spurlock generators are off line, improving the power quality to customers in the area. In addition, EKPC noted that the transmission facility improvements would provide:

- Additional loadability margin during the most critical contingency
- Deferral of several transmission facility upgrades
- Reduction in transmission system losses

ANALYSIS

Power Flow Models

CAI performed an independent power flow study to determine the impact on the bulk power system for the addition of CT's #4 and #5 at the JK Smith generating station and the Kentucky Pioneer Energy project. The studies were conducted in two steps; for CT's 4 and 5 alone, and in combination with the KPE generators. Additional power flow studies were performed to analyze the addition of two CT's at JK Smith in combination with the EA Gilbert unit at Spurlock and then adding the KPE generators. The EA Gilbert study prepared by CAI differs from the study

done by EKPC in that the EKPC study included six CT's at JK Smith and did not include the KPE generators.

The reference case used to develop the power flow models was the 2002 Series, NERC/MMWG Base Case Library for 2004 Summer. The JK Smith CT's #4 and #5 and Phase I facilities were already modeled in the 2004 Summer case, with the exception of the second Fawkes tie line (Case 100). The transmission facility data table in the appendix identifies the facilities and the data used in the power flow models. Case 101 is the same as Case 100 but also includes the second 138 kV Fawkes tie. For the Phase II model, the impedance values for the additional lines and transformers were taken from the 2009 Summer model from the same 2002 Series NERC/MMWG Base Case Library. They are marked with double asterisks in the transmission facility data table; otherwise CAI calculated the values. This table also includes the transmission facilities modeled for the addition of the EA Gilbert unit at Spurlock. The generation dispatch used in all the cases and the system loading, area losses, and generation summary for EKPC are shown below in Table II. The output level of the KPE plant was modeled at 540 MW and the EA Gilbert unit at 268 MW.

Cases 200 and 210 include CT's #4 and #5, the KPE generators, and both the Phase I and Phase II transmission facilities. Cases 200 and 210 are identical except for the generation dispatch used. Case 200; generation at Spurlock 2 and Dale 1 in the EKPC system was reduced when the generation from KPE was added. Case 210; generation at Spurlock and Dale was not reduced; the KPE generation was dispatched (exported) to six utilities; three in the north and three in the south.

Cases 300 and 310 include CT's #4 and #5 at JK Smith, the EA Gilbert unit at Spurlock, and the 345 kV transmission line looped-in to Spurlock. Case 300; generation at Cooper 2 and Love Hydro in the EKPC system was reduced when the EA Gilbert unit was added. Case 310; generation at Cooper and Love was not reduced; the EA Gilbert generation was dispatched to the same six utilities as in case 210.

Case 410 includes CT's #4 and #5 at JK Smith, EA Gilbert Unit 3, and the KPE generators. The generation was dispatched to the same six utilities as in cases 210 and 310.

The power flow study was conducted using CAI's TRANSMISSION 2000[®] Power Flow (PFLOW) program and its associated Contingency Processor (CP). Computer-generated results are provided in the appendix.

TABLE II

Generator Dispatch (MW)

Generator Name	Voltage (kV)	Phase I		Phase II		CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE
		CT's 4 and 5		CT's 4, 5, and KPE		CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE
		Case 100	Case 101	Case 200	Case 210	Case 300	Case 310	Case 410
E.A. Gilbert 3	345	N/A	N/A	N/A	N/A	268	268	268
Kentucky Pioneer	138	N/A	N/A	540	540	N/A	N/A	540
H.L. Spurlock 2	345	519	519	3	534	530	531	540
H.L. Spurlock 1	138	325	325	325	325	325	325	325
J.S. Cooper 2	161	225	225	225	225	0	225	225
J.S. Cooper 1	161	116	116	116	116	116	116	116
J.K. Smith 1	138	110	110	110	110	110	110	110
J.K. Smith 2	138	110	110	110	110	110	110	110
J.K. Smith 3	138	110	110	110	110	110	110	110
W.C. Dale 3	69	80	80	80	80	80	80	80
W.C. Dale 4	138	80	80	80	80	80	80	80
J.K. Smith 4	138	70	70	70	70	70	70	70
J.K. Smith 5	138	70	70	70	70	70	70	70
Love Hydro	138	40	40	40	40	0	40	40
W.C. Dale 1	69	24	24	0	24	24	24	24
W.C. Dale 2	69	24	24	24	24	24	24	24
Sum of Generation:	---	1903	1903	1903	2458	1917	2183	2732

- Notes: 1. N/A = Facility did not exist in the case
 2. Shading shows the difference between cases

System Loading, Area Losses, and Generation Summary (MW)

	Phase I		Phase II		CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE
	CT's 4 and 5		CT's 4, 5, and KPE		CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE
	Case 100	Case 101	Case 200	Case 210	Case 300	Case 310	Case 410
Load:	1948	1948	1948	1948	1948	1948	1948
Losses:	67	67	67	82	81	79	88
Total:	2015	2015	2015	2030	2029	2027	2036
Generation:	1903	1903	1903	2458	1917	2183	2732
Total Interchange:	-112	-112	-112	428	-112	156	696
Sum:	2015	2015	2015	2030	2029	2027	2036

- Notes: 1. Interchange imports are negative
 2. Interchange exports are positive

Power Flow Results

The KPE plant injects 540 MW of power at 138 kV to the JK Smith Substation. The EA Gilbert generator injects 268 MW into the bisected 345 kV line between Zimmer and Stuart and into the 138 kV transmission system at the Spurlock Substation. The normal system power flows are shown in Table III below.

TABLE III

Normal System Power Flows at JK Smith and KPE Substations (MW)

Location	Normal Rating (MVA)	Phase I CT's 4 and 5 Case 101	Phase II CT's 4, 5, and KPE		CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE Case 410
			Case 200	Case 210	Case 300	Case 310	
JK Smith to Avon 345 kV	434	---	206	101	-154	-141	122
KPE Circuit 1 to JK Smith 138 kV	425	---	167	219	---	---	209
KPE Circuit 2 to JK Smith 138 kV	425	---	167	219	---	---	209
JK Smith to Lake Reba Tap 138 kV	251	156	190	223	169	164	217
JK Smith to Spencer Road 138 kV	251	---	169	173	118	119	173
JK Smith to Dale 138 kV	251	83	157	174	86	84	170
JK Smith to Powell County 138 kV	251	125	151	174	140	135	169
JK Smith to Fawkes 138 kV	251	105	136	163	110	108	158

Note: 1. --- = Facility does not exist
 2. Negative values indicate a flow in the opposite direction

Table IV lists the overloaded facilities under normal system conditions (i.e., all transmission lines in-service). There are no normal system overloads in Cases 101 or 200.

TABLE IV

Overloaded Facilities Under Normal System Conditions

Location	Normal Rating (MVA)	Phase II CT's 4, 5, and KPE	CT's 4, 5, and EA Gilbert		CT's 4, 5, EA Gilbert, and KPE
		Case 210 Max (%)	Case 300 Max (%)	Case 310 Max (%)	Case 410 Max (%)
Morehead to Rodburn 69 kV	33	102	---	---	109
AO Smith to Spencer Road 69 kV	48	101	---	---	102
Rodburn 138-69 kV Transformer	33	101	104	103	106

Note: --- = Facility was loaded to less than 85% of the normal rating

A comparison of the transmission system overloads under single contingency conditions is shown in Table V. A review meeting was held with EKPC to discuss the study results, specifically the overloads identified in Table V. The transmission line ratings in Table V that were used to evaluate the transmission system are today's ratings for these facilities. As future generation or loads develop, these facilities will be upgraded. Most of the lines are presently limited by terminal equipment. When necessary, this terminal equipment can be replaced, allowing the existing lines to be operated at higher load levels. Future transformer overloads will be mitigated, either by operating procedures or by adding new transformers. EKPC provided information regarding new ratings, where replacement of terminal equipment provides an upgrade path, or other mitigation strategies proposed for the overloads identified in Table V. These are summarized on Table VI.

CONCLUSIONS

1. Based on transmission studies completed to-date by EKPC and by our own independent power flow analysis, the proposed KPE plant, with its associated transmission system additions and upgrades, will not decrease the reliability of service to retail customers.
2. Our review and discussions with EKPC indicate that additional transmission studies will be performed to further define and evaluate transmission system conditions as the in-service date of the KPE project is established relative to other future power plant or transmission projects by EKPC and its neighboring utilities. Future studies will include short circuit and transient stability analysis, which are not available at this time.

Since additional transmission studies will be required, we recommend that the Kentucky Siting Board provide conditional approval of the project at this time and request that the Board be provided with the final transmission studies for review prior to project commencement.

TABLE V
Overloads Under Single Contingency Conditions
Maximum % of Emergency Rating

Number of Facilities	Location	Circuit	Base kV	Emergency Rating (MVA)	CT's 4, 5, EA Gilbert and KPE					
					CT' 4 and 5 Case 101	CT's 4, 5 and KPE Case 200	CT's 4, 5 and KPE Case 210	CT's 4, 5 and EA Gilbert Case 300	CT's 4, 5 and EA Gilbert Case 310	KPE Case 410
1	Fawkes Tap to Lake Reba Tap 138 kV	1	138	163	95	102	115	108	104	118
2	Boonesboro North Tap to Dale 138 kV	1	138	252	---	97	113	---	---	113
3	Lake Reba to Lake Reba Tap 138 kV	1	138	171	97	102	108	102	100	109
4	Kenton to Spurlock 138 kV	2	138	280	90	---	102	113	112	109
5	Loudon Avenue to Avon 138 kV	1	138	302	---	---	96	---	---	103
1	Fawkes to Richmond South 69 kV	1	69	72	140	140	140	140	140	140
2	Berea to Lake Reba 69 kV	1	69	72	139	138	138	139	139	138
3	Fawkes to North Madison 69 kV	1	69	56	129	128	129	129	129	129
4	Lake Reba to Richmond 69 kV	1	69	56	106	114	121	110	109	122
5	Winchester South to Winchester 69 kV	1	69	80	105	89	98	87	88	99
6	Baker Lane to Holloway Junction 69 kV	1	69	69	101	101	101	101	101	101
7	Clark County to Sylvania 69 kV	1	69	90	91	116	122	112	112	124
8	Farmers to Morehead West 69 kV	1	69	48	86	99	120	110	109	124
9	Salt Lick to Spencer Road 69 kV	1	69	22	---	122	114	---	---	112
10	AO Smith to Spencer Road 69 kV	1	69	59	---	106	111	107	106	112
11	Parker Seal to Winchester 69 kV	1	69	79	---	97	104	92	92	106
12	Rockwell to Winchester 69 kV	1	69	63	---	---	104	---	---	105
13	North Corbin to Sweet Hollow 69 kV	1	69	72	96	97	100	94	97	101
14	Rice Tap to Waco 69 kV	1	69	47	---	---	96	---	---	101
15	Cave Run to Salt Lick 69 kV	1	69	22	---	100	93	---	---	91
1	Rodburn 138-69 kV Transformer	1	138-69	40	116	120	147	140	139	152
2	Fawkes 138-69 kV Transformer	1	138-69	171	98	103	109	103	102	110
3	Loudon Avenue 138-69 kV Transformer	1	138-69	129	99	94	105	103	102	108
4	Farmers 138-69 kV Transformer	1	138-69	48	92	86	105	105	104	108
5	Lake Reba 138-69 kV Transformer	1	138-69	171	---	102	107	101	100	108
6	Spencer Road 138-69 kV Transformer	1	138-69	79	---	101	103	95	95	104

Note: --- = Facility is loaded to less than 85% of the emergency rating

TABLE VI
Single Contingency Analysis with Facility Upgrades
Maximum % of Emergency Rating

Number of Facilities	Location	Circuit	Base kV	Upgraded	CT' 4 and 5	CT's 4, 5 and KPE			CT's 4, 5 and EA Gilbert		CT's 4, 5, EA Gilbert and KPE
				Emergency Rating (MVA)		Case 101	Case 200	Case 210	Case 300	Case 310	Case 410
1	Fawkes Tap to Lake Reba Tap 138 kV	1	138	222	70	75	84	79	76	87	
2	Boonesboro North Tap to Dale 138 kV	1	138	428	---	57	67	---	---	67	
3	Lake Reba to Lake Reba Tap 138 kV	1	138	222	75	79	83	79	77	84	
4	Kenton to Spurlock 138 kV	2	138	280 (1)	90	---	102	113	112	109	
5	Loudon Avenue to Avon 138 kV	1	138	302 (1)	---	---	96	---	---	103	
1	Fawkes to Richmond South 69 kV	1	69	89	113	113	113	113	113	113	
2	Berea to Lake Reba 69 kV	1	69	89	112	112	112	112	112	112	
3	Fawkes to North Madison 69 kV	1	69	89	81	81	81	81	81	81	
4	Lake Reba to Richmond 69 kV	1	69	69	86	93	98	89	88	99	
5	Winchester South to Winchester 69 kV	1	69	140	60	51	56	50	50	57	
6	Baker Lane to Holloway Junction 69 kV	1	69	69 (2)	101	101	101	101	101	101	
7	Clark County to Sylvania 69 kV	1	69	140	58	75	78	72	72	80	
8	Farmers to Morehead West 69 kV	1	69	69	60	69	83	77	76	86	
9	Salt Lick to Spencer Road 69 kV	1	69	39	---	69	64	---	---	63	
10	AO Smith to Spencer Road 69 kV	1	69	69	---	91	95	91	91	96	
11	Parker Seal to Winchester 69 kV	1	69	89	---	86	92	82	82	94	
12	Rockwell to Winchester 69 kV	1	69	89	---	---	74	---	---	74	
13	North Corbin to Sweet Hollow 69 kV	1	69	72 (2)	96	97	100	94	97	101	
14	Rice Tap to Waco 69 kV	1	69	69	---	---	66	---	---	69	
15	Cave Run to Salt Lick 69 kV	1	69	69	---	32	30	---	---	29	
1	Rodburn 138-69 kV Transformer	1	138-69	40 (2)	116	120	147	140	139	152	
2	Fawkes 138-69 kV Transformer	1	138-69	171 (1)	98	103	109	103	102	110	
3	Loudon Avenue 138-69 kV Transformer	1	138-69	129 (1)	99	94	105	103	102	108	
4	Farmers 138-69 kV Transformer	1	138-69	64	69	65	79	79	78	81	
5	Lake Reba 138-69 kV Transformer	1	138-69	171 (1)	---	102	107	101	100	108	
6	Spencer Road 138-69 kV Transformer	1	138-69	107	---	75	76	70	70	77	

- Notes: 1. Presently under review for reconfiguration or upgrade of equipment
2. Mitigation through operating procedure
3. --- = Facility is loaded to less than 85% of the emergency rating
4. Shading shows rating changes from Table V

EXHIBITS

Exhibit 1 – Transmission System Map

Exhibit 2 – One-Line of Proposed Transmission Facilities