**Final Report**
**Focused Review of Documentation**
**Filed by East Kentucky Power Cooperative, Inc.**
**For a Proposed 345 kV Transmission Line**
**Within Kentucky**
**Case No. 2006-00463**

Presented to:

## The Kentucky Public Service Commission

By:

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June 25, 2007

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June 25, 2007

Kentucky Public Service Commission
Attn: John A. Rogness, III, Manager
Management Audit Branch
211 Sower Blvd.
Frankfort, Kentucky 40601-8294

Dear Mr. Rogness:

The Liberty Consulting Group *(Liberty)* is pleased to submit the attached report to The Kentucky Public Service Commission (*the Commission).* This report provides the results of Liberty's review of the application of East Kentucky Power Cooperative, Inc. (*EKPC*) for a Certificate of Public Convenience and Necessity to construct the following transmission line project:

Case No. 2006-00463 345 kV Transmission Line from J.K. Smith to West Garrard

The focus of Liberty's review for this project was EKPC's analysis of the need for and engineering aspects of the proposed high voltage transmission line. Liberty found that EKPC needs the proposed transmission line on the proposed schedule, and that EKPC performed the appropriate system studies and analyses to justify the need for the proposed line.

Liberty appreciates the opportunity to work with the Commission on projects of this importance.

Sincerely,

John Antonuk
President

# Table of Contents



**List of Tables**

**List of Figures**



**Appendix A**

# I. Introduction and Conclusion Summary

## A. Purpose and Scope of this Report

### 1. Background

Pursuant to KRS 278.255, the Kentucky Public Service Commission (*Commission* or *KPSC*) retained The Liberty Consulting Group (*Liberty*) to perform a focused Need Review of documentation associated with a 345 kilovolt (kV) transmission line proposed for construction by East Kentucky Power Cooperative, Inc. (*EKPC* or *Company*).

Liberty is a management and technical consulting firm that specializes in the public-utility industry. Liberty has extensive experience in conducting focused reviews of this type. Liberty has served commissions in 33 different states and the District of Columbia in conducting focused reviews and management audits similar to the work related to the EKPC transmission project.

This report provides the results of Liberty's review of the application of EKPC for a Certificate of Public Convenience and Necessity (*Certificate*) to construct a 345 kV transmission line between the J. K. Smith Station and the proposed West Garrard substation.

### 2. Project Scope and Objectives

The overall objective of this project was to review EKPC's analyses regarding the need for, and engineering aspects of, the proposed high voltage transmission line. The proposed line would be located in portions of Clark, Garrard, and Madison Counties, Kentucky. The proposed facilities will be approximately 35.6 miles long. Included in this report is an independent evaluation of EKPC's analyses and conclusions in support of the reasonableness of the need for the proposed transmission line.

Liberty reviewed EKPC's work but did not produce an independent transmission study. However, this report does encompass all of the issues relevant to the need for the additional transmission line. An evaluation of the overall cost was not part of the scope of work for this project, nor were the engineering design aspects of the proposed line, and, as such, those issues are not discussed or evaluated in this report.

Liberty's work focused on the following aspects of the Need Review:

1. The utility's analysis of the ability of existing facilities to reliably serve existing and expected load, including the utility's power flow analyses and stability analyses.

2. The utility's analyses that support the need for the proposed transmission line. The evaluation included whether the utility gave adequate consideration to:
   a. The upgrade of existing lines or facilities and transmission routes,
   b. Wheeling power through neighboring systems as an alternative to construction,

c. The use of existing rights-of-ways, and
d. The consideration and viability of a comprehensive survey of alternative routes.

## B. Project Overview

### 1. Project Description

EKPC is an electric utility regulated in Kentucky by the KPSC and headquartered in Winchester, Kentucky. EKPC is a not-for-profit organization providing wholesale electricity to 16 distribution cooperatives that serve 500,000 Kentucky homes, farms, businesses, and industries across 89 counties. EKPC provides power through plants located in Mason, Clark, and Pulaski counties, renewable energy plants in Boone, Laurel, Greenup, and Hardin counties, along with gas peaking units, hydro-power, and more than 2,800 miles of transmission lines. Together, EKPC and the member cooperatives are known as Kentucky's Touchstone Energy Cooperatives.

On May 22, 2007, EKPC filed an application *(Application or Filing)* with the Commission to construct a 345 kV line that is more than one mile in length. By Kentucky law, such a facility requires a Certificate prior to construction. The Commission assigned the application Case No. 2006-00463.[1]

The proposed 345 kV transmission line would be approximately 35.6 miles in length, running from the J.K. Smith Station in southern Clark County to the proposed West Garrard substation, west of Lancaster, Kentucky.[2] The line will run in a general southwest direction, through Clark, Madison, and Garrard Counties. About three-quarters of the proposed route would be co-located with existing transmission lines, by either rebuilding existing lines or constructing a new line beside existing lines.

The proposed transmission facilities will be used to transmit electric power required by the projected load that will be served from the new generating units at the J. K. Smith Station. This site presently has seven Combustion Turbines (CTs) installed, with a total net capacity of 594 MW in the summer and 826 MW in the winter. EKPC's generation expansion plan includes the addition of five CTs and a coal-fired baseload unit, with a total net capacity added of 698 MW in the summer and 768 MW in the winter. The total net capacity installed at the site after these unit additions will be 1,292 MW in the summer and 1,594 MW in the winter.[3] On May 11, 2007, the Commission approved the construction of the two CTs and the coal-fired baseload unit with a net capacity 446 MW in the summer and 474 MW in the winter. With the Commission approved capacity, J. K. Smith Station will have a net capacity of 1,040 MW in the summer and 1,300 MW in the winter. The capacity and performance of the existing transmission lines in the vicinity of the J.K. Smith Station are not adequate to deliver the Commission approved generation to native load customers. The projected cost of the proposed transmission line is $38.4 million.[4]

[1] Filing.
[2] Filing.
[3] Filing Exhibit #3.
[4] Filing Exhibit #1.

## 2. Summary of Liberty's Work

Liberty performed its independent Need Review by organizing its work in two main Task Areas. This report addresses these Task Areas as follows:

**Task Area One – Chapter Two, Technical Need Review**

To determine if the proposed facilities were required from a technical viewpoint, Liberty reviewed EKPC's analyses of the proposed 345 kV facilities, including its power flow analysis and long-range plans, to determine whether they would reliably integrate the Commission approved generation into the EKPC transmission system.

**Task Area Two – Chapter Three, Alternatives**

To determine if EKPC's analyses properly considered appropriate engineering alternatives to meet its needs, Liberty's evaluation considered whether EKPC gave adequate consideration to:

a. The upgrade of existing lines or facilities and transmission routes,
b. Wheeling power through neighboring systems as an alternative to construction,
c. The use of existing rights-of-ways,
d. The consideration and viability of a comprehensive survey of alternative routes, and
e. Proper economic comparison of the alternatives.

**Review Process**

Liberty reviewed EKPC's filed application for Case No. 2006-00463. In addition, Liberty reviewed data and documents provided by EKPC in response to written information requests from Liberty. Liberty conducted extensive on-site interviews in Winchester, Kentucky on May 30-31, and June 1, 2007, with EKPC management and subject-matter experts as listed below:

| | |
|---|---|
| Mary Jane Warner | Manager of Engineering |
| Sherman Goodpastor | Senior Corporate Counsel |
| Darrin Adams | Manager, Transmission Planning |
| Chuck Dugan | Manager, Power Supply Operation |
| Frank Ouva | Manager, Finance |
| John Shupp | Electric Branch Manager |
| Gary Davidson | Resource Planning |
| Paul Rupard | Senior Protection Engineer |
| Brandon Grillon | Transmission Engineer |
| Joseph Settles | Supervisor, Natural Resources |
| H. K. Cunningham | Senior Right-of-Way Analyst |
| William Sharp | Senior Right-of-Way Agent |
| Sally Witt | Forecasting and Market Analysis |
| Nicolas Comer | Communications Coordinator |

## C. Conclusion Summary

On the basis of materials reviewed, interviews conducted, and Liberty's experience, Liberty makes the following conclusions related to the need for the 345 kV transmission line from the J.K. Smith Station to the West Garrard substation as proposed by EKPC:

1. EKPC needs the construction of its proposed J.K. Smith to West Garrard 345 kV transmission line on the proposed schedule in order to meet the electric service requirements of serving native load customers resulting from the additional new Commission-approved generation at the J.K. Smith Generating Station.

2. Liberty concurred with EKPC that the preferred alternative of constructing a new 345 kV line from the J.K. Smith Station to West Garrard is the optimum route for installing the transmission necessary to support the addition of new generation at the J.K. Smith Station.

# II. Technical Need Review

EKPC applied to the Commission for a Certificate to construct a 345 kV transmission line. This line would be approximately 35.6 miles long, running from the J.K. Smith Generating Station to the proposed West Garrard Substation. The line would be located in portions of Clark, Garrard, and Madison Counties, Kentucky.

EKPC would use the proposed transmission facilities to transmit the electric power required by the projected native load, served from new generating units to be added to the J.K. Smith Station. The capacity and performance of the existing transmission lines in the vicinity of the J.K. Smith Station are not adequate to deliver this new generation to native load customers.

## A. Reliability Criteria

### 1. Definition

Liberty reviewed the steady state criteria[1] and the transient stability criteria[2] used by EKPC to determine if its requirements are reasonable and within the bounds of good utility practice. The review consisted of an evaluation of thermal contingency performance requirements,[3] dynamic contingency performance requirements,[4] allowable voltage limits,[5] and an assessment of contingencies chosen for their reasonable likelihood of occurrence. Liberty also reviewed generation bias, which is discussed in the next section of this report.

### 2. Discussion

EKPC's most recent revision of its Transmission System Planning Criteria is dated February 9, 2007. It states that it meets or exceeds the reliability standards established by SERC. EKPC has an established voltage criterion for all levels of its transmission system that specifies allowable voltage ranges for operation of the transmission system, for both normal and emergency system conditions, and specific operating voltages at generating stations.[6]

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[1] Steady state criteria are the outage conditions that a power system is designed to meet for reliability purposes. The criteria state the type of contingencies that must be withstood without overloading equipment while providing adequate voltages to customers.
[2] Stability criteria are the outage conditions that a power system is designed to meet for reliability purposes. The criteria state the type of contingencies that must be withstood without interfering with the dynamic operation of the power system.
[3] Part of the steady state criteria that states the types of outages that the system is designed to withstand while maintaining power flow on equipment within its thermal capabilities.
[4] Part of the dynamic criteria that states the type of outages that the system is designed to withstand while maintaining a stable relationship with the dynamic elements of the power system.
[5] In addition to designing a power system to prevent overloads for reasonably expected contingencies, the system must be designed to provide adequate voltage to customers for proper operation of their electric equipment. Allowable voltage limits on the transmission system are such that if maintained, customer equipment on the lower voltage distribution system will operate properly.
[6] Response to Liberty Data Request #7.

EKPC's transmission system planning criteria also establish contingencies for which the above steady state, stability, and voltage limits apply. EKPC requires that voltage and thermal limits remain within normal limits for all elements in normal service conditions, and that they remain within emergency limits under all contingency conditions. In addition, for a specified set of predetermined contingencies, no loss of load or system instability is permitted.[7]

The reliability criteria used by EKPC are deterministic in nature, as they assume the probability of occurrence of the outage is 1.00. The conditions for which EKPC designs its system to no loss of load, and without the curtailment of firm transfers, are depicted in the table directly below. Single contingencies (N-1),[8] and some double contingencies (N-2), are used in EKPC's system design without loss of load or firm transfer curtailment. Because EKPC designs for some double contingencies, Liberty would classify the EKPC transmission planning criteria as N-1 plus. EKPC defines a single contingency element as a generator, transmission circuit, or a transformer, but not a breaker or a bus, because those elements, when they experience an outage on that element, cause multiple transmission element outages for a single event.

**Table II.1**
**EKPC Transmission Contingencies and Measurements[9]**

| | System Impacts or Limits | | |
|---|---|---|---|
| **Contingencies[a]** | **Thermal Limits** | **Voltage Limits[b]** | **Loss of Demand Or Curtailed Firm Transfers** |
| **None** | Normal | 0.955 – 1.050 | No |
| **Extreme Load Due to Unusual Weather[c]** | Emergency | 0.925 – 1.050 | No |
| **Generator, Transmission Circuit, or Transformer[d]** | Emergency | 0.940 – 1.050 | No |
| **Outage of Two Generators** | Emergency | 0.925 – 1.050 | No |
| **Generator and Transmission Circuit** | Emergency | 0.925 – 1.050 | No |
| **Generator and a Transformer** | Emergency | 0.925 – 1.050 | No |

a – All contingencies, except where noted, are single line to ground or three phase faults with normal clearing. For all testing conditions, network stability should be maintained and cascading should not occur.
b – For peak load conditions as measured at the low side distribution transformer bus.
c - Based on a 10 percent not to exceed forecast.
d – Includes outages which do not result from a fault.

In addition, transmission that radialy supplies a distribution substation is limited to a load exposure index of 100 MW-miles and total exposure of a looped sub-transmission circuit should not exceed 2,400 MW-miles.[10,11]The EKPC Transmission System Planning Criteria used in the

[7] Response to Liberty Data Request #7.
[8] N-1 refers to the system state as normal minus one element.
[9] Response to Liberty Data Request #7.
[10] The load exposure index is simply the substation load in MW multiplied by the line exposure in miles.
[11] The customer risk to an outage if on a radial or looped circuit may be quite different with this criterion.

conduct of the studies for the addition of new generation to J. K. Smith is very similar to its current planning criteria.[12]

### 3. Analysis

The National Electric Reliability Council (NERC) established voluntary reliability standards for utilities to follow. These NERC standards are often referred to as N-1 standards, and require that system voltages and ratings remain within applicable limits under specified conditions, and that system dynamics be maintained for specified conditions. For all N-2 conditions, the NERC Reliability Standard allows for planned or controlled loss of demand or curtailment of firm transfers.[13] SERC, one of the NERC reliability Council Regions is responsible for implementing the NERC reliability standards. SERC has adopted the NERC Reliability Standards as its own. As a member of SERC, EKPC must conform to or exceed the reliability standards established by SERC.

Liberty found that the EKPC thermal and transient stability contingency performance requirements used in the studies for the proposed transmission lines conformed to or exceeded the design requirements of SERC and were reasonable. Liberty also found that EKPC voltage limits were reasonable, inclusive of system requirements, and consistent with SERC requirements.

Liberty concluded that EKPC's reliability standards are reasonable, and are in conformance with good utility practice, because they meet or exceed the standards established by SERC.

## B. Generation Bias and Loop Flows[14] on the EKPC 345kV Transmission System

### 1. Definition

Liberty reviewed the generation bias used by EKPC in its technical analyses to ensure that generation bias was reasonable and did not distort study results or transmission requirements. Generation bias weights the level of generation used in the study compared to how system generation is normally dispatched in a manner to produce conservative results.

[12] Filing Exhibit #4, Exhibit Adams-1, Appendix B.
[13] Response to Liberty Data Request #7.
[14] A loop flow is created by the inherent nature of the power system. Power flows on a system element in inverse relation to its impedance. That is, if the impedance of a circuit is increased, the power flow on that circuit will decrease. If a power transaction is made between two entities for a specified amount of power, that power will flow essentially on every transmission path in the transmission system. The impedance of each path will determine the power that flows. These flows are referred to as loop flows and can only be controlled by physically altering the system topology or though use of devices that alter power levels on system elements, such as series reactors or capacitors or power angle transformers.

## 2. Discussion

Generation bias is always present in a power system as load and generation are never in balance at any one time except on a control area basis. In addition, generation bias changes throughout time as loads vary and generation dispatch is altered. There are two kinds of generation bias that occur. The first is the bias that occurs on one's own system when economically dispatching owned generation to meet own load. The second type of generation bias occurs when market transactions take place that can be remote from the subject system, but result in power flows through that system. These are known as loop flows.

The topology of the 345kV transmission system in the area of Kentucky covered by this study, the generation connected to it, and generation bias, is provided in Figure II.1, and the description below.[15] There are three major generating plants located across the northern part of the system. Those stations are the Trimble County, Ghent, and Spurlock generating stations. The Trimble County Station has 1100 MW base and 925 MW of CT generation; the Ghent Station has 1950 MW of base generation; and the Spurlock Station has 1400 MW of base generation.[16] Those stations in turn connect to the Ramsey, Cliffty Creek, Stuart, and Killen generating stations that are off the Kentucky system to the north. Just south of that tier of generation, Cane Run, Mill Creek, and the J. K. Smith generating stations add 575 MW of base generation, 1475 MW of base generation, and 275 MW of base and 800 MW of peaking (CT) generation respectively.[17]

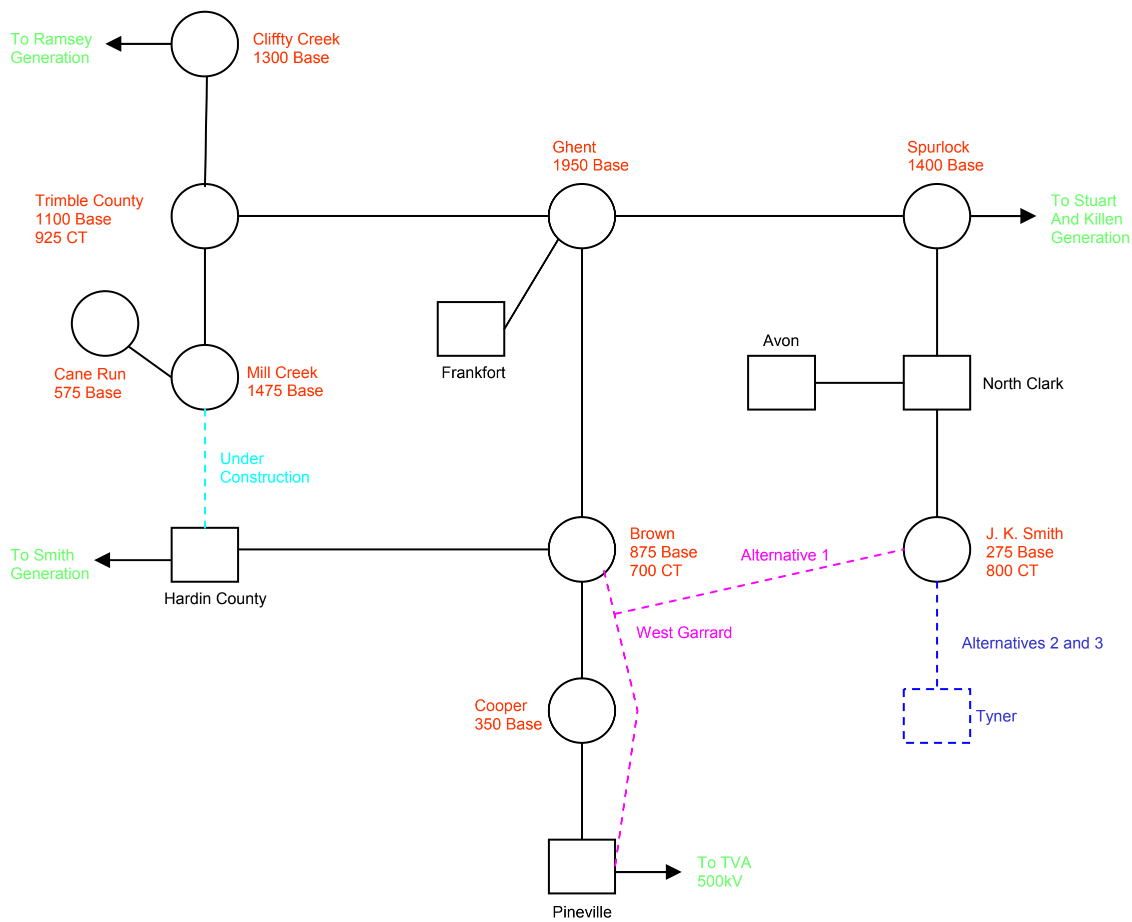
Until the installation of Trimble County 2, only one north to south 345kV path existed across Kentucky, through the Ghent to Brown to Pineville circuit. When the Ghent to Brown 345kV circuit was out of service, there was no way for northern Kentucky generation to move southward, except over the lower voltage system in Kentucky or around Kentucky on the remaining high voltage system. North to south generation flows were forced to the east and west, creating flow gates[18] on those power systems or loading low voltage facilities in Kentucky, creating flow gates there. The installation of the Mill Creek to Hardin County 345kV line improved system performance for this contingency by completing another 345kV loop that would allow high capacity transmission paths to remain between generating stations under contingent conditions. Addition of generation at Spurlock and J. K. Smith adds further pressure on the north to south transmission capacity in Kentucky.

The diagram below clearly shows that construction of Alternative 1 (J. K. Smith to West Garrard 345kV line and energization at 345kV of the currently open second circuit between Brown and Pineville) relieves this pressure by completing two additional 345kV loops in the transmission system. Alternatives 2 and 3 install transmission farther south of J. K. Smith and connect into the lower voltage system; some improvement is seen through these alternatives, but they do not

[15] Response to Liberty Data Requests #1 and #3.
[16] Response to Liberty Data Request #5.
[17] Response to Liberty Data Request #5.
[18] A flow gate is analogous to a choke point. The natural distribution of power across the system increases on system elements in inverse relation to the path impedance. Eventually a transmission limit is reach. That location is called a flow gate and system operators monitor that point to ensure that power flows across the system do not jeopardize system security.

provide a high capacity path southward to Cooper or to Pineville. As such, Alternatives 2 and 3 have limitations on system value added when compared to Alternative 1.

**Figure II.1**
**Generation (MW) and Topology of the Kentucky 345kV Transmission System**[19]




The main goal of the system planner is to represent reasonable generation and load conditions when designing the future system in order for it to be able to withstand simulated contingencies.[20] Generation bias is a normal outgrowth of system planning efforts, and is modeled in the technical analyses. As part of this technical analysis, EKPC designs its transmission system to meet 50/50 load projections. EKPC models only long-term contractual flows across its system in its design studies, not the shorter-term market transactions. In this manner, EKPC states that it is not building its transmission system at its customer's expense for use by others.[21]

[19] Response to Liberty Data Requests #1, #3, and #5.
[20] In addition, and more subtly, a system planner endeavors to design a transmission system that is most robust to untested and unknown events.
[21] Interview of May 31, 2007.

When a request is made for Available Transfer Capacity (ATC) between any transmission systems, the Midwest Independent System Operator (MISO) assumes that the transaction takes place and checks for overloaded facilities or voltages out of specified limits across the system. When a transaction takes place, the power does not flow from point to point but spreads out across the system in inverse relation to the impedance (loop flows). The MISO looks at system elements whose flows change by 5 percent or more (of the transaction amount) and ignores flow changes on system elements that are less than 5 percent of the proposed transaction.[22] Liberty believes that the MISO makes this choice to keep the analysis physically manageable, and because small flow changes on elements that reach their ratings, in the MISO analyses, are indicative of elements that are a problem in their own right and not that of the transaction.

The flow changes on the EKPC transmission system in response to ATC changes across its system are typically in the order of 2 to 3 percent and are therefore ignored by the MISO. If EKPC hits a transmission limit, the MISO requests that EKPC redispatch its generation, which EKPC is obligated to do as a member system. Under the transmission topology that exists today, this has normally meant running gas units at J. K. Smith, while decreasing coal generation at Spurlock. Therefore, while EKPC customers financially support market transactions by paying higher energy costs due to generation redispatch, they do not share in the benefits of those transactions, and they have no recourse for cost reimbursement.[23]

On May 11, 2007, the MISO and EKPC announced an agreement that would allow EKPC to be reimbursed for increased costs when asked to redispatch by the MISO. While this is an improvement over the current situation, EKPC will not be reimbursed for redispatch costs to relive constraints caused by response to ATC changes of less than 5 percent of any transaction amount.[24,25]

## 3. Analysis

In addition to the natural generation bias explained above, the electricity market surrounding Kentucky adds to the flow of power from north to south across Kentucky. An abundance of low cost coal power is available north of Kentucky. To the south of Kentucky, gas has been the predominate choice of fuel for new generation. With fuel prices more stable for coal and with current high gas prices, the electricity market reacts by flowing power from north to south across Kentucky and through the EKPC transmission system.[26] EKPC does not model this market generation bias in their technical studies because of the customer financial considerations stated above.

It can be readily seen that construction of Alternative 1 (J. K. Smith to West Garrard 345kV line and energization at 345kV of the currently open second circuit between Brown and Pineville) completes two additional 345kV loops in the transmission system. While Alternatives 2 and 3 install transmission farther south of J. K. Smith, connect into the lower voltage system, and cause

[22] Interview of May 31, 2007.
[23] Interview of May 31, 2007.
[24] MISO/EKPC news release of May 11, 2007.
[25] Interview of May 31, 2007.
[26] Interview of May 31, 2007.

some improvement, not having a high capacity path southward to Cooper or to Pineville produces limitations on the system value added by those alternatives.

Liberty found that EKPC modeled generation bias appropriately in its technical analyses, both from an on-system generation dispatch and market viewpoint. Liberty also found that such modeling was reasonable to protect EKPC customers from supporting economic transactions from which they do not benefit. Additionally, Liberty found that although support of market transactions at the sole cost of EKPC customers should not be designed into development of the system, such transactions can have severe financial consequences on EKPC customers, and that those consequences should be considered in system development alternative selection choices.

## C. Thermal Ratings

### 1. Definition

Liberty reviewed the thermal ratings of the limiting transmission line components, including equipment in the substation, to ensure that EKPC applied appropriate ratings and chose equipment that is reasonably compatible with the system. Liberty reviewed both normal and emergency ratings.

### 2. Discussion

EKPC documents its transmission planning equipment ratings in "East Kentucky Power Cooperative Transmission Planning Facilities Ratings Methodology," dated April 30, 2007. All equipment is rated separately for normal and emergency operation[27] under both summer and winter conditions. The most limiting rating is recognized as the rating for the given transmission facility by season. These ratings are used in all technical design analyses.[28] EKPC constructs detailed transmission ratings tables from -4$^{o}$ F to 104$^{o}$ F for use by system operators in determining the limiting elements as a function of ambient temperature. The design temperature of 32$^{o}$ F for winter conditions and 95$^{o}$ F for summer conditions are clearly marked on the ratings sheets. EKPC limits the loadings of lines or buses based on the limiting component rating at the actual or expected operating temperatures.[29]

For system power-flow studies, EKPC bases the adequacy of all components of a line or bus at forecasted peak demand (50/50 load forecast) on ratings determined in accordance with its "Transmission Planning Facilities Ratings Methodology" document. The facility loading is limited to the rating of the limiting component, and EKPC upgrades system components as necessary. Ratings for various transmission line components are developed in accordance with the facilities rating methodology and are described as follows.[30]

[27] EKPC does not use short time emergency ratings in either system design or operations.
[28] Response to Liberty Data Request #10.
[29] Response to Liberty Data Request #10.
[30] Response to Liberty Data Request #10.

### Conductors

EKPC uses the "ECAR[31] Conductor Thermal Rating Program (68-TAP-28)" to rate its conductors. Major assumptions include 32° F for winter conditions and 95° F for summer conditions, 2 mph wind,[32] 80° C for normal operation, and a 24 hour limit (generally 100° C) for emergency operation. The maximum design temperature for the line, or actual clearance limits, are used if those limits are lower than the 80° C normal rating.[33]

### Circuit Breakers

Circuit breakers are rated at the manufacturer's nameplate rating. Current transformer ratings are adjusted according to rating factors developed in Westinghouse's "Memorandum On Thermal Characteristics of Current Transformers Used With Circuit Breakers."

### Bushings

EKPC uses manufacturer nameplate ratings for continuous and emergency ratings.

### Current Transformers (Not associated with circuit breakers)

EKPC uses manufacturer nameplate ratings for continuous and emergency ratings.

### Buses

EKPC uses the same method as that used for conductors.

### Disconnect Switches

EKPC uses conservative rating factors developed in accordance with IEEE[34] Standard C37.37 applied to the manufacturer's nameplate rating. Those factors are 1.05 and 1.20 for summer normal and emergency ratings respectively and 1.25 and 1.30 for winter normal and emergency ratings respectively.

### Wave Traps

EKPC uses conservative rating factors developed in accordance with ECAR Guide 88-EEP-42 applied to the manufacturer's nameplate rating. Those factors are 1.01 and 1.04 for summer normal and emergency ratings respectively and 1.12 and 1.15 for winter normal and emergency ratings respectively.

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[31] East Central Area Reliability Council.
[32] The units of the wind component should be checked. Liberty has generally seen the wind component as 2 feet per second approximating the air flow due to natural convection. Some companies intentionally use higher speed wind in the summer (generally above 80° F) based on actual wind data.
[33] Interview of May 31, 2007.
[34] Institute of Electrical and Electronic Engineers.

### Protective Relaying

EKPC typically applies relay settings such that conductor loading is not limited. In cases where adequate protection requires relay settings that limit transmission circuit ratings, the transmission line is rated at that reduced limit.

### Series Reactors

EKPC uses manufacturer nameplate ratings for continuous and emergency ratings.

### Shunt Reactive Devices

EKPC uses manufacturer nameplate ratings for continuous and emergency ratings.

### High Voltage Power Transformers

EKPC develops summer and winter normal and emergency ratings for its transformers. A normal rating is a continuous rating and an emergency rating is a 4-hour rating. Emergency ratings also allow up to 1 percent loss of life for each emergency operation event. 65° C rise transformers[35] are rated in accordance with NEMA[36] Publication Number TR 98-1964 called "Standards Publication Guide for Loading Oil-Immersed Power Transformers with 65 C Average Winding Rise." Assumptions are made regarding pre-loading of the transformer; 0° C and 35° C are used for the winter and summer ambient temperatures, and nameplate multipliers are developed for OA and OA/FOA/FOA[37] transformers.

A similar method is used to rate 55° C rise transformers using USAS[38] Appendix: C57.92, "Standard Institute Guide for Loading Oil-Immersed Distribution and Power Transformers," dated June 1962. The following table presents the transformer nameplate multipliers.

**Table II.2**
**Transformer Nameplate Rating Factors**

| Transformer Description | Summer Normal | Summer Emergency | Winter Normal | Winter Emergency |
|---|---|---|---|---|
| **65° C Rise OA** | 0.95 | 1.36 | 1.26 | 1.76 |
| **65° C Rise OA/FOA/FOA** | 0.955 | 1.29 | 1.19 | 1.47 |
| **55° C Rise OA** | 0.945 | 1.425 | 1.33 | 1.80 |
| **55° C Rise OA/FOA/FOA** | 0.945 | 1.345 | 1.30 | 1.65 |

[35] The temperature rise of a transformer relates to rating. The rating specified will produce an average winding rise of that temperature above the stated 30° C ambient temperature.
[36] National Electrical Manufacturers Association.
[37] Transformers have different ratings depending on the use of oil and air as coolants. OA is the rating with oil and air without forced circulation and FOA is forced oil and air cooling by the use of pumps and fans.
[38] Now an American National Standards Institute document.

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Ratings are jointly developed and use the most limiting respective method for each component.

## 3. Analysis

EKPC does not use or develop short-time ratings. Many utilities do so and design their transmission lines to sag at more elevated temperatures than those used for long-time emergency ratings. A typical short-time rating would be 15 minutes, which allows enough time for operator action to alleviate the problem. Such action is also recognized in NERC[39] Reliability Criteria. By not having short-time ratings, EKPC is forced to build its system to withstand contingencies without exceeding the long-time emergency rating. Coupled with the fact that many component emergency ratings are equipment nameplate ratings, the EKPC transmission system is not designed or operated as efficiently as it could be.

During the interviews, Liberty discussed the conservatism contained in EKPC thermal ratings in various contexts.[40] EKPC was very much aware of the conservatism in its ratings and has a current ongoing effort to evaluate these matters. Liberty notes that some of the guides used in rating of equipment have been updated and now allow higher loadings and that some companies are using elevated wind speeds for summer high temperature operation. Additional transformer capacity might be able to be obtained after analysis, and in consultation with the manufacturer, by adding additional cooling or fans,[41] and the use of actual heat run data coupled with preloading that more approximates the load cycle or the expected contingency load cycle itself. Each equipment manufacturer may use a different design temperature, which complicates comparison of ratings between equipment.

EKPC stated that system winter peaks normally occur between $0^{o}$ F and $10^{o}$ F and would not be expected to occur above temperatures of $15^{o}$ F to $20^{o}$ F. The winter design temperature is $32^{o}$ F. EKPC also stated that summer peaks usually occur near the design temperature of $95^{o}$ F.[42] The design temperatures chosen and the probability of exceedence of the 50/50 load forecast used create much different risks to system security between the summer and winter periods, with summer being much riskier.

An example is helpful to see the risk differential. The system is designed at a winter design temperature of $32^{o}$ F, using a load forecast that has a 50 percent chance of being exceeded. Generally, forecasts that are exceeded are due to non-average weather. This example assumes it is colder than average and loadings are heavier. In the winter, as the temperature is decreased during the extreme event, the ratings of system components are increased due to the reduced temperature, mitigating the impact of increased system loading to some degree. In addition, a system design temperature that appears to be above the average is used, creating even greater loading margin.

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[39] National Electric Reliability Council.
[40] Interviews of May 30, 2007, May 31, 2007, and June 1, 2007.
[41] The manufacturer only adds sufficient radiators with fans and forced cooling to meet the design specifications. There is usually physical room to install more.
[42] Interview of May 31, 2007.

Such is not the case for the summer period. A system design temperature of 95° F is used and this is the approximate point at which the average system peak is expected to occur. The result is that no extra margin exists related to the design temperature, as is the case in the winter period. The system is designed at a summer design temperature of 95° F, using a load forecast that also has a 50 percent chance of being exceeded. Generally, forecasts that are exceeded are due to non-average weather. In this example, it is warmer than average and loadings are heavier. In the summer, as the temperature is increased during the extreme event, the ratings of system components are decreased due to the increased temperature, further aggravating the impact of increased system loading.[43]

EKPC does use 100° C for the development of its long-time emergency conductor ratings and such a temperature is compatible with what is widely used in the industry. Aluminum begins to anneal at approximately 93° C. In other words, the heating and cooling cycle causes loss of life of the conductor. Such loss of life is acceptable for the infrequent times that an emergency system condition will exist. This point is important, as many of the system limits identified by EKPC in its technical studies are conductor emergency limit violations far exceeding conductor ratings.[44] Updating other EKPC conservative ratings for transmission line components would not significantly change the need for major new construction if conductor emergency limits were greatly exceeded.

Liberty found that in general, EKPC thermal ratings were very conservative, did not use short-time emergency ratings, and did not equally spread risk of extreme seasonal weather conditions across both the summer and winter seasons. Liberty also found that EKPC had already identified these weaknesses in its ratings procedures and was taking steps to update and incorporate corrective measures.

Liberty also found that conductor emergency ratings were based on parameters widely used in the utility industry. Many of the system additions required by the addition of generation at J. K. Smith were due to violations of long-time emergency limits, far exceeding conductor emergency limits, and Liberty would not expect major construction requirements to change significantly if EKPC updated its ratings procedures.

## D. Fault Timing Analysis

### 1. Definition

Liberty reviewed the fault duration and equipment operating times used in the transient stability analysis to determine whether EKPC used reasonable values.

[43] In some cases, EKPC uses nameplate ratings of equipment at all temperatures. This might be an issue depending on the manufacturer's choice of design temperature.
[44] Filing Exhibit #4, Exhibit Adams-3.

## 2. Discussion

Utilities perform transient stability studies to ensure that generators remain synchronized with the system during faulted conditions. These studies simulate various types of faults on the transmission system and the response of protective equipment, such as circuit breakers. The analyst must know the response time of the protective relay systems and circuit breakers to properly simulate faults on the system. The model must reflect whether equipment is gang-operated[45] or operated on an independent pole basis.[46] The application of high speed reclosing,[47] sync-check reclosing,[48] or dead-line reclosing,[49] and the configuration of the bus also must be taken into account.

Various types of faults can occur on a power system. Generally speaking, a three-phase fault creates larger system swings than a single-phase-to-ground fault, and faults that involve delayed clearing[50] create larger system swings than those that are cleared in normal time.[51] These faults can occur on lines, transformers, busses, or circuit breakers with varying system component interruptions resulting.

All of EKPC's 345 kV circuit breakers bought for the J. K. Smith generating project are independent pole breakers. EKPC 345 kV transmission substations are designed either as breaker and one half substations[52] or ring busses[53] that will become breaker and one half substations in

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[45] Gang-operated means that the three phases of a switch or circuit breaker are mechanically coupled and generally operate in tandem or by a single trip coil.

[46] Independent pole operation occurs where each phase of equipment such as a circuit breaker has its own trip coil so it may operate independently of the other phases.

[47] High speed reclosing on the transmission system is where a line is closed back within approximately one half second after it trips without regard for system voltage on either side of the breaker.

[48] Sync-check reclosing is where both sides of the circuit breaker must be at system voltage before the breaker is closed. This type of reclosing is generally used at generating stations to prevent damage to the generators for close in faults.

[49] Dead-line reclosing is where no automatic high speed or sync-check reclosing takes place; rather a manual closure of the circuit breaker is initiated some time after the fault has cleared.

[50] A fault that involves delayed clearing occurs when a circuit beaker fails to operate as it should and requires additional time for backup protective equipment to operate to clear the fault. Additional facilities beyond the faulted facility will also be required to be removed from service.

[51] A fault cleared in normal time is one where protective equipment operates properly and only the faulted element is removed from service.

[52] Breaker and one half substations, as shown in Appendix A, have bus layouts with groups of three breakers and two line positions between two buses. The buses are connected to other "three breakers – two line positions" groups. EKPC does not connect step-down transformers to the main buses. A ring bus layout usually has no common buses but has a breaker between each line position (the number of breakers is equal to the number of line positions) to form a ring where each line position is connected by two breakers. Each line position for straight bus layouts is connected to one common bus by one breaker. For both breaker and one half bus and ring bus layouts, a breaker can be opened without de-energizing a line (this is not true for straight bus layouts). However, for the failure of a breaker in breaker and one half layouts, only one line position may, in some cases, be affected. For the failure of a breaker in ring bus layouts, two line positions will always be affected. Failure of a breaker in straight bus layouts affects all line positions.

[53] A ring bus, shown in Appendix A, is where a circuit breaker is placed between each terminating element beginning with three breakers. As each element is added to the substation, an additional circuit breaker is added to the ring. Generally, a maximum of 6 breakers are used in this fashion and the substation is converted to a breaker and one half configuration for more than 6 connections.

the future, and that no transformers are connected to the bus positions. EKPC's 138 kV J. K. Smith Substation is a straight bus[54] design.

EKPC stated that the 345 kV breakers were simulated to normally operate in 3.75 cycles with 1.75 cycle relay time and 2-cycle breaker operating time. EKPC stated that the 345kV delayed clearing time is 9.75 cycles and that it was lower than the critical clearing time.[55] Additionally, EKPC stated that the 345kV relays were guaranteed to operate in 1.5 cycles.[56]

On the 138kV system, EKPC used 5-cycle clearing time for normal faults consisting of a 2-cycle relay time and a 3-cycle breaker operating time. Further, EKPC stated that they simulated a 12.75-cycle breaker failure time at J. K. Smith 138kV.[57]

### 3. Analysis

Four cycles is historically typical of normal clearing times for 345 kV faults. Stuck breaker timing of 8 to 9 cycles allows for the tripping process to be repeated, time to sense and communicate the stuck breaker condition to backup facilities, and a time margin. Values of 8 to 9 cycles are typical of that used in the industry for 345 kV applications. EKPC's use of 9.75 cycle clearing time for a delayed cleared fault appeared long, especially given that EKPC had newer 345kV relays that were guaranteed to operate in 1.5 cycles. EKPC responded to a Liberty Data Request that validated the maximum 1.5-cycle relay time for the 345kV relays.[58] EKPC also supplied a relay scheme time diagram showing how the 9.75-cycle 345kV breaker failure time was developed. The 9.75 breaker failure timing scheme was developed for use at the Spurlock Substation to accommodate the installation of Spurlock #4. EKPC duplicated the scheme for the installation of CFB-1 at J. K. Smith.[59]

Five cycles is historically typical of normal clearing times at 138kV installations. 138kV circuit breakers typically clear in three cycles, extending the normal clearing time by a cycle when compared to 345kV installations. Relays used are the same as in 345kV substations and have the same operating times. Because of the longer clearing time of 138kV breakers, the breaker failure time would be increased by two cycles over 345kV schemes, given the same time margin and use of the same relays. EKPC supplied a relay scheme time diagram showing how the 12.75-cycle 138kV breaker failure time was developed. An 11.75 breaker failure timing scheme using high speed fault detectors was developed for use at the Spurlock Substation to accommodate the installation of Spurlock #4. EKPC duplicated the scheme for the installation of CFB-1 at J. K. Smith without high speed fault detectors, resulting in an additional cycle of operating time.[60,61]

[54] A straight bus, shown in Appendix A, is where many line positions are connected to a single bus. It is inherently less desirable from a reliability viewpoint in that the failure of a circuit breaker causes many elements to be removed from service.
[55] The critical clearing time at a substation is the maximum time that the most severe fault at that substation can remain connected to the system without causing system instability.
[56] Interview of May 31, 2007.
[57] Interview of May 31, 2007.
[58] Response to Data Request #21.
[59] Response to Liberty Data Request #22.
[60] Response to Liberty Data Request #22.
[61] Interview of May 31, 2007.

The goal of the system protection engineer requires the balancing of competing requirements. A protection system must operate as fast as possible in order to minimize system investment or maximize transfer levels, yet it must operate slowly enough so that the protection scheme does not misoperate. Liberty notes that some companies have significantly reduced margins to minimize investment or maximize transfer levels. Use of redundant high-speed relay schemes restores confidence in proper relay operation and is required by some NERC reliability councils for the bulk power system. Other utilities, when confronted with unacceptable system operations at absolute minimum clearing times, have installed series circuit breakers to ensure clearing of faults in normal time and eliminating the need to design the system to delayed clearing of faults.

Liberty found that the fault durations and equipment times for the faults simulated in the EKPC transient stability studies were reasonable, conservative,[62] and similar to times used in the industry.

## E. Load Forecasting

### 1. Definition

Liberty reviewed EKPC's load forecasting methods on both a system and sub-system basis to assess whether they represented the future in a reasonable manner. Items reviewed included the use of weather-based forecasting and the weather inputs to the forecast. Liberty also reviewed the econometric model assumptions used in load forecasting.

### 2. Discussion

EKPC's load forecast is prepared every two years in accordance with EKPC's Rural Utilities Service (RUS) approved Work Plan. EKPC prepares the forecast by working jointly with member systems to prepare their individual forecasts and uses the member system forecasts as its starting point.[63] Member system forecasts are all individually forecast and combined in order to determine EKPC's 20-year forecast. The member systems use their individual forecasts to develop their own construction work plans, long-range construction plans, and financial forecasts. EKPC uses the overall system forecast in such areas as marketing analysis, transmission planning, power supply planning, and its financial forecasting. For transmission planning, EKPC develops peak load conditions for the various substations, and does not include transmission losses in this part of the planning process.[64]

EKPC prepares both a summer and winter coincident and non-coincident peak forecast, for its member systems, and transmission losses are added to these projections to obtain the EKPC forecast. EKPC also projects annual energy requirements on an individual member system basis. EKPC load forecasters do not project reactive requirements as part of the Company's load

[62] Clearing times on the EKPC transmission could be reduced at these locations in the future if required by then current system conditions.
[63] Interview of May 30, 2007.
[64] Interview of May 30, 2007.

forecast. Those projections for the reactive portion of the load are left to the system planner, who incorporates such data based on historical system performance.[65,66] Liberty reviewed 2006 summer and 2006/2007 member system power factors and saw that they ranged from approximately 93 to 96 percent in the summer and from approximately 97 to 99 percent in the winter.[67]

EKPC divides its service territory into seven regions and assigns each member system to one of those regions. Historical data is collected on population, income, and employment levels on the Kentucky county level and from both the U. S. Bureau of Labor Statistics and the U. S. Bureau of Economic Analysis in order to ensure consistency with national data. For forecasting support, EKPC subscribes to the services of an economic consultant who projects consistent regional forecasts for population, income, and employment. This consultant uses U. S. economic data as the baseline for his own projections as a cross-check to ensure that the localized EKPC forecasts are not out of line with national forecasts. EKPC performs its own residential, commercial, and manufacturing forecasts with data specific to that segment of the economy; transmission losses and other adjustments are also made.[68]

EKPC load forecasts are performed using normal weather.[69] Historical data is weather normalized for use in the model. EKPC also performs sensitivity modeling as part of its forecast to determine a high-load and low-load case. EKPC assumes that weather extremes, in terms of Heating Degree Days and Cooling Degree Days, will be 2 standard deviations above and below the forecast. Other assumptions are that the residential electricity price will be either 15 percent higher or lower than the base case, and that the number of residential customers will be either two standard deviations above or below the base case. EKPC also assumes a 90/10 probability level of energy use by small and large commercial customers.[70]

The EKPC 2006 Load Forecast projected total system energy requirements to increase by 3.9 percent per year from 2006 through 2016. Included in these projections was that firm winter peak demand would increase by 4.2 percent per year from 2006 through 2016 and that firm summer peak demand would increase by 3.9 percent per year over the same period.[71] Liberty was provided a current confidential breakdown of the EKPC 10-year member system summer and winter load forecasts in response to a Data Request.[72] That response indicated that the 2015/2016 coincident winter peak, with transmission losses, was projected to be 3468 MW compared to the earlier 2006 Load Forecast which projected a value of 3931 MW for that time period. Similarly, this Data Request also projected a firm coincident 2015 summer peak, with transmission losses,

[65] Interview of May 30, 2007.

[66] At the Interview of May 30, 2007, EKPC stated that EKPC planners track the load power factor of member systems. EKPC has agreements with its member systems that each is moving towards a 97 percent load power factor and is penalized if power factor is below 90 percent.

[67] Response to Liberty Data Request #17.

[68] Response to Liberty Data Request #9.

[69] Normal weather is considered to be average weather. That is, the summer or winter weather conditions could be expected to be exceeded every other year. This forecast is also referred to as a 50/50 forecast, defining its probability of exceedence.

[70] Response to Liberty Data request #9.

[71] Response to Liberty Data Request #9.

[72] Response to Liberty Data Request #8.

of 2725 MW compared to the 2006 Load Forecast, which projected a value of 3153 MW for the 2015 summer peak. The difference in the forecasts is attributable to the fact that the information in the Data Request excludes the Warren RECC load while the 2006 Load Forecast definitely included that load, beginning in April of 2008.[73] In December 2006, Warren RECC decided not to become a member of EKPC.

EKPC transmission planners use the 50/50 system coincident peak load forecast while member systems use their 90/10 coincident peak load forecast for their planning purposes.[74]

### 3. Analysis

EKPC's forecasts are primarily based on growth in the use of electric energy derived from economic and demographic data. The econometric approach used by EKPC, although different in some ways, is very similar to that used by many electric utilizes. Liberty identified opportunities for forecast improvement, that if not currently investigated by EKPC, might improve forecast consistency and accuracy. One of those opportunities would be to benchmark the EKPC load forecast. This could be done by taking an old 2005 forecast for 2006 loads, inserting actual 2006 data for the various input parameters, such as weather, employment, etc, and then comparing the original forecast loads for 2006 with the actual 2006 loads. This process can build confidence in or identify areas of improvement in the model. Further, Liberty believes that a plus and minus 15 percent range for changes in residential electricity prices is not equivalent to a 90/10 probability of occurrence as assumed. The stability forecasted in marginal energy costs, due to the installation of Coal Fluidized Bed (CFB) units that consume inexpensive low BTU coal, will also make energy prices more predictable and less likely to such swings.[75]

Along the same vein, EKPC analyzes both robust and lackluster load growth on a compounded weather and economic basis. Large variations in weather can occur from year to year, but large swings in the economic drivers are less likely. Liberty would therefore suggest that EKPC look at an extreme weather case with normal economic activity, and an extreme economic case with normal weather, which may be more likely. The use by EKPC of two standard deviations for weather extremes actually equates to approximately 96 percent of the data under a normal distribution curve and would put the weather extreme probabilities at the summer and winter peaks at approximately 98/02. This results in load forecasts being too high.

Liberty also points out that many summer peaking utilities are using a 90/10 load forecast because of the compounded negative impact of increased loads and reduced equipment ratings.

While Liberty has suggested some adjustments to EKPC's forecasting processes, overall, Liberty believes that EKPC's load forecasting methods, economic inputs, and adjustments are reasonable and adequate for company-wide transmission reinforcement studies, and that reasonable study results would be produced.

[73] Response to Liberty Data request #9.
[74] Interview of May 30, 2007.
[75] Response to Liberty Data Request #24.

# F. Technical Analysis

## 1. Definition

Liberty reviewed the power flow,[76] transient stability,[77] and other technical analyses used to justify the project. Other technical analyses could include reactive requirements or short circuit[78] analysis. The review consisted of a review of the models used, the size of the system model used (to determine if it is of sufficient size and of sufficient detail to produce valid study results), the application of the reliability criteria to assure proper simulations, and a review of the results themselves to ascertain whether EKPC drew proper conclusions from its analysis.

## 2. Discussion

### General

In determining the optimum system requirements to integrate the new CFB-1 unit and new combustion turbines (CTs) at J. K. Smith into the power system, EKPC performed all power flow, transient and long-term[79] stability, and short circuit studies that were required. EKPC solicited input from neighboring utilities and the MISO. EKPC supplied all parties with a study scope prior to beginning its analyses.

### Power Flow[80]

Liberty reviewed the power flow model used by EKPC to conduct its analyses to ensure that the model was a reasonable representation of the system and of sufficient detail to produce valid study results. EKPC uses the General Electric Power System package of programs, which have compatible power flow, stability, and short-circuit programs. This program package is used industry wide for power flow modeling and represents state of the art modeling software.

[76] Power flow analysis is done with a mathematical impedance model of the power system. Final or steady state (when angular change between generators has ceased) voltages are calculated at nodes and power flows are calculated on the various pieces of equipment. Contingencies are simulated to ensure that equipment loadings and voltages stay within prescribed limits.

[77] Transient stability analysis is done with a mathematical impedance model of the system but also includes time in the calculation. Usually the time varying component is .01 seconds and the analysis is simulated to about 2 seconds. Various faults are modeled on the system with their associated clearing times and equipment taken out of service. A power flow analysis is performed at each time increment, and voltages, power flows, and angular differences between generators are calculated. These time changing power flows, voltages and angular differences produce a speed change at generators. If a generator cannot remain within certain speed limits, it becomes unstable and is automatically tripped off line.

[78] When faults occur on the power system, short circuits are created and large amounts of current flows to the fault. To isolate the faulted element, power system protective devices must interrupt the current that is flowing into the fault. The power system is mathematically modeled so that the amount of current flowing into the fault is calculated. Power system protection equipment can only interrupt finite current values. Interruption of faults above the rated vale of the equipment can cause damage to the protective equipment.

[79] Long term stability analysis is stability analysis that is performed out to 15 to 20 seconds or longer. This analysis captures the feedback actions of generator controls that do not react in the first few seconds of the simulation.

[80] Filing Exhibit #4, Exhibit Adams-1.

For its initial System Impact Study power flow analysis,[81] EKPC used a 2003 Series full MMWG[82] model that was reduced with equivalents[83] for all utilities other than EKPC, Louisville Gas and Electric (LGE) and neighboring systems. EKPC/LGE jointly developed these models in early 2004 with detailed representations of both systems. Surrounding systems were included with the full representation of the MMWG case. For the 2015 summer peak case, the 2012 summer MMWG case and loads were used for all systems other than EKPC/LGE. Similarly, for the 2015/2016 winter case, the 2010/2011 MMWG winter case and loads were used for all systems other than EKPC/LGE. The transmission system outside of EKPC/LGE was represented down to the 138 kV/115 kV level. Transmission on the EKPC/LGE systems was modeled down to the 69 kV level. Loads and transmission topology for the EKPC/LGE systems were study year projected loads and topology as projected in March 2004, without additional generation at J. K. Smith. The following table more clearly shows the system modeling detail and loads used.

**Table II.3**
**Load and Transmission Representations in EKPC's Initial System Impact Study**

| Year Studied | EKPC/LGE Systems Detailed Model | Neighboring Systems Full MMWG Model | All Other Systems Reduced MMWG Model |
|---|---|---|---|
| 2005 S | 2005 S | 2005 S | 2005 S |
| 2005/2006 W | 2005/2006 W | 2005/2006 W | 2005/2006 W |
| 2010 S | 2010 S | 2010 S | 2010 S |
| 2010/2011 W | 2010/2011 W | 2010/2011 W | 2010/2011 W |
| 2015 S | 2015 S | 2012 S | 2012 S |
| 2015/2016 W | 2015/2016 W | 2010/2011 W | 2010/2011 W |

Generation bias was included in the cases by using a weighted merit order[84] dispatch on the EKPC system. All generation (except for the Laurel Dam hydro generation) including the new CTs and CFB-1 at J. K. Smith were assumed running, with generation far removed from the EKPC system to the north and south reduced by an equal amount. Additional generation bias occurs when generation contingencies are modeled. Loads on the system were modeled as constant impedance.[85] The Warren RECC load was assumed to be an EKPC load as of April 1, 2008.

EKPC analyzed the performance of its system and that of neighboring utilities for normal conditions and for single contingencies with the worst-case generator out of service. Generation variations, and double contingencies that might limit the output at J. K. Smith were also studied. EKPC assumed that all normal overloads that had a flow change of 3 percent or greater with the addition of generation at J. K. Smith, were due to the addition of that generation, if the overload did not exist prior to the addition of the generation. Similarly, EKPC used a 5 percent criterion

[81] Filing Exhibit #4, Exhibit Adams-1.
[82] Multi-regional Model Working Group.
[83] Liberty notes that computer power has increased to the point where it is more economical to run the larger networks than to expend engineering time to perform equivalents to reduce their size.
[84] Merit order is removing units from service starting with the most expensive to operate or placing units in service starting with the unit least expensive to operate.
[85] A constant impedance load is one where the real and reactive component values are not allowed to change with changes in voltage. Load therefore varies with voltage.

for contingency overloads. The top three alternatives from its screening study were analyzed further.

### Transient and Long-Term Stability

The model used for stability analysis was the ECAR 2009 Summer Dynamic Case developed in 2003 from the NERC 2002 Series MMWG 2009 Power Flow case. The real portion of the load was modeled as constant current,[86] and the reactive[87] portion of the load was modeled as constant impedance.[88]

EKPC uses the General Electric Power System package of programs referenced above. EKPC stated that it used full representation IEEE machine models in its analysis.[89]

System disturbances were modeled both with and without the new units at J. K. Smith. EKPC used stuck breaker faults (3 pole and single pole) with all facilities in service and a single line to ground fault normally cleared with one transmission element out of service to test its system. EKPC stated that they simulated 3 pole stuck breakers at J. K. Smith even though the breakers purchased were independent pole breakers.[90] Stability runs were simulated out to 10 seconds to ensure that positive damping continued beyond the system's initial response.

### Short Circuit Analysis[91]

EKPC used its 2005 summer power flow model and modified it to make it suitable for fault analysis. All control areas except EKPC/LGE and their surrounding systems were removed, and zero sequence impedances were added to the remaining system representation. EKPC made general assumptions for the zero sequence impedance of equipment off its system. Faults were run at neighboring utility busses and provided to those utilities for input and to validate the accuracy of EKPC's model. EKPC uses the General Electric Power System package of programs referenced above.

[86] Modeling the real or resistive load as constant current accounts for load change during power swings as the same amperes of resistive load (like a incandescent light bulb) at a lower voltage will draw less power form the system.

[87] Voltage and current alternate their magnitude 60 times a second in accordance with their sinusoidal waveform. When the angular difference between the two is zero, all power flowing is called "real power" and can be measured in Watts. When the voltage waveform is angularly ahead of the current waveform, power other than Watts is required to supply the power relationship. This power is called "reactive or imaginary" power. In the case described, it is inductive reactive power that is required and this reactive power (lagging) tends to lower system voltage. Similarly, when the current waveform angularly leads the voltage waveform, capacitive reactive power (leading) is required to satisfy the power relationship and system voltage is raised. Reactive power is also referred to as VARs, or Volt Amperes Reactive.

[88] Modeling the reactive portion of the load as constant impedance does not allow for some motor load change during power swings, because, at a lower voltage, some motors will draw increased power from the system.

[89] Interview of May 31, 2007.

[90] Interview of May 31, 2007.

[91] Filing Exhibit #4, Exhibit Adams-1.

Both three phase and line-to-ground faults were run at a multitude of busses, with and without the proposed generation at J. K. Smith, to assure that circuit breakers remained within their interrupting capabilities.

**Updated Analyses**[92]

In December of 2006, WRECC announced that it would remain with TVA for its power supply needs. EKPC reevaluated its generation expansion and transmission plans with that new information. EKPC updated the power flow portion of its system impact study, with the thought that the same generation would be added, but at an altered schedule, and that the same transmission system would result. Updated power flow cases were constructed to simulate the summer periods of 2007, 2010, and 2015. Similarly, updated winter cases for 2007/2008, 2010/2011, and 2015/2016 were constructed. EKPC in essence duplicated its study approach of the first system impact study with regards to input from others, the number of new generators at J. K. Smith, and the 2005 Series of MMWG cases. The two CTs and CFB-1 approved by the Kentucky Public Service Commission are scheduled to be in service in January 2009 and October 2010 respectively.

EKPC stated that adding approximately 100 MW of generation at J. K. Smith required transmission modifications due to overloaded transmission elements under contingency conditions.[93] According to the ratings listings, the limits identified are conductor emergency limits.[94] Additional transient stability simulation or short circuit analyses were not performed. In addition, the only alternative studied was the preferred alternative, Alternative 1. EKPC also updated its double contingency analysis.

EKPC also performed a cascading analysis as part of its investigation into the possibility of installing the new J. K. Smith to West Garrard 345kV circuit on the same tower with the J. K. Smith to Fawkes 138kV circuit. In that analysis, EKPC assumed that any transmission element that is 5 percent or more overloaded will trip, and investigated successive tripping with both zero and 4,000 MW north to south flow. In both transfer cases, the solution did not converge.[95,96,97]

## 3. Analysis

EKPC performed analyses and simulated contingencies required by their system design criteria and identified overloads according to their approved ratings methodology. EKPC also performed sensitivity analyses in order to assess how robust the resultant transmission system was. EKPC used models that extended far beyond its service territory that were reasonable for the time frames studied and solicited input to its studies from neighboring utilities.

[92] Filing Exhibit #4, Exhibit Adams-3.
[93] Filing Exhibit #4 and Response to Data Request #26.
[94] Response to Liberty Data Request #10.
[95] Non-convergence, or the inability to result in a solution, although a good precursor, does not mean by itself that a cascading outage will occur as it can be also indicative of quirks in the mathematical solution.
[96] Filing Exhibit #4, Exhibit Adams-4.
[97] It is Liberty's opinion that an analysis so conducted, and with EKPC's conservative ratings methodology, is not predictive of cascading outages, however, is predictive if cascading does not occur.

EKPC simulated stability studies at peak load times only. While Liberty understands the requirement for CT operation is generally tied to the peak load period and unit economic dispatch, conditions can arise where CTs could be called upon to run at much lighter loads to address area security or the rapid successive loss of major system units. Liberty would therefore suggest that EKPC simulate lighter load stability cases and some of the parameters that can greatly influence system response to disturbances in future analyses.[98]

Liberty found that the technical analysis software used by EKPC is comparable to those generally in use by utilities conducting such analyses and that the system representations were reasonable. Liberty raised concerns regarding certain aspects of the EKPC analyses. These items are detailed in the economic analysis and ratings sections of this report. Liberty also concluded that those concerns would not alter the selection of Alternative 1 as the preferred transmission alternative.

Liberty found that EKPC properly applied its transmission system planning criteria in its analyses, that its study results were conservative, and that EKPC properly interpreted study results according to its current standards.[99]

## G. Summary

Liberty found that the EKPC thermal and transient stability contingency performance requirements used in the studies for the proposed transmission lines that would support the new generation at J.K. Smith conformed to, or exceeded the design requirements of SERC and were reasonable. Liberty also found that EKPC voltage limits were reasonable, inclusive of system requirements, and consistent with SERC requirements.

Liberty concluded that EKPC's reliability standards are reasonable, and are in conformance with good utility practice, since they meet or exceed the standards established by SERC.

Liberty found that EKPC modeled generation bias appropriately in its technical analyses, both from an on-system generation dispatch and market viewpoint. Liberty also found that such modeling was reasonable to protect EKPC customers from supporting economic transactions from which they do not benefit. Additionally, Liberty found that although support of market transactions at the sole cost of EKPC customers should not be designed into development of the system, such transactions can have severe financial consequences on EKPC customers, and that those consequences should be considered in system development alternative selection choices.

[98] Some of those parameters would be load representations during system voltage excursions, full modeling of generator step up and station service facilities and specific modeling of station service load.

[99] Liberty notes that the current installation schedule for the approved generators at J. K. Smith would require immediate commencement of transmission construction for the CFB-1 facility. EKPC studies show that about 100 MW (2 CTs are rated 168 MW summer and 196 MW winter) can be added at J. K. Smith without transmission reinforcement. That indicates to Liberty that should CFB-1 be deferred for whatever reason, that the 345kV construction could very likely also be deferred with the addition of a simple transfer trip loading scheme applied to one of the new CTs.

Liberty found that in general, EKPC thermal ratings were very conservative, did not use short-time emergency ratings, and did not equally spread risk of extreme seasonal weather conditions across both the summer and winter seasons. Liberty also found that EKPC had already identified these weaknesses in its ratings procedures and was taking steps to update and incorporate corrective measures.

Liberty also found that conductor emergency ratings were based on parameters widely used in the utility industry. Many of the system additions required by the addition of generation at J. K. Smith were due to violations of long-time emergency limits, far exceeding conductor emergency limits, and Liberty would not expect major construction requirements to significantly change if ratings procedures were updated.

Liberty found that the fault durations and equipment times for the faults simulated in the EKPC transient stability studies were reasonable, conservative and similar to times used in the industry.

While Liberty has suggested some adjustments to EKPC's forecasting processes, overall, Liberty believes that EKPC's load forecasting methods, economic inputs, and adjustments are reasonable and adequate for company-wide transmission reinforcement studies, and that reasonable study results would be produced.

Liberty found that the technical analysis software used by EKPC is comparable to those generally in use by utilities conducting such analyses and that the system representations were reasonable. Liberty raised concerns regarding certain aspects of the EKPC analyses. These items are detailed in the economic analysis and ratings sections of this report. Liberty also concluded that those concerns would not alter the selection of Alternative 1 as the preferred transmission alternative.

Liberty further found that EKPC properly applied its transmission system planning criteria in its analyses, that its study results were conservative, and that EKPC properly interpreted study results according to its current standards.

# III. Alternatives

This chapter presents the results of Liberty's review of the alternatives EKPC considered and the associated analyses that support EKPC's need for the proposed transmission line. The chapter addresses:

- The upgrade of existing lines or facilities and transmission routes
- Addition of generation and power factor improvement
- Whether wheeling power through neighboring systems or through interconnections with other utility systems would be a viable alternative to construction of the proposed new transmission line
- The use of existing rights-of-way
- Economic analyses of alternatives, and
- The consideration and viability of a comprehensive survey of alternative routes.

## A. Upgrades

### 1. Definition

Liberty evaluated whether EKPC gave adequate consideration to upgrades of existing transmission lines for both EKPC and neighboring utilities and the use of alternative transmission line routes. Liberty included a review of the application of new technology or automation in its evaluation.

### 2. Discussion

EKPC initially identified many options that could successfully integrate the new generation at J. K. Smith into its transmission network. These options included both upgrading of existing transmission facilities and the addition of new facilities. EKPC performed a screening analysis to identify the more viable candidates.[1] As part of that analysis, EKPC reviewed which existing transmission lines could be rebuilt from a physical and operational viewpoint.[2] EKPC used these rebuild opportunities as part of the input into the EPRI-GTC Transmission Line Routing Methodology.[3] The EKPC analysis also determined that approximately 100 MW of generation could be connected to the system at J. K. Smith before emergency conductor limits were reached.[4]

[1] Filing Exhibit #4, Exhibit Adams-1.
[2] Response to Liberty Data Request #15.
[3] Filing Exhibit #3.
[4] Filing Exhibit #4 and Response to Liberty Data Request #26.

### 3. Analysis

Installing generation and transmitting its output over long distances to load centers requires high voltage transmission facilities. EKPC verified that the present EKPC system would not be sufficiently robust to meet applicable reliability standards after connecting the new J. K. Smith generation to the system. EKPC thoroughly evaluated all reasonable solutions, all of which included some upgrades to present facilities.

Liberty did not identify any additional transmission facilities that could be upgraded in capacity at their current voltage level that would eliminate the need for the new facilities. In addition, Liberty did not identify any additional options for resolving system loading problems resulting from the connection of new generation at J. K. Smith to the system.

Liberty did not identify additional facilities that could be upgraded in voltage that would eliminate the need for the new facilities. If facilities were to be upgraded from a voltage standpoint, the system would lose the support of those facilities under contingency conditions. That loss of contingency support from those upgraded facilities might require additional facilities beyond those for which EKPC is requesting construction approval.

Liberty found that no additional upgrades in capacity or voltage options other than those already identified by EKPC could replace the need for the new facilities.

## B. Addition of Generation and Power Factor Improvement

### 1. Definition

Liberty evaluated whether EKPC gave adequate consideration to the installation of local generation and power factor improvement as viable alternatives to construction of the new facilities.

### 2. Discussion

In addition to on-system upgrades or interconnections with neighboring systems, other alternatives may solve reliability problems. In cases where a utility encounters thermal restrictions, it can consider the addition of local generation. When a utility experiences voltage constraints, it may employ the addition of capacitors/reactors or other new technology reactive devices.

Series capacitors[5] were not considered in the EKPC analyses. Series capacitors can provide system benefits when voltage drop is a consideration, or power flows over two paths are such that the transmission system is not efficiently used. Significant overloads occurred on most of the

[5]Power flow varies inversely to the impedance. A series capacitor reduces the reactance portion of a transmission line's impedance. With reduced impedance, more power will flow on that circuit changing the flows on other transmission paths.

existing 138kV paths that exited the J. K. Smith Station, which required additional facilities to be constructed. EKPC did consider the installation of a series reactor[6] in one of its three top reinforcement candidates (Alternative 2). [7] All system violations noted in the studies were due to thermal overloads and no voltage violations were observed.[8]

EKPC did not consider the addition of local generation, since the system problems encountered were related to the installation of Commission approved generation, and were not load related. Generation installed for resource adequacy is usually installed at large centralized generating stations, such as J. K. Smith, which was designed for expansion.

EKPC monitors the load power factor[9] of its member systems by season. At the time of the EKPC coincident 2006 summer peak, member system load power factors ranged from approximately 0.93 to 0.96, as measured at the low side of the transformers serving them. At the time of the coincident 2006/2007 winter peak, member system load power factors varied from approximately 0.97 to 0.99, similarly measured. EKPC has a goal of encouraging its member systems to attain a 0.97 load power factor at peak, and is making progress towards that goal.[10]

## 3. Analysis

Voltage considerations played no part in integrating new J. K. Smith generation into the transmission grid because of the multitude and magnitude of thermal overloads encountered when examining the system and expansion alternatives. The system planner generally addresses thermal overloads first.[11] The application of shunt capacitors or new technology reactive support devices would not be effective in reducing power flows on overloaded facilities. Similarly, improvement of load power factor would not be effective in reducing overloaded facilities.

Voltage drops, or unevenly loaded facilities, were not a concern in integrating new J. K. Smith generation into the transmission system. The application of series capacitors would not be effective in efficiently redistributing power flows on the system, as overloads occurred on most of the 138kV paths exiting J. K. Smith, which required additional facilities to be constructed.

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[6] Installation of a series reactor works opposite to a series capacitor and reduces the power flow on that circuit
[7] Filing Exhibit #4, Exhibit Adams-1.
[8] Filing Exhibit #4, Exhibits Adams-1 and Adams-3.
[9] Voltage and current alternate their magnitude 60 times a second in accordance with their sinusoidal waveform. When the angular difference between the two is zero, all power flowing is called "real power", the power factor is 1.00 and power can be measured in Watts. When the voltage waveform is angularly ahead of the current waveform, power other than Watts is required to supply the power relationship. This power is called "reactive or imaginary" power. In the case described, it is inductive reactive power that is required and this reactive power (lagging) tends to lower system voltage. Similarly, when the current waveform angularly leads the voltage waveform, capacitive reactive power (leading) is required to satisfy the power relationship and system voltage is raised. Reactive power is also referred to as VARs, or Volt Amperes Reactive. Power factor is merely the cosine of the angle between the voltage and current waveforms and lagging/leading merely refers to the physical angular relationship of the voltage and current waveforms.
[10] Response to Liberty Data Request #17.
[11] Most of the power flow on the transmission system is real power. Altering the reactive flow of power has little impact on overall circuit loading.

Liberty found that the installation of local generation, power factor improvement, series or shunt capacitors/reactors, or other new technology reactive devices were not viable alternatives for the facilities requesting siting approval.

## C. Wheeling

### 1. Definition

Liberty reviewed whether EKPC gave adequate consideration to wheeling power through adjoining systems via existing or new interconnections with other systems.

### 2. Discussion

The Commission approved the installation of two CTs and CFB-1 at the J. K. Smith Station. The J. K. Smith Generating Station is located in central Kentucky, and is relatively remote from the high capacity transmission system in Kentucky.[12] Since the installation of generation at this site is Commission approved, Liberty confined its review to whether EKPC considered interconnections to neighboring utility systems in its design of the transmission system required to integrate that generation into the transmission system.

EKPC considered many alternatives to integrate the new generation at J. K. Smith into the system. Two of the three top candidates used EKPC facilities only (Alternatives 2 and 3) and the EKPC preferred alternative (Alternative 1) interconnected with an underutilized LGE transmission path from Brown to Pineville, and energized it at 345kV.[13]

### 3. Analysis

EKPC considered many alternatives to support integration of the new generation at J. K. Smith into the system. The EKPC preferred alternative (Alternative 1) interconnected with an underutilized LGE transmission path from Brown to Pineville, and energized it at 345kV. The other two top candidates used EKPC facilities only (Alternatives 2 and 3).

Liberty found that the only viable interconnection or wheeling opportunity for the integration of new generation at J. K. Smith into the transmission system was using either the LGE Brown to Cooper to Pineville 345kV circuit currently in use, or energizing and using the second circuit at 345kV as suggested by EKPC. Liberty found that EKPC gave adequate consideration to the use of interconnections as alternatives to construction of new facilities.

[12] Response to Liberty Data Request #1.
[13] Filing Exhibit #4, Exhibit Adams-1.

## D. Economic Analysis of Alternatives

### 1. Definition

Liberty reviewed the methods used by EKPC in its economic analyses to assess whether the methods used were reasonable, when used in conjunction with power system expansion studies, to provide for the proper selection of the least cost transmission expansion alternative. Liberty also reviewed the assumptions used by EKPC in its economic analyses.

### 2. Discussion

EKPC uses a levelized 12.57 percent fixed charge rate in its economic analysis. EKPC does not pay Federal Income Tax under Section 501C12 of the U. S. Tax Code. In calculating its fixed charge rate, EKPC includes interest, with a times interest ratio of 1.15 to 1.20, a return on investment, straight-line depreciation, insurance, property tax, and O&M. EKPC calculates interest during construction for a project and includes it as part of the installed project cost. EKPC uses a 7.3 percent present worth factor that is reflective of its debt cost and a nominal inflation rate in the conduct of its economic analyses.[14]

EKPC screened many transmission alternatives that could accommodate the installation of additional generation at the J. K. Smith Station. Three alternatives were considered top candidates for detailed evaluation. Those three alternatives were as follows: the J. K. Smith to West Garrard 345kV line (Alternative 1); the J. K. Smith to Tyner 345kV line, the Tyner 345kV transformer, and the W. C. Dale to Boonesboro 138kV reactor (Alternative 2); and the J. K. Smith to Tyner 345kV line, the Tyner 345kV transformer, and the J. K. Smith to Spencer 138kV line (Alternative 3). The initial economic analysis for these alternatives was contained in the May 2006 System Impact Study Report. In that analysis, EKPC calculated the present worth both of common facilities necessary to support any of the alternatives, and of each of the three alternatives, including system reinforcements required through 2009, in January 2006 dollars. The installation date of the additional generation at the J. K. Smith Station was 2009. Those costs from the May 2006 System Impact Study Report were: $27.5 million for common facilities, $69.7 million for Alternative 1, $88.2 million for Alternative 2, and $95.0 million for Alternative 3.[15]

After conducting these studies in 2006, EKPC learned that the Warren RREC load would not be coming onto the EKPC system in 2008 as planned. This resulted in a change in generation requirements, and consequently EKPC reviewed transmission requirements and costs as well, and reported on the results of that review in its February 2007 System Impact Study Report. In this newer economic analysis, EKPC calculated the present worth, in January 2006 dollars, for the common facilities to be $29.4 million. EKPC only updated the costs of Alterative 1 in this review. The Alternative 1 cost was now projected to be $79.8 million in January 2006 dollars.

[14] Interview of May 31, 2007.
[15] Filing Exhibit #4, Exhibit Adams-1.

However, in this review, EKPC included the present value of projects that supported Alternative 1, and that would be installed after installation of the generation, out through 2015.[16]

At the request of Liberty, EKPC performed an energy and capacity value analysis of the three originally considered alternatives.[17] In this analysis, EKPC was asked to consider changes in system losses due to variation in load level, the cost of avoided energy, and the cost of avoided capacity. This additional analysis was to be applied to each of the three transmission systems associated with each of the Alternatives 1 through 3. The analysis was conducted through 2022; this is the point at which system expansion plans would be the same for each alternative, in order to place all of the present worth evaluations on the same basis. EKPC calculated the present worth of losses, in January 2008 dollars, and used Alternative 3 as the base system to calculate differentials against because this alternative had the lowest costs in terms of incremental losses. The results of that analysis were that Alternative 1 had $14.0 million more in present value of losses than Alternative 3, Alternative 2 had $5.6 million more in present value of losses than Alternative 3, and Alterative 3 had $0 against itself.[18]

## 3. Analysis

Present value analysis is a method used to compare alternatives that have different installation dates, lives, and depreciation schedules. In essence, the long-term cost of installing and owning each project is discounted back to a common date in order to compare all alternatives on equal footing. Liberty believes that the present value analysis conducted in the May 2006 EKPC System Impact Study was insufficient because it essentially compared only the present value of the first cost of the three alternatives, and did not include longer-term costs beyond this point. In addition, no allowance was made for energy and capacity savings differentials between the alternatives, and no future projects required to support the alternative were included in the analysis. Inclusion of future projects is important because additional CTs, CFB-2 and CFB-3 will be added to the J. K. Smith Station.[19,20] This was the most important economic decision made by EKPC, and when considered in isolation, does not support the EKPC choice of Alternative 1 for its transmission expansion.

Liberty believes that there is sufficient information available from the analyses already performed by EKPC, and the loss analysis requested by Liberty,[21] to determine the proper transmission expansion choice for J. K. Smith. Therefore, Liberty made its own estimation of the present value cost of the three alternatives. In this analysis, Liberty used the EKPC fixed charge rate, the present worth factor, and project costs set forth by EKPC, as they appear to be reasonable. Liberty ignores the common costs at J. K. Smith, since they would apply equally to any of the three alternatives, and uses 3.0 percent for inflation. Liberty also incorporates the major projects identified by EKPC in its May 2006 System Impact Study for all construction

[16] Filing Exhibit #4, Exhibit Adams-3.
[17] Response to Liberty Data Requests #24 and #25.
[18] Response to Liberty Data Request #25.
[19] Filing Exhibit #4, Exhibit Adams-1.
[20] EKPC did identify major construction requirements of the three alternatives as generation is added at J. K. Smith but did not include their costs in the analysis.
[21] Response to Liberty Data Requests #24 and #25.

activity through 2022, estimating the length of line construction required for such activity.[22] Liberty also used January 2009 as its present worth date. Liberty used a date of fall 2016 for the installation of CFB-2 and January 2016 for the in service date of its associated transmission requirements. Liberty used a date of October 2022 for the installation of CFB-3 and January 2022 for the in service date of its associated transmission requirements. The Table below presents the results of Liberty's estimated present value analysis.

**Table III.1**
**Estimated Present Value of Three Transmission Alternatives ($ X 1,000)**

| **Alternative 1** | | | | | |
|---|---|---|---|---|---|
| **Construction Requirements Description** | **1/2006 Cost** | **In Service Date** | **Installed Cost** | **30 Year Present Value** | **1/2009 Present Value** |
| Smith-W Garrard 345 Line | 49,095 | 6/2009 | 54,452 | 81,133 | 78,276 |
| Other Requirements | 2,000 | 11/2009 | 2,251 | 3,354 | 3,236 |
| Losses | | | | | 15,027 |
| 3-138kV Lines 38 Miles at $350K/Mile | 13,300 | 1/2016 | 17,874 | 26,632 | 16,263 |
| Tyner 345 Line, Transformer, and Smith-Spencer 138kV | 63,820 | 1/2022 | 102,412 | 152,594 | 61,058 |
| **Total** | | | | | **173,860** |

| **Alternative 2** | | | | | |
|---|---|---|---|---|---|
| **Construction Requirements Description** | **1/2006 Cost** | **In Service Date** | **Installed Cost** | **30 Year Present Value** | **1/2009 Present Value** |
| Smith-Tyner 345, Transformer, and Reactor | 61,280 | 6/2009 | 67,967 | 101,271 | 97,705 |
| Other Requirements | 3,595 | 11/2009 | 4,046 | 6,029 | 5,619 |
| Losses | | | | | 6,051 |
| 2-138kV Lines, 20 miles at $350K/Mile | 7,000 | 1/2016 | 9,407 | 14,016 | 8,559 |
| Smith-W Garrard 345 | 48,225 | 1/2022 | 77,387 | 115,307 | 46,138 |
| **Total** | | | | | **164,072** |

[22] Filing Exhibit #4, Exhibit Adams-1.

| **Alternative 3** | | | | | |
|---|---|---|---|---|---|
| **Construction Requirements Description** | **1/2006 Cost** | **In Service Date** | **Installed Cost** | **30 Year Present Value** | **1/2009 Present Value** |
| Smith-Tyner 345 Line, Transformer, Smith-Spencer 138kV | 67,695 | 6/2009 | 75,082 | 111,872 | 107,933 |
| Other Requirements | 2,090 | 11/2009 | 2,352 | 3,504 | 3,266 |
| Losses | | | | | 0 |
| Smith-W Garrard 345 | 48,225 | 1/2022 | 77,387 | 115,307 | 46,138 |
| **Total** | | | | | **157,337** |

From the above table, Alternative 3 is shown to be least cost, followed by Alternative 2. The most expensive alternative is Alternative 1, EKPC's preferred construction choice. However, Liberty would not recommend a transmission expansion plan based solely on its estimated economic analysis as shown above. There are five reasons why Liberty would not do so, and why other factors must be considered when selecting the preferred transmission alternative. The first reason is that the Liberty analysis is an estimated analysis designed to identify clearly undesired alternatives; Liberty's analysis did not identify any such undesirable alternatives, from an economic point of view. Secondly, from simply an economic point of view, the alternatives are very close in costs, with only a 10 percent difference between the highest and lowest cost alternative. Third, as pointed out by EKPC, only major projects required for the installation of CFB-2 and CFB-3 were identified.[23] Additional project identification and inclusion in any present value analysis could reduce the small cost differential between alternatives. Fourth, the technical studies were conducted with a zero generation market flow bias across Kentucky.[24] However, there is a real bias of generation flow across Kentucky that can alter the economics between the alternatives. Generally, the more restrictive an alternative is, the more market penalties one would expect. Lastly, the EKPC System Impact Study indicates that Alternatives 2 and 3 produce more transmission restrictions in the interim period prior to 2022, indicating a less robust system response to simulated disturbances than those experienced with Alternative 1.[25] For these reasons, Liberty views the alternatives as economically equivalent, and that final alternative selection must be based on other factors.

The creation of 345kV loops is very important in Kentucky, especially in this region. In addition to any market bias, there is a large amount of base-load coal generation in Northern Kentucky that tends to flow southward towards load that is not served by local generation. Liberty believes that this is the reason why transmission alternatives expanding to the south of the J. K. Smith Station were the preferred alternatives that made the final EKPC evaluation list in 2006. Furthermore, the strength of Alternative 1 is that it creates another 345kV loop in northern

[23] Filing Exhibit #4, Exhibit Adams-1.
[24] Interview of May 31, 2007.
[25] Filing Exhibit #4, Exhibit Adams-1.

Kentucky from Spurlock to Brown and a second transmission circuit is created[26] in southern Kentucky between Brown and Pineville, and on to the TVA system. (See Figure II.1 in Chapter II of this report). These system improvements take place 12 years earlier if Alternative 1 is constructed than if either Alternatives 2 or 3 are constructed.

In EKPC's February 2007 review, only Alternative 1 was reviewed and that review included future project requirements. EKPC calculated the common costs, in January 2006 dollars, to be $29.4 million in this 2007 study compared to $27.5 million in the 2006 study. The two figures are very close. In order to compare EKPC's 2006 analysis with its 2007 analysis, Liberty subtracted the $9.0 million present value, in January 2006 dollars, of all future project costs, from the $79.8 million present value of Alternate 1, as calculated by EKPC. This results in a cost of $70.8 million for the 2007 analysis, which compares very closely to the $69.7 million present value calculated in the 2006 analysis.[27] Thus, Liberty concludes that there is essentially no difference between the 2006 and 2007 economic evaluations, as conducted by EKPC.

Liberty found that the 2006 economic analysis performed by EKPC was incomplete because the value of future losses and the cost of future projects beyond initial construction, projected to a common future system point, were not included. Consequently, Liberty performed its own estimated economic analysis and found that the three alternatives are essentially equivalent from an economic viewpoint. However, from an overall system development standpoint, Liberty found that Alternative 1 provides 345kV looped benefits to the system 12 years sooner, when compared to the other alternatives. Moreover, Liberty found that Alternative 1 responds better to future potential system disturbances and north to south generation bias flows.

Liberty also found that because the 2007 and 2006 calculated costs of Alternative 1 were so close, that economic changes since the analysis in the 2006 study was performed will not change the relative economic ranking of the three alternatives.

## E. Alternative Routes

### 1. Definition

Liberty reviewed the process used by EKPC to see if overall it followed the "Kentucky Transmission Line Siting Model Project Report,"[28] assessed whether EKPC gathered sufficient public input in the routing process, assessed whether EKPC worked in a constructive manner to address landowner concerns, and reviewed the overall final route selection process made by EKPC. Included in Liberty's analysis was a determination as to whether EKPC gave adequate consideration to the use of existing rights-of-way (co-location).

[26] Two 345kV Brown to Pineville circuits were built in the 1970s. One of the circuits was energized at 345kV and the other was put into service at 138kV open circuited at the Pineville end.
[27] Filing Exhibit #4, Exhibit Adams-3.
[28] Response to Liberty Data Request #2.

## 2. Discussion

EKPC followed the EPRI-GTC[29] Transmission Line Routing Methodology, augmented by the long-time EKPC practice of hosting property owner open houses to gather area specific input prior to the selection of the preferred route. As stated above, this method has been tailored for better application in Kentucky through a detailed stakeholder process. EKPC employed Photo Science Geospatial Solutions to gather data and perform the statistical analysis associated with the EPRI-GTC routing methodology. Photo Science gathered and verified the data, but decisions were made by EKPC subject matter experts.[30,31]

The EPRI statistical model develops Macro Corridors based on land use information and property owner input. The Macro Corridors are evaluated and compared based on the three main modules entitled Built Environment, Natural Environment, and Engineering Concerns. From this process, Alternative Corridors are developed within the Macro Corridors. Once the Macro Corridors and Alternative Corridors are developed, further public input is solicited through environmental and property owner public open houses to solicit comments from property owners most likely to be affected. Route Alternatives are identified within the Alternative Corridors by scoring with a standardized system to balance the various impacts such as cost of or proximity to the line in the Built Environment, Natural Environment, and Engineering Concerns categories. The Route Alternatives are then screened using Expert Judgment to select the Preferred Route. Considering collocation and rebuild opportunities, and applying its Expert Judgment, EKPC selected route Hr as its Preferred Route. Route Hr[32] includes 11.8 miles of existing line rebuild, 14.8 miles of collocation with existing lines, and 9.0 miles of Greenfield construction.[33]

EKPC stated that they sent notices to all landowners who were within one half mile of the proposed line for Greenfield locations and 1,000 feet for rebuild and collocation locations. EKPC also stated that each property owner concern was referred to an internal committee to be addressed for potential resolution. Each property owner was sent a map indicating whether its property would, would not, or might be impacted. Some property owner concerns also may have been referred to EKPC engineering personnel.[34] County property information was used in this process. EKPC stated that they would desire flexibility in the final center line location of the facility so that additional land owner concerns could be resolved without violating the siting certificate.[35,36]

After the Alternative Routes were selected by the program and the data normalized, EKPC applied EKPC specific weighting factors that it developed prior to the route selection process. These weighting factors were developed by an internal EKPC committee and applied to the

[29] Electric Power Research Institute - Georgia Transmission Corporation.
[30] Interview of May 30, 2007 and Response to Liberty Data Request #12.
[31] Filing Exhibit #3.
[32] Graphically displayed on Filing Exhibit #2.
[33] Filing Exhibit #3.
[34] Liberty suggested that EKPC specifically follow up on each property owner concern to ensure that the information loop has been closed.
[35] Interview of May 30, 2007.
[36] Response to Liberty Data Request #13.

normalized data. EKPC stated that these weighting factors were developed by its internal committee in early 2006 after the siting model workshop was completed. Once the Alternative Routes were ranked in this manner,[37] EKPC applied its Expert Judgment[38] to the top three ranking routes. The weights of the Expert Judgment matrix were developed after the alternative routes had been identified by the EPRI model. EKPC stated they tried to include things in their Expert Judgment, such as views and accessibility, which they believed were not included in the EPRI model.[39]

## 3. Analysis

Liberty reviewed the EKPC routing process and noticed that in the Macro Corridor Study Built Environment module, the Data Layer entitled "Proximity to Eligible Historical and Archeological Sites" stated that in terms of degrees of suitability, it was slightly more suitable to site a proposed power line within 300 feet of a historical or archeological site, rather than 300 to 600 feet from such a site. EKPC stated that this counter-intuitive result was in fact a result of the process where group consensus was not reached. The siting project consulting team recognized this anomaly, noted that the difference was small, and that it was unlikely to cause a meaningful difference in the model results.[40]

Liberty reviewed all landowner siting concerns provided to EKPC as part of the public input process.[41] Liberty discussed each siting concern stated by property owners with EKPC, while viewing large-scale property parcel maps,[42] to determine if EKPC was familiar with the concern, and to determine what the internal resolution was.[43]

Liberty also reviewed the parcel maps[44] of the entire route with EKPC for what appeared to be siting anomalies[45] and alternative routing options. The anomalies noted were the result of mapping coordination problems when other databases were overlaid with EKPC data, and EKPC also explained why each alternative routing option was not considered.[46]

Initially, Liberty was concerned that the selection of Expert Judgment weighting factors could have influenced the decision process in cases where the weighting factors were determined after the weighted ranking of the alternatives had already been determined. However, these concerns were resolved in the course of Liberty's analysis.

[37] The raw data, normalized data, and ranking with EKPC specific weighting factors appear in Filing Exhibit #10.
[38] Filing Exhibit #3, Exhibit Warner-2.
[39] Interview of May 30, 2007.
[40] Response to Liberty Data Request #14.
[41] Filing Exhibit #3, Exhibit Warner-2, Appendix B.
[42] Filing Exhibits #8.01 through #8.13.
[43] Interview of May 30, 2007.
[44] Filing Exhibits #8.01 through #8.13.
[45] An example would be where the lines should be parallel and are not.
[46] Interview of May 30, 2007.

The table below presents the data on the normalized ranking of route line segments as it appears in the filing.[47] The data generally groups around the decision of whether to rebuild the facilities south of Newby Substation.[48] The rebuilding options generally score better and group together. The table also shows that the top scoring routes are very close in their sum of weighted totals. The small differences between the top routes indicates to Liberty that the top alternatives are essentially equal from a siting perspective.

**Table III.2**
**Normalized Route Weighted Ranking[49]**

| Route | Line Segments | Sum of Weighted Totals | Rank |
|---|---|---|---|
| Gr | 1,3,6,8,10r,11,14 | 0.35 | 1 |
| Er | 1,3,6,7,9,10r,11,14 | 0.39 | 2 |
| Hr | 1,3,6,8,10r,12r,13,14 | 0.40 | 3 |
| Cr | 1,3,4,5,9,10r,11,14 | 0.42 | 4 |
| Fr | 1,3,6,7,9,10r,12r,13,14 | 0.44 | 5 |
| G | 1,3,6,8,10,11,14 | 0.47 | 6 |
| Dr | 1,3,4,5,9,10r,12r,13,14 | 0.47 | 7 |
| Ar | 1,2,5,9,10r,11,14 | 0.49 | 8 |
| E | 1,3,6,7,9,10,11,14 | 0.52 | 9 |
| H | 1,3,6,8,10,12,13,14 | 0.55 | 10 |
| Br | 1,2,5,9,10r,12r,13,14 | 0.55 | 11 |
| C | 1,3,4,5,9,10,11,14 | 0.55 | 12 |
| F | 1,3,6,7,9,10,12,13,14 | 0.59 | 13 |
| A | 1,2,5,9,10,11,14 | 0.62 | 14 |
| D | 1,3,4,5,9,10,12,13,14 | 0.62 | 15 |
| B | 1,2,5,9,10,12,13,14 | 0.70 | 16 |

Liberty found that EKPC followed the Kentucky specific siting process developed by stakeholders in the "Kentucky Transmission Line Siting Model Project Report" and that its decision process was well documented and clearly presented. Liberty also found that EKPC gathered sufficient public input in the routing process and that EKPC worked in a constructive manner to address landowner concerns.

Liberty also found that in the cases where the top routes were essentially equal from a siting perspective, that timing of EKPC's selection of its Expert Judgment weighting factors did not influence the route selection process. Liberty reviewed the overall final route selection made by EKPC and found its selection process to be reasonable. Liberty also found that the final route selected optimized the co-location opportunities. Liberty also believes that Commission determined flexibility in the final determination of the project centerline could be beneficial to further address landowner concerns.

[47] Filing Exhibit #10.
[48] Rebuild options South of Newby are indicated by the small letter "r" in the route and line segment identification of the Normalized Route Weighted Ranking Table.
[49] Filing Exhibit #10.

## F. Summary

Liberty did not identify any additional transmission facilities that could be upgraded in capacity at their current voltage level that would eliminate the need for the new facilities. Liberty did not identify any additional options for resolving system loading problems resulting from the connection of new generation at J. K. Smith to the system.

Liberty did not identify additional facilities that could be upgraded in voltage that would eliminate the need for the new facilities. If facilities were to be upgraded from a voltage standpoint, the system would lose the support of those facilities under contingency conditions. That loss of contingency support from those upgraded facilities might require additional facilities beyond those for which EKPC is requesting construction approval.

Liberty found that no additional upgrades in capacity or voltage options other than those already identified by EKPC could replace the need for the new facilities.

Liberty found that the installation of local generation, power factor improvement, series or shunt capacitors/reactors, or other new technology reactive devices, were not viable alternatives for the facilities requesting siting approval.

Liberty found that the only viable interconnection or wheeling opportunity for the integration of new generation at J. K. Smith into the transmission system was utilizing either the LGE Brown to Cooper to Pineville 345kV circuit currently in use, or energizing and using the second circuit at 345kV as suggested by EKPC. Liberty found that EKPC gave adequate consideration to the use of interconnections as alternatives to construction of new facilities.

Liberty found that the 2006 economic analysis performed by EKPC was incomplete because the value of future losses and the cost of future projects beyond initial construction, projected to a common future system point, were not included. Consequently, Liberty performed its own estimated economic analysis and found that the three alternatives are essentially equivalent from an economic viewpoint. However, from an overall system development standpoint, Liberty found that Alternative 1 provides 345kV looped benefits to the system 12 years sooner, when compared to the other alternatives. Moreover, Liberty found that Alternative 1 responds better to future potential system disturbances and north to south generation bias flows.

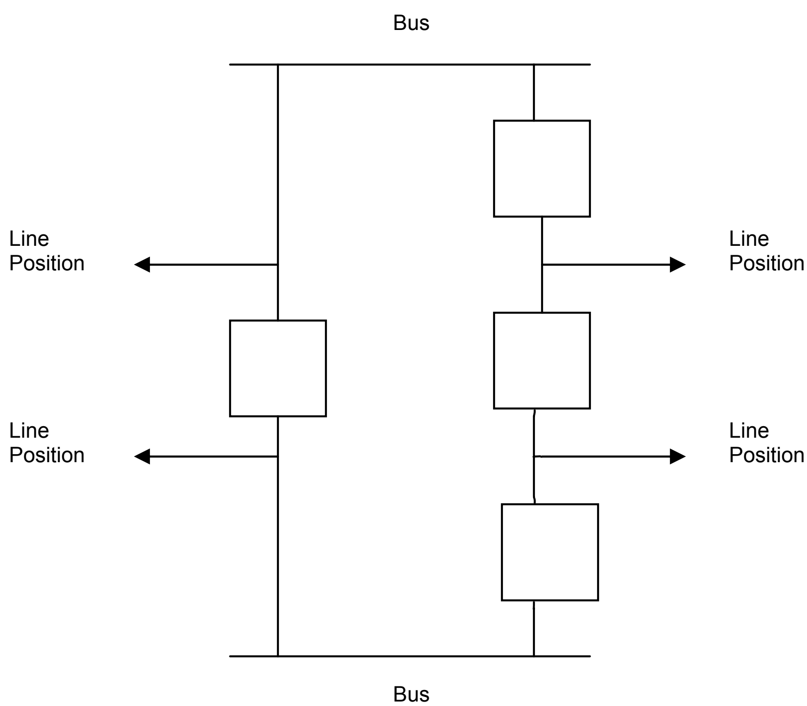
Liberty also found that because the 2007 and 2006 calculated costs of Alternative 1 were so close, that economic changes since the analysis in the 2006 study was performed will not change the relative economic ranking of the three alternatives.

Liberty found that EKPC followed the Kentucky specific siting process developed by stakeholders in the “Kentucky Transmission Line Siting Model Project Report” and that its decision process was well documented, and clearly presented. Liberty also found that EKPC gathered sufficient public input in the routing process and that EKPC worked in a constructive manner to address landowner concerns.

Liberty also found that in the cases where the top routes were essentially equal from a siting perspective, that timing of EKPC's selection of its Expert Judgment weighting factors did not influence the route selection process. Liberty reviewed the overall final route selection made by EKPC and found its selection process to be reasonable. Liberty also found that the final route selected optimized the co-location opportunities. Liberty also believes that Commission determined flexibility in the final determination of the project centerline could be beneficial to further address landowner concerns.

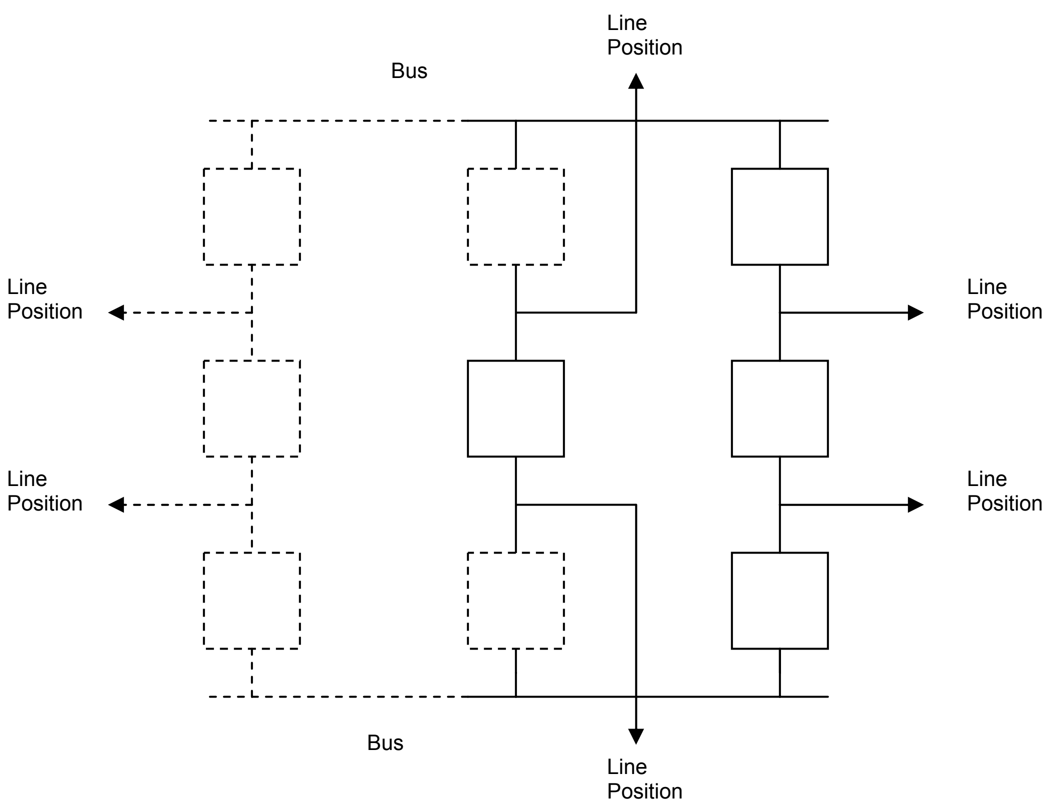
# Appendix A – Figure 1

**Four Breaker Ring Bus**
**Set Up for Future Breaker and**
**One Half Configuration**



# Appendix A – Figure 2

## Four Breaker Ring Bus
## Expanded Into a Breaker and One



# Appendix A – Figure 3

## Four Breaker
## Straight Bus Configuration