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Energy and Environment Cabinet

Commonwealth of Kentucky
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David L. Armstrong
Chairman

James W. Gardner
Vice Chairman

Charles R. Borders
Commissioner

January 10, 2011

PARTIES OF RECORD

RE: Patterson & Dewar Engineers Final Report
Case No. 2010-00164

Enclosed please find a copy of the cover letter and final report from Patterson & Dewar Engineers. The cover letter and final report has been filed in the record of the above referenced case. Any questions regarding this memorandum should be addressed to John Rogness of the Commission Staff at 502-564-3940, extension 229.

Sincerely,

Jeff Derouen
Executive Director

Attachment

Patterson & Dewar Engineers, Inc.
Hood ▪ Patterson & Dewar, Inc.

RECEIVED

JAN 07 2011

PUBLIC SERVICE
COMMISSION

January 6, 2011

Mr. John Rogness III
Kentucky Public Service Commission
P.O. Box 615
211 Sower Boulevard
Frankfort, Kentucky 40602

RE: KPSC Case # 2010-00164 / Transmission CPCN ~ Final Report

Dear Mr. Rogness,

Enclosed please find 20 bound copies, one unbound, and one electronic copy of the Patterson & Dewar Engineers, Inc. final report on the focused audit of Kentucky Utilities application for a new transmission line in western Kentucky. An

We appreciate the opportunity to have worked with you and your colleagues at the KPSC on this project. Please do not hesitate to call if you have any questions or comments regarding our report or any other issue.

Sincerely,

Gary E Grubbs

Gary Grubbs, PE
Principal Engineer

Patterson & Dewar Engineers, Inc.
Hood ▪ Patterson & Dewar, Inc.

FOR THE KENTUCKY PUBLIC SERVICE COMMISSION

REPORT OF FOCUSED REVIEW

Documentation and Testimony from KU For a Proposed 161 kV Transmission Line Within Kentucky

KPSC Case No. 2010-00164

January 6th, 2011

Patterson and Dewar Engineers, Inc.
850 Center Way
Norcross, GA 30071

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(Fax) 770-453-1411

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TABLE OF CONTENTS

FOCUSED REVIEW
KENTUCKY PUBLIC SERVICE COMMISSION
Case No. 2010-00164

January 2011

I. EXECUTIVE SUMMARY

A. Purpose

As requested by the Kentucky Public Service Commission (KPSC), Patterson and Dewar Engineers, Inc. (P&D) performed a Focused Review of Case No. 2010-00164, an application by Kentucky Utilities Company[1] (KU) for a Certificate of Public Convenience and Necessity (CPCN) to construct a new 161,000 volt (161 kV) transmission line from Grahamville Substation to the Electric Energy, Inc. (EEI) transmission line near the Department of Energy (DOE) plant near Paducah, Kentucky.

P&D has been providing a wide range of electrical engineering services for over sixty years including the planning and justifying process for new capital transmission and substation projects. P&D has an experienced and qualified staff that is very familiar with Kentucky's electric transmission grid and infrastructure as well as the neighboring facilities of the Tennessee Valley Authority (TVA).

This report presents the results of P&D's focused review of KU's application for the CPCN for the construction of transmission facilities in McCracken County, Kentucky.

B. Background

On November 23, 2010, KU submitted a request to the KPSC for a CPCN for the construction of a 1.69 mile long 161 kV transmission line from KU's Grahamville Substation to the EEI transmission line near the DOE property in McCracken County, Kentucky.

Based on the Direct Testimony submitted to the KPSC by Edwin R. Stanton, LG&E and KU Service Company's Director – Transmission, filed on November 23, 2010, this transmission line is necessary to accommodate serving the transmission needs of the municipalities of Paducah and Princeton, Kentucky. Lonnie E. Bellar, LG&E and KU Service Company's Vice President of State Regulation and Rates, also filed testimony on November 23, 2010, regarding the history of how these municipalities had terminated their full requirement contracts with TVA near the end of 2004. Once TVA was no longer the service provider for the municipalities, it declined their subsequent request for transmission service. Paducah and Princeton had no alternative but to seek alternative transmission services from KU.

The KU transmission system was found by the Southwest Power Pool (the Independent Transmission Operator (ITO)) to be deficient in its ability to service the total load of the two cities. Consequently, KU began the process of developing plans to add and/or upgrade facilities in order to provide Paducah and Princeton with transmission service similar in quality and reliability to the service that had previously been provided by TVA. TVA is not a transmission-

[1] In November 2010, EON U.S. LLC was renamed LG&E and KU Energy LLC.

owning public utility under the terms of the Federal Power Act and thus does not have the same obligation to provide firm transmission service to entities for which it does not also provide electric power service. KU is required to provide transmission service to third-party network customers such as Paducah and Princeton under FERC Orders 888 and 890.

C. Project Scope

The scope of this project was to provide the KPSC a focused review of KU's analyses and studies supporting the need for, evaluation of alternatives and the preliminary engineering and design of the proposed project. P&D has performed its independent review of KU's analyses, but did not produce its own transmission study.

In reviewing the technical need for the project, P&D examined in detail the adequacy and reasonableness of the electrical load forecasts, power flow analyses, reliability criteria, fault studies and engineering economic evaluations to determine if reasonable assumptions and methods were utilized. Also, P&D reviewed the alternatives considered to evaluate KU's thoroughness in considering all reasonable alternatives. Additionally, the process used by KU to optimize the transmission line routing was reviewed.

D. Review Process

P&D's process for reviewing the filed application for Case No. 2010-00164 included reviewing the original filed documents, responses to submitted requests for additional information and data, and meeting with Louisville Gas and Electric (LG&E) and KU management and subject-matter experts. The following attendees participated in the on-site meeting at the KU offices in Lexington, Kentucky on December 10, 2010.

Name	Company
Adam Smith	KU
Alan Strunk	KU
Keith Yocum	KU
Tom Seeley	KU
Marty Reinert	LG&E/KU
Elie Russell	KPSC
Gary Hasty	P&D Engineers, Inc.
Gary Grubbs	P&D Engineers, Inc.
John Rogness	KPSC
Lindsey Ingram	Stoll Keenon Ogden, PLLC
Michael G. Toll	LG&E/KU

E. Conclusions

After reviewing the documents submitted and conducting the on-site meeting with management and subject-matter experts, P&D concludes the following:

1. The construction of the 161 kV transmission line from the Grahamville Substation to the EEI transmission line near the DOE plant has been clearly and accurately established as needed to allow KU to reliably provide transmission service for the full

electrical load requirements of the municipal electric systems of Paducah and Princeton, Kentucky.

2. KU has performed all of the appropriate engineering studies using reasonable assumptions and well established methodologies to establish the need for the proposed 161 kV transmission line.

3. The two line routes identified are the only reasonable alternatives to provide the solution for the identified need to permit KU to provide transmission service to the Paducah and Princeton municipalities.

4. With only two feasible alternatives for the siting of the new transmission line, KU has utilized well accepted and proven methodologies in selecting the preferred line route (the Grahamville Substation to the EEI transmission line) to minimize costs, environmental concerns and public impacts.

II. TECHNICAL REVIEW

A. Project Description

KU filed with the KPSC on November 23, 2010, an application for a CPCN to construct a 1.69 mile transmission line from KU's Grahamville Substation to the EEI transmission line near DOE's Gaseous Diffusion Plant in McCracken County, Kentucky.

Construction of the new 161 kV transmission line is planned to be standard H-frame type tower configuration with bundled conductors with thermal capacity similar to or exceeding the existing line between Grahamville and DOE. This new proposed line route will parallel the existing line for most of the line route.

The new line will terminate at the Grahamville Substation on a dedicated 161 kV circuit breaker. On the EEI interconnection end, a three-terminal line configuration will be used. A new structure will be added in the EEI 161 kV transmission line in the second span outside the DOE substation and the new line will interconnect at this location. High speed communications via fiber optic circuits and the new generation of electronic relays will be used to reliably protect the new and existing facilities. This configuration avoids the more expensive cost of terminating on a circuit breaker in the DOE substation.

B. Technical Need

1. Load Forecasts

The loads evaluated in the base models were developed through a well defined process as defined by North American Electric Reliability Corporation (NERC), Southeastern Electric Reliability Council (SERC) and Southwest Power Pool (SPP), acting as the Independent Transmission Operator (ITO). The electrical load forecasts used by the ITO to develop a System Impact Study for the cities of Paducah and Princeton were provided by the Kentucky Municipal Power Agency (KMPA) for the period through 2022. The KMPA forecasts are coincident peak forecasts. The System Impact Study was developed based upon Paducah being supplied electrical energy from two 161 kV delivery points (Paducah and Coleman Road Substations) and Princeton being provided from a single 161 kV substation. The total summer peak loads at these three delivery points were projected to be 203.6 MW in 2010 increasing to 232.7 MW in 2022.

The load forecasts show that both cities are summer peaking with projected summer load levels 50 percent or more above the winter levels. With equipment ratings lower in the summer, it was reasonable to only evaluate summer models since the conditions will remain summer critical into the future. Year to year load increases were forecasted to increase slightly more for Paducah than for Princeton. Total combined annual growth rates were forecast to be between 1.0 and 1.2 percent. With territorial service boundaries for the municipalities defined with neighboring utilities, the growth rate of these municipalities will be modest since most of their service territories are already developed. These growth rates are very reasonable and similar to projections for other Kentucky cities of similar size and load mix.

Only normal weather forecasts were provided and used in KU's analyses. Extreme weather impacts are typically used in evaluating projects with long lead times such as substations and transmission lines. However, in this case the use of extreme weather forecasts would likely only increase load levels by 10 ~ 15 percent over a twenty year period. Since the Power Flow Analyses demonstrate that the existing capability to reliably serve the two municipalities' loads has already been exceeded, using extreme weather forecasts would not alter the need for the line and thus were not considered necessary. P&D agree with KU's analyses.

2. Power Flow Analyses

P&D reviewed the Power Flow simulations used in support of this application. Details of the study conditions, models, and contingencies are provided in the Southwest Power Pool, Facilities Study 2008-004, Revision 2, and February 3, 2008.

Only steady state simulations of contingencies were performed by KU. Since no additional generation was added and no changes are planned that would alter the dynamic performance of the bulk transmission system, no stability studies were deemed necessary. Likewise no off-peak or shoulder models were evaluated, since the transmission service problems would not occur during these conditions. Base models used in the studies were the 2010 summer, 2010 winter and 2016 summer power peak flow models developed by the SPP (operating as KU's ITO) by creating mathematical impedance models of the transmission lines, generators, transformers and other elements of the power system. Two additional models were developed to provide additional system configurations. The first was a 2010 summer model with the DOE load reduced from the 150 MW level to the projected 30 MW. There is no timetable yet for this anticipated load reduction. The second additional model developed was a 2016 summer case without the KU Green River electric generation plant operational. Although commercial operation is currently planned for 2015, the 2016 model was developed under the assumption that the plant would be shut down. In the absence of the Green River plant, electric generation to the area was provided by other KU and LG&E generators with additional power imported from PJM. New facilities associated with the proposed additional Green River generation plant were also removed from the case along with the 750 MW generator at the Green River Generating Plant, including the fourth 161-138 kV transformer and the construction of the Green River ~ Paradise 161 kV transmission line.

System deficiencies were determined by evaluating the performance of the bulk transmission system under normal and single contingency conditions. The list of contingencies studied included the loss of major 500 kV transmission lines, large power transformers (500 ~ 345 kV and 345 ~ 161 kV) and key area 161 kV transmission lines. The loss of the existing Grahamville ~ DOE 161 kV transmission line caused overloads on other study area 161 kV facilities as well as dangerously low voltages in the area overall. Additionally, this existing Grahamville ~ DOE 161 kV transmission line becomes overloaded during the outage of other 161 kV facilities in the area.

In many cases and in localized situations, the occurrence of low voltage can be remedied by the addition of reactive power into the power system from other sources such as capacitor banks. However, in this case the voltage deterioration was so severe that non-convergence of the mathematical Power Flow models occurred. Non-convergence is indicative of major voltage collapse conditions that cannot be corrected by the addition of static type devices (capacitor banks) that inject additional reactive

VARs into the system. Thus, this condition must be corrected with one or more additional system facilities (transmission lines, generators, etc.) to strengthen the network and assure that adequate voltage is maintained for the single contingencies.

Since the outage of the existing Grahamville ~ DOE 161 kV transmission line causes overloaded conditions on other transmission facilities and the high probability of voltage collapse in the study area, the most logical solution was to add another electrical path between the Grahamville and DOE substations to eliminate the single contingency problem. This solution would also correct the other identified problem of overloads on the existing Grahamville ~ DOE 161 kV transmission line during the outage of other 161 kV facilities in the area by providing a second path to share the total load transfer between these two substations. Also, the addition of a 5% reactor on both the existing line and the new line would prevent either line from loading beyond its determined thermal limits.

KU determined that it would be more cost effective to terminate the new line on the EEI WI 161 kV transmission line just outside the DOE substation. While this would avoid the more expensive cost associated with terminating it inside the DOE substation, a three-terminal line configuration will be required. Technological advances in the design and operation of high speed relays and the use of fiber optic circuits for instantaneous communications has now permitted the use of three-terminal lines to be relayed and operated with an extremely high level of reliability.

Constructing other new lines in the area could conceivably correct the identified voltage and loading problems. However, no other alternative was identified that corrected the identified deficiencies as completely without requiring the addition of considerably more miles of transmission line and other facilities. Double contingencies are normally evaluated for the purpose of identifying whether cascading or major system collapse would occur for the modeled conditions. In this case the addition of a second Grahamville ~ DOE 161 kV transmission line will result in a stronger and more robust transmission system than before. After the proposed line is added, the transmission system should be less vulnerable to double contingencies than currently exists and less susceptible to cascading.

The largest electrical load in the area is located at the DOE Gaseous Diffusion Plant. Changes in the nuclear industry have caused the load to vary substantially over the years. As previously mentioned, an additional model was developed and evaluated to study the impacts of lower loads at this facility since it has been announced that this load will be reduced significantly in the future.

It is recognized that the combination of electrical load and generation in the Paducah, Kentucky area has a large impact on the loading conditions of many of the facilities in the area. The Shawnee (1,600 MW) and Joppa (1,010 MW) generation plants typically produce more generation than is used in the area and the excess must be transferred outside of the local region. TVA recently announced that it will soon be retiring Unit 10 (160 MW) at the Shawnee Steam Plant. While TVA indicated that in the future all of its fossil generation at Shawnee may be retired, a timetable for doing so was not provided. KU did not evaluate the impacts of TVA's plans since it had not been announced when the studies were completed. Ideally, it would be desirable to consider all of the possible scenarios of load and generation in the area but realistically, only the most reasonable extremes can be evaluated. While the area load variations appear to have been fully evaluated without significant impacts, a large reduction in area generation was not fully simulated. Since the problems identified are primarily related to overloading conditions, it is reasonable to assume that some reductions in generation at Shawnee would most likely improve system conditions rather than making them more pronounced.

P&D has concluded that KU's analyses are reasonable and that the addition of a second tie line between the Grahamville and DOE 161 kV Substations is the most logical and best solution to the identified overload and low voltage problems.

3. Reliability Criteria

The reliability standards used by KU were reviewed by P&D. Very detailed and thorough reliability criteria have been developed by NERC and their member systems in recent years. The NERC Reliability Standards TPL-001 through TPL-004 outlines the fundamental requirements for planning a reliable interconnected bulk transmission system.

Base Case simulation models are developed for summer and winter peak periods for the most recent NERC Multi-Regional Modeling Working Group Base Case Series. In addition a longer term model at least 10 years into the future is developed each year. The models have detailed representations of the LG&E, KU and East Kentucky Power Cooperative (EKPC) areas for all facilities 69 kV and higher. Generation is initially dispatched on an economic basis and electrical loads included are forecasted by the Network Customers. Planned outages of more than three months duration are simulated. While other transfers may occur, only those economic and scheduled transfers between systems are included if commitments are in place and known. If future transfers are desired, they must be evaluated on their own merits and impacts evaluated and addressed. This development of Base Case models has been extremely well developed over the past many years and these models have proven to be excellent representations of the bulk network over the years that can be used to simulate the bulk system's operation under all future conditions.

Following the NERC Reliability Standards, EON U.S. LLC. established five levels of performance for evaluating the operational integrity of the bulk transmission system as shown below. Since being sold to Pennsylvania Power and Light (PP&L) and being renamed as LG&E and KU, the established levels of performance have continued. Only Levels 1 and 2 were pertinent to the studies for Case 2010-00164 since generation changes were not a part of this project.

✓ Level 1

- Power flows will not exceed the normal thermal limit
- System voltages shall be within the limits specified for normal conditions
- Network Loads are served from normal delivery points

✓ Level 2

- Power flows shall not exceed the emergency thermal limit

- Transmission voltages at Generator Connections shall be greater than specified in **Table 3**
- System voltages shall be within the limits specified for contingency conditions
- Network Loads that are removed from service due to the fault clearing action can be reconnected using Load and Restoration and Switching procedures.

Level 3

- Transmission voltages at Generator Connections shall be greater than specified in Table 3 Bulk Electric System voltages shall be greater than 0.80 p.u.
- Subsequent tripping of Bulk Electric System facilities with power flows in excess of the emergency thermal limit shall not cause
    1) Low voltage at generators connected to the Bulk Electric System
    2) Power flows in excess of the emergency thermal limit on two or more Bulk Electric System facilities
    3) Non-Consequential Load Loss in excess of 10 percent of the forecasted seasonal peak load

Level 4

- Following generation re-dispatch or shedding of 5 percent of forecasted seasonal peak load
    1) Bulk Electric System power flows shall not exceed the emergency thermal limit
    2) System voltages shall be within the limits specified for contingency conditions
    3) Transmission voltages at Generator Connections shall be greater than specified in Table 3

Level 5

- If the analysis concludes that there are cascading outages caused by the occurrence of the event, an evaluation of implementing a change designed to reduce or mitigate the likelihood of such consequences shall be conducted.

Additional generator and transmission contingency information has been provided in Tables 1 ~ 3. **Table 1** lists the required performance levels associated with each of the NERC contingency categories. **Table 2** indicates to what transmission voltage level the power plants will be regulated to in the Base Case models. **Table 3** shows the minimum acceptable transmission voltage level at each generating unit connection necessary to maintain generator voltage and auxiliary bus voltage above 95 percent of nominal with the unit operating at maximum MW and MVAR output.

KU followed NERC's well accepted thermal facility and system voltage limits in its transmission system simulations. All contingency selections followed NERC Guidelines in all modeling considerations. After review and evaluation, P&D has determined that the standards and assumptions used in KU's modeling analyses meet or exceed the NERC and SERC standards.

4. **Fault Studies**

KU plans to install 5% reactors on both the existing Grahamville ~ DOE line and the new proposed Grahamville ~ EEI 161 kV transmission line to both reduce area overloads and contingency flows. With these reactors in place, the line impedances will be increased and short circuit currents will be reduced. P&D agrees that it is reasonable to assume that the area fault currents would not be impacted significantly and that the completion of a detailed fault study or further stability analyses is not warranted.

5. **Economic Evaluations**

The results of KU's "need evaluation" identified only two feasible alternatives; rebuilding the existing Grahamville DOE line (creating a double circuit) or constructing a second separate line. Since both alternatives would utilize similar construction techniques, it is reasonable to conclude that since the Grahamville EEI line has a much shorter length; it will have a lower cost. Therefore, KU concluded that a detailed present worth economic evaluation comparing the two alternatives was not required.

Based on its review of the load forecasts, power flow analyses, and reliability criteria, P&D concludes that KU has performed all of the appropriate engineering studies and used reasonable assumptions and well established methodologies to establish the need for the proposed 161 kV transmission line.

C. Project Alternatives

Having established a clear need for the construction of the 161 kV transmission line from the Grahamville Substation to the DOE plant, project alternatives were identified and evaluated.

The first option investigated was to rebuild the exiting transmission line to accommodate two 161 kV circuits. However, this would violate KU's transmission planning guidelines for new construction since loss of both circuits would be considered as a single contingency event.

The second option was to construct a separate line. Two routes for the new line were selected that would work electrically and could be constructed parallel to existing 161 kV transmission lines for most of the proposed routes. Co-locating lines provides many benefits including minimizing right-of-way and maintenance costs, reducing the visual clutter of the landscape, and reducing land use impacts to property owners. KU identified two route alternatives and appear to have thoroughly investigated options to determine the optimum line route.

P&D agrees that the two line routes identified are the only reasonable alternatives to provide the solution for the identified need to permit KU to provide firm transmission service to the Paducah and Princeton municipalities both now and well into the future.

D. Transmission Line Route Selection

Mr. Edwin R. Staton's testimony on this case filed November 23, 2010, thoroughly addresses the route selection process used for the proposed line. The process followed involved five steps and was outlined by the KPSC at an October 3, 2005, informal conference in Case Nos. 2005-00142 and 2005-00154. Those steps are as follows:

- Establish the need
- Identify all lines that could work electrically
- Identify the least cost alternative
- Consider the rate impact of alternative lines that are not the least cost
- Perform comparisons of the routes based on built, natural and engineering criteria.

KU has followed all of these steps with the exception of Step 4. Since the least cost route was selected as the preferred line routing, this step was not necessary. Step 5 used methodology developed by the Electric Power Research Institute for the siting of overhead transmission lines and this is well accepted in the industry.

The preferred line route will closely approach two residential structures. Agreements have been reached with both property owners to accommodate the new proposed line. In the first case, a residential structure will be removed and the owner relocated. In the second case, a mobile home will be relocated to a location no closer than 75 feet from the new transmission line centerline. The right-of-way for the proposed line is 150 feet. Since agreements have been satisfactorily reached with all property owners, it was not necessary to consider other more expensive alternative transmission line designs to increase the distance between the line and residential structure.

After reviewing the documents related to the transmission line route selection, P&D concludes that KU has utilized well accepted and proven methodologies in selecting the preferred line route to assure that the costs, environmental concerns and public impacts are minimized as a result of new line construction.

III. QUESTIONS SUBMITTED

A. Initial Questions Submitted to KU on December 7, 2010

1. Provide a one-line diagram for the transmission area surrounding the proposed line.
2. Provide the design and reliability criteria used for the transmission system power flow studies.
3. Provide the following information for the Power Flow scenarios studied:
   a. What season and year system models were used in the power flow studies?
   b. What area transfers were in place in these models?
   c. Discuss the sensitivity of the results of the studies to these transfers.
4. Provide the generation dispatch scenarios used at the Tennessee Valley Authority's ("TVA") Shawnee Steam and other electrically close generation plants in each case studied and discuss the sensitivity of the results of these studies to these transfers.
5. TVA recently announced plans to retire older fossil generating units including Unit 10 at Shawnee Steam Plant. Was this and future additional retirements considered in these analyses? If so, which units were considered and for what timeframe?
6. Provide a summary of the short-circuit analysis performed for the proposed new transmission line.
7. Currently it is stated that only 125 MW of firm load can be provided to Paducah, KY and Princeton, KY without the proposed system improvements. After the proposed line is in service how much total load can be supplied to these two entities?
8. What are the projected load growths rates (normal and extreme) for both Paducah and Princeton?
9. Were the prior TVA developed Paducah and Princeton load growth studies used for load forecasting or were new ones developed by Kentucky Utilities Company ("KU") or others?

10. Provide a brief description of the load forecasting process(s) used for Paducah and for Princeton.
11. How will the proposed transmission line be terminated at the DOE end?
12. How close will the nearest residential structure be to the new transmission line?
13. What alternative line designs such as single pole, vertical phase, etc. were considered to increase the distance to structures?
14. Given the change in Tariff Administrator due to the change in corporate ownership, does this impact the existing OATTi or other proposed cost recovery mechanism?
15. Will the change of corporate ownership and the timing of the change with respect to the application, impact or change reliability coordination?

B. Additional Questions Submitted to KU on December 10, 2010

1. Provide the load levels studied at the DOE Gaseous Diffusion Plant for this project.
2. Provide a copy of the "2008-004 Facility Study" associated with this project.

TABLE 1: TRANSMISSION CONTINGENCIES AND MEASUREMENTS

NERC CAT.	CONTINGENCY	STEADY STATE ANALYSIS	DYNAMIC ANALYSIS	REQUIRED PERFORMANCE LEVEL
A	No Contingencies	Yes		1
B 1-3	Outage of a generator, transmission circuit, transformer or shunt device		a, b	2
C3	Outage of two generators	Yes	b	2
C3	Outage of a generator and a transmission circuit	Yes	b	2
C3	Outage of a generator and a transformer	Yes		2
	Outage of a transmission circuit or transformer with plant at max output	Yes		2
C1	Outage of a bus section	Yes	c	3
C2	Outage of a breaker	Yes	c	3
C5	Outage of two circuits on a multiple circuit tower line. [more than 1 mile in length]	Yes	d	3
C3	Outage of two transmission circuits.	Yes	b	4
C3	Outage of a transmission circuit and a transformer	Yes	b	4
C3	Outage of two transformers	Yes	b	4
C6-8 D1-3	Outage of a generator, transmission circuit or transformer	No	e, f	2
C9,D4	Outage of a bus section	No	e, f	3
D5	Outage of a breaker	No	g	3
D6	Outage of tower line with three or more circuits`	Yes	a	5
D7	All transmission on a common right-of way [more than 1 mile in length]	Yes	a	5
D8	Outage of a substation (one voltage level plus transformers	Yes	a	5
D9	Outage of a switching station (one voltage level plus transformers	Yes	a	5
D10	Outage of all generating units at a station	Yes	a	5
D11	Loss of a large load or major load center	Yes	a	5

Fault Types:

a) None
b) Single Line Ground or 3-Phase, with Normal Clearing
c) Single Line Ground, with Normal Clearing
d) Non 3-Phase, with Normal Clearing
e) Single Line Ground, with Delayed Clearing
f) 3-Phase with Delayed Clearing
g) 3-Phase with Normal Clearing

TABLE 2: REGULATED PLANT VOLTAGE

POWER PLANT (NAME)	TRANSMISSION		
	BUS (KV)	VOLTAGE (KV)	VOLTAGE (PER UNIT)
Brown	Brown N 138	141	1.022
Bluegrass	Buckner 345	352	1.020
Cane Run	Cane Run SW 138	139	1.007
Ghent	Ghent 345	352	1.020
Green River	Green River 138	141	1.022
Mill Creek	Mill Creek 345	352	1.020
Paddy's Run	Paddy's Run 138	139	1.007
Trimble County	Trimble Co 345	352	1.020
Tyrone	Tyrone 69	70	1.014
Elmer Smith	Smith 138	141	1.022

TABLE 3: MINIMUM TRANSMISSION VOLTAGE AT GENERATOR CONNECTIONS

TRANSMISSION BUS	CONNECTED GENERATOR	MINIMUM VOLTAGE (KV)	MINIMUM VOLTAGE (P.U.)	LIMIT
Brown Plant 138	Brown 1		0.935	Gen
"	Brown 2	133.0	0.964	Aux
Brown North 138	Brown 3	128.5	0.931	Aux
Brown CT 138	Brown 5		0.928	Gen
"	Brown 6	128.2	0.929	Gen
"	Brown 7		0.929	Gen
"	Brown 8		0.918	Gen
"	Brown 9		0.918	Gen
"	Brown 10		0.918	Gen
"	Brown 11		0.918	Gen
Cane Run SW 138	Cane Run 4		0.936	Gen
"	Cane Run 5	129.9	0.941	Gen
Cane Run 6	Cane Run 6	129.7	0.940	Gen
Ghent 138	Ghent 1	130.7	0.947	Aux
Ghent 345	Ghent 2		0.959	Gen
"	Ghent 3	332.6	0.964	Gen
"	Ghent 4		0.963	Gen
Green River 138	Green River 3		0.926	Aux
"	Green River 4	130.3	0.944	Aux
Mill Creek 345	Mill Creek 1		0.958	Gen
"	Mill Creek 2	330.5	0.958	Gen
"	Mill Creek 3		0.953	Gen
"	Mill Creek 4		0.953	Gen
Paddy's Run 138	Paddy's Run 13	129.3	0.937	Gen
Trimble Co 345	Trimble Co 1	331.2	0.960	Gen
Trimble Co CT 345	Trimble Co 5	325.3	0.943	Gen
"	Trimble Co 6		0.943	Gen
"	Trimble Co 7		0.943	Gen
"	Trimble Co 8		0.943	Gen
"	Trimble Co 9		0.943	Gen
"	Trimble Co 10		0.943	Gen
Smith 138	Smith 1		0.942	Gen
"	Smith 2	130.4	0.945	Gen