



**Kansas City Power & Light Company**

**KCP&L Greater Missouri Operations Company**

# **BULK ELECTRIC SYSTEM PLANNING CRITERIA**

**TRANSMISSION PLANNING  
APRIL 1, 2009**

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## 1.0 INTRODUCTION

The primary purpose of the Company's (inclusive of Kansas City Power & Light Company (KCP&L) and KCP&L Greater Missouri Operations Company (GMO)) bulk electric system is to supply our customers with economic and reliable electrical energy. To achieve this objective Transmission Planning has developed minimum planning criteria, which provides the basis for the design and operating criteria of the Company's bulk electric system. This Criteria presents the characteristics of a well-planned bulk power electric system, describes the basis for model testing and lists the reliability and adequacy tests to be used to evaluate the performance of the Company's bulk electric system. Reliable operation of the Company's interconnected bulk electric system requires that the system comply with these Criteria. The Company's Bulk Electric System Planning Criteria meets or exceeds all North American Electric Reliability Corporation (NERC) Reliability Standards and Southwest Power Pool (SPP) Transmission Planning Criteria.

Prior to July 2008, GMO was known as Aquila. With the acquisition of Aquila by Great Plains Energy (parent of KCP&L), these Criteria now applies to the former Aquila Missouri electric service territory. In this document "KCP&L" is inclusive of both KCP&L and GMO service areas. "GMO" will be used to refer to items only applying to KCP&L Greater Missouri Operations Company.

KCP&L is a member of the SPP Regional Transmission Organization (RTO). SPP is one of the eight regional reliability council members of NERC. SPP performs the requirements of a Reliability Coordinator and Planning Authority function for KCP&L. KCP&L performs the requirements of a Transmission Operator and Transmission Planner function. The SPP Criteria is revised on an on-going basis as needed to incorporate the policies, standards, and principles by which the coordinated planning and operation of the interconnected electric system is achieved.

In February 2005, the NERC Board of Trustees adopted Version 0 of the new NERC Reliability Standards with an effective date for implementation of April 1, 2005. These new Reliability Standards define the reliability requirements for planning and operating the North American bulk electric system. They were developed from the previous NERC Operating Policies and Planning Standards into a form that would fit the NERC Reliability Functional Model of the electric utility industry.

In 2006, the Federal Energy Regulatory Commission (FERC) certified NERC as the Electric Reliability Organization (ERO), approved a base set of 83 reliability standards, and required NERC to develop a Compliance Monitoring and Enforcement Program (CMEP). In April 2007, FERC approved delegation agreements between NERC and eight (8) regional entities (RE), including SPP, responsible to perform the delegated reliability compliance and monitoring functions.

The Reliability Standards include four standards on Transmission Planning (TPL) with a total of 89 requirements or sub-requirements on transmission system performance and regional reliability assessments. These TPL standards are applicable to the Planning Authority and Transmission Planner functions of the NERC Reliability Functional Model.

## 2.0 KCP&L TRANSMISSION PLANNING

The interconnected transmission system should be capable of performing reliably under a wide variety of expected system conditions while continuing to operate within equipment and electric system thermal, voltage, and stability limits. Electric systems must be planned to withstand contingencies and maintenance outages. Extreme event contingencies, which measure the robustness of the electric systems, should be evaluated for risks and consequences. The NERC Reliability Standards define specific transmission planning requirements that provide reliability for the bulk interconnected electric system. SPP provides coordinated regional transmission planning requirements to promote reliability through its Criteria Section 3, “Regional Transmission Planning”, and related Attachment O, “Coordinated Planning Procedures”, in the SPP Open Access Transmission Tariff (OATT).

It is the policy of KCP&L to maintain as high an interconnection capability with adjoining systems as is economically prudent. These interconnections with adjoining systems shall be designed such that KCP&L will remain interconnected following all of the more probable transmission and generation outage contingencies as described in the NERC Reliability Standards found in Table I. It is recognized that emergencies that occur in adjoining systems can affect KCP&L, just as the emergencies within KCP&L can affect adjoining systems. Therefore, joint studies will be made on a regular basis to investigate various system emergencies that can occur and their effects on the various systems involved. In this way, the effectiveness of existing and planned interconnections will be periodically measured and the design of the system periodically updated so that the interconnection capability and reliability will be maintained. In these activities KCP&L will perform the requirements of the Transmission Planner function as defined in the NERC Reliability Functional Model.

Transmission planning criteria for the KCP&L electric system shall at a minimum conform to the NERC Reliability Standards and SPP Transmission Planning Criteria Section 3 and meet the following:

- a) Excessive concentration of power being carried on any single transmission circuit, multi-circuit transmission line, or right-of-way, as well as through any one transmission station shall be avoided.
- b) Adequate transmission capability shall be maintained to provide for intra-regional, inter-regional and trans-regional power flows under

- normal and more probable contingency conditions as defined in Table I of the NERC Reliability Standards (see attached Appendix 1).
- c) Switching arrangements shall be utilized that permit effective maintenance of equipment without excessive risk to the electric system.
  - d) Switching arrangements and associated protective relay systems shall be utilized that do not limit the capability of a transmission path to the extent of causing excessive risk to the electric system.
  - e) Sufficient reactive capacity shall be planned within the KCP&L electric system at appropriate places to maintain transmission system voltages within plus or minus 5% under normal and within plus 5% or minus 10% for contingency conditions, for all busses. Certain transmission busses such as, Northeast, Bull Creek, and Osawatomie require higher voltage levels to provide for successful starting of combustion turbines located there. At those busses KCPL will maintain additional reactive resources to meet the individual bus voltage requirements.
  - f) KCP&L electric transmission facilities shall be rated, as a minimum, in accordance with SPP Criteria 12 and Section 4 of this Criterion titled "KCP&L Overload Policy for Transmission Facilities". KCP&L uses 90 degrees C as the conductor temperature for normal transmission line ratings for ACSR conductors.

The strategy for transmission planning at KCP&L is driven primarily by two main goals. The first goal is compliance with reliability standards at the national (NERC/FERC), regional (SPP) and local (KCP&L) levels. The second goal is to provide transmission capacity for existing and new loads and existing and new electric supply resources.

Transmission planning for reliability standards compliance is performed for all planning horizons; operational (real time to 1 year in future), near term (1 to 5 years in future), and long term (5 to 10 years in future). It generally involves the analysis of the transmission system under various operating conditions, the identification of any reliability standard violations, and the development of plans or actions to mitigate each violation.

Transmission planning for capacity expansion to serve loads and new supply resources are performed for both the near term and long term planning horizons. Transmission planning must interface with the planning performed by the Distribution Provider and Resource Planner functions of the NERC Reliability Functional Model. The Distribution Provider provides input on the size and location of loads to the transmission planning process. The Resource Planner provides the size and locations of future resources through the SPP process. Long term transmission planning is performed to develop an overall plan for expansion of the transmission system. This would include the approximate capacity and location of transmission assets required for future operations. Near term transmission planning is performed to refine portions of the long-term

transmission plan on localized areas and provide more definition of required transmission assets.

Another part of transmission expansion is driven by transmission service requests and generation interconnection requests made to SPP as the RTO. KCP&L participates in SPP's transmission system planning process to assess the ability of the transmission system to provide these requested services in the near and long term planning horizons. This includes development of plans or new transmission asset additions that will be required to meet reliability standards if the requested services are granted.

## **2.1 Transmission Contingency Analysis**

The KCP&L transmission system shall be planned and constructed so that the contingencies as set forth in these Criteria will meet the applicable NERC Reliability Standards for Table I and SPP Transmission Planning Criteria and their applicable requirements and measurements.

Table I in Appendix 1 was developed to thoroughly search out the most severe, credible contingencies for study, creating the assurance that the many possible contingencies not studied are less severe. Appendix 1 lists the normal and contingency conditions under which the electric transmission system is to be analyzed. It also lists the limits or impacts that the transmission system can sustain and still meet an acceptable performance level.

### **2.1.1 Base Case Analysis**

KCP&L will support and participate in the SPP Model Development Working group (MDWG) development and verification of base case transmission system models. KCP&L base case models will maintain at least the following attributes:

- System facilities shall be modeled to reflect normal operating conditions and limits
- Line and equipment loading shall be within normal rating limits.
- Voltage levels shall be maintained within plus or minus 5% of nominal voltage
- All customer electrical demands shall be supplied, and all contracted firm (non-recallable reserved) transfers shall be maintained.
- Stability (dynamic and steady state) of the network shall be maintained.
- Cascading outages shall not occur.

### **2.1.2 Loss of Single Component Analysis**

KCP&L will perform single contingency studies under the following conditions:

- Initiating incident results in a single element out of service.
- Line and equipment loadings shall be within emergency rating limits.

- Voltage levels shall be maintained within plus 5% or minus 10% of nominal voltage for all busses.
- No loss of customer electric demand (except as noted in Appendix 1, Footnote b).
- No curtailment of contracted firm (non-recallable reserved) transfers shall be required.
- Stability (angular and voltage) of the network shall be maintained.
- Cascading outages shall not occur.

### **2.1.3 Loss of Two or More Transmission Components**

KCP&L will perform contingency studies under the following conditions:

- Initiating incident may result in two or more (multiple) components out of service including common right-of-way and common structure circuits.
- Line and equipment loadings shall be within emergency thermal rating limits.
- Voltage levels shall be maintained within plus 5% or minus 10% of nominal voltage for all busses.
- Stability (angular and voltage) of the network shall be maintained.
- Planned outages of customer demand or generation (as noted in Appendix 1) may occur.
- Contracted firm (non-recallable reserved) transfers may be curtailed.
- Cascading outages shall not occur.

### **2.1.4 Extreme Contingency Events**

KCP&L will perform contingency studies where extreme contingency events could lead to uncontrolled cascading outages or system instability. KCP&L shall document the measures and procedures to mitigate or eliminate the extent and effects of those events.

## **2.2 Study Requirements**

KCP&L participates in all SPP coordinated planning studies and performs internal load flow, transient stability and voltage stability studies to meet NERC Reliability Standards compliance.

These studies will consider all contingencies applicable to the appropriate NERC Table I, Category A through D events.

Annually, KCP&L will perform summer and winter peak operating studies for the upcoming seasons. Intermediate range studies covering the two to five year planning horizons to address both intra- and interregional reliability will be performed as needed. A 10-year expansion planning study will be conducted no less than biannually.

For transient stability studies, angular stability shall be maintained between KCP&L and neighboring systems when the loss of the electric network component was caused by a three-phase fault at the worst location with breaker clearing times shown in Table 1 below:

Table 1 345kV and 161kV Breaker Clearing Times (Cycles/Seconds)

|                | <b>NORMAL CLEARING TIME</b> | <b>STUCK BREAKER CLEARING TIME</b> |
|----------------|-----------------------------|------------------------------------|
| 161 KV BREAKER | 7.2 Cycles (0.12 Second)    | 25.0 Cycles (0.42 Second)          |
| 345 KV BREAKER | 3.6 Cycles (0.06 Second)    | 10.8 Cycles (0.18 Second)          |

For voltage stability studies, stability shall be maintained under single and multiple contingencies throughout the KCP&L area. The performance and voltage stability criteria listed below will be followed:

- Critical voltage (voltage at bottom of V-Q curve) and reactive power margin should be sufficient such that stability is ensured following the loss of nearby reactive power sources and
- Reactive capacity shall be sufficient to ensure that transmission system voltage is maintained within plus 5% or minus 10% of nominal for single contingencies.

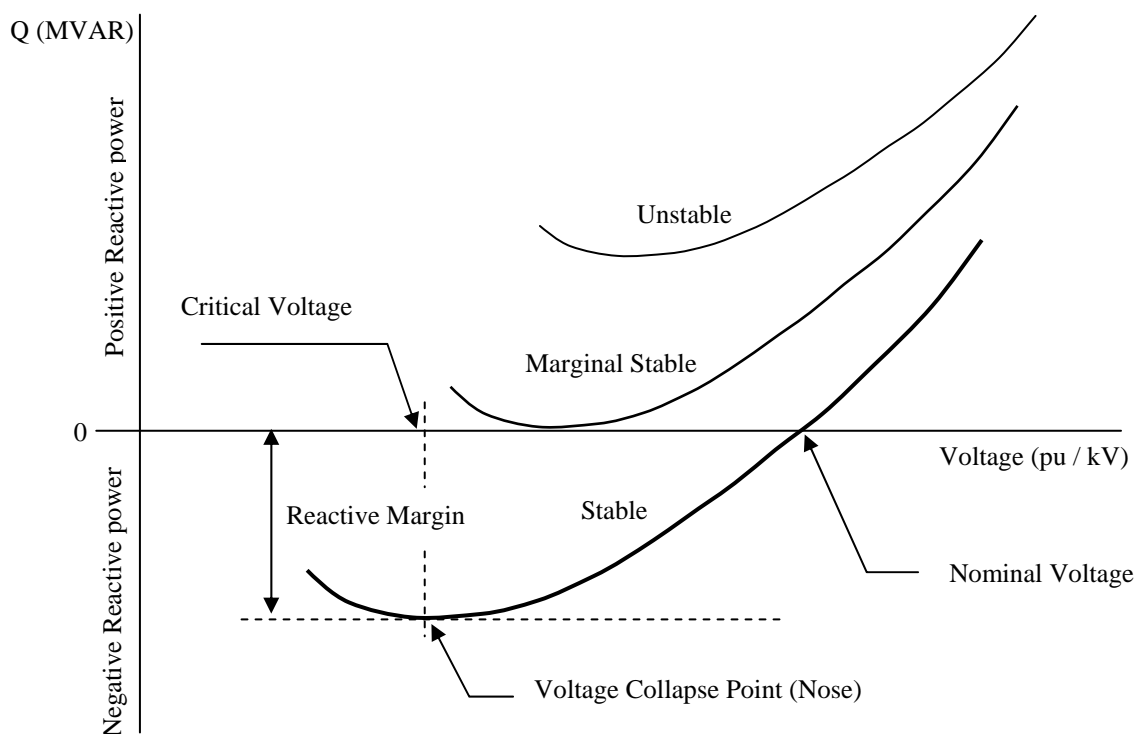


Figure 1 V-Q Curve

### 2.3 Transmission Planning for Serving New Customer Load

Customer Services Distribution Engineering has traditionally planned for serving existing and new load additions on the KCP&L distribution systems (<69kV). This includes deciding when new transmission sources are needed to meet increased demand on the distribution system due to overloaded distribution facilities or inadequate distribution voltage profiles. These new substations are incorporated into KCP&L's transmission expansion plan by optimizing the existing transmission system network or expanding the system into these areas.

Historically KCP&L has provided new transmission sources for the distribution system by either inserting new load serving substations in existing transmission lines when possible or building new transmission lines to connect the new substations. In areas where expansion of the 34kV system is no longer the prudent solution, converting these 34kV loads to 12kV requires new 161/12kV substations.

Inserting new substations in existing lines was done for reasons of economics and site requirements. This practice has led to transmission lines with numerous two terminal load serving substations along their length. Operational and reliability problems can arise from this practice when the amount of total load served by these substations exceeds the capability of the transmission lines serving them with the outage of one end of the line. To avoid these problems

KCP&L has established the following planning criteria for the number of two-terminal substations between source substations and building the second transmission line into a radial substation:

- During normal or contingency conditions, when the amount of connected load-serving transformer capacity on a transmission path serving only two terminal substations exceeds the normal rating of any of the transmission lines between the source substations or when the third two-terminal substation is added between source substations, a third transmission source shall be required that connects into one of the two-terminal substations. However, the installation of this new line is dependent on site, availability of right-of-way and environmental considerations.
- A second transmission source shall be required for a radial substation when the radial substation load cannot be served from backup distribution sources for the outage of the radial transmission line. The timing of this new transmission line is also dependent on site, availability of right-of-way and environmental considerations.

At the time of the acquisition of Aquila, the GMO system was reviewed to determine if it met the requirements of section 2.3 of the Criteria. There were areas of the GMO system identified that did not meet the requirements of section 2.3. Plans will be developed in the future to bring those areas into accord with these Criteria, subject to siting, availability of right-of-way and environmental considerations.

### **3.0 MONITORING TRANSMISSION SYSTEM PERFORMANCE**

An important part of transmission planning is monitoring transmission system performance. This includes monitoring the performance of specific elements within the transmission system and benchmarking the overall performance of the KCP&L transmission system against past performance and other similar transmission systems. To accomplish this effort KCP&L's Transmission Services has an inter-departmental work group which analyzes transmission system performance on a monthly basis. This group produces an annual report entitled KCP&L Transmission System Reliability Indices Report.

#### **3.1 Transmission Reliability Indices**

Transmission Reliability Indices have been established to monitor Transmission Outage Frequency (Frequency), Forced Outages per Hundred line Mile Year (FOHMY), Transmission SAIDI or Customer Minutes Outage (SAIDI<sub>T</sub>, or CMO),

and Transmission System Availability (Availability). These indices are used to provide quantitative measures of transmission system reliability. All of the above reliability indices are based on forced outages only in the transmission system for 69kV and above facilities. Transmission reliability indices are evaluated monthly, quarterly, and annually to monitor transmission system performance and are used to recommend corrective measures to maintain and improve transmission system reliability. Transmission outages are broadly classified by cause codes. Transmission outages due to major events are recorded but may be excluded from reliability indices evaluation to achieve comparability.

#### **4.0 CALCULATION of AVAILABLE TRANSFER CAPABILITY**

The calculation of Available Transfer Capability (ATC) is a very complex and dynamic procedure. KCP&L realizes that there are many technical and policy issues concerning the calculation of ATC that will evolve with industry changes. A key element of NERC's ATC principles is "Regional or wide-area coordination is necessary to develop and post information that reasonably reflects the ATC's of the interconnected transmission network". Therefore, KCP&L will follow SPP guidelines and methodology as outlined in Section 4.0 of SPP Criteria.

SPP takes a regional approach in the determination of Available Transfer Capability (ATC). The regional approach calls for SPP to evaluate the inter-area transfer capability of its Transmission Owners (i.e. KCP&L). This approach provides a high level of coordination between ATC reported by SPP and Transmission Owners on SPP Open Access Same-time Information Network (OASIS) nodes.

The SPP utilizes a "constrained element" approach in determining ATC. This approach is referred to as a Flowgate ATC methodology. Constrained facilities, termed "flowgates", used in this approach are identified primarily from a non-simultaneous transfer study using standard incremental transfer capability techniques that recognize thermal, voltage and contractual limitations. Stability limitations are studied as needed. Flowgates serve as proxies for the transmission network and are used to study system response to transfers and contingencies. Using flowgates with pre-determined ratings, this process is able to evaluate the ATC of specific paths on a constrained element basis (flowgate basis) while considering the simultaneous impact of existing transactions. The calculation of ATC is a very complex and dynamic procedure. SPP realizes that there are many technical and policy issues concerning the calculation of ATC that will evolve with industry changes. Therefore, the SPP Operating Reliability Working Group and the SPP Transmission Working Group will have the joint authority to modify the implementation of Section 4 of the Criteria based on experience and improvements in technology and data coordination. Any changes made by these groups will be subject to formal approval as outlined in the SPP By-laws at the first practical opportunity.

The determination of ATC via Flowgates utilizes proxy elements to represent the power transmission network. This process depends on the selected Flowgates to act as pre-determined limiting constraints to power transfer. The process by which ATC will be determined when using the Flowgate proxy technique incorporates the Definitions and Concepts within SPP Criteria 4.

Determination of ATC via Flowgates adheres to the following approach:

- Establishes a network representation (power flow model).
- Identifies potential limits to transfer (thermal, voltage, stability, contract).
- Determines response factors of identified limits relative to transfer directions (TDF).
- Determines impacts of existing commitments (Firm, Non-Firm)
- Applies margins (TRM, CBM, a & b multipliers).
- Determines maximum transfer capabilities allowed by limits and applied margins (ATC, FATC, NFATC).

#### **4.1 ATC Calculation and Posting Timeframes**

To assist Transmission Providers with Short-Term service obligations under FERC Order 888 and 889, SPP will calculate the monthly path ATC for the upcoming 16-months for all potential commercial paths for Transmission Providers in the SPP Region. This data will be posted for use in evaluating the SPP OATT requests.

Daily and Weekly ATC is calculated on a daily basis and posted at the time of run. SPP will also provide control area/balancing areas (CA/BA) to CA/BA path conversions to any individual providers needing that information to administer their own tariff. Hourly calculations are done hourly for anywhere from 12 to 36 hours ahead depending on time of day. SPP has a firm-scheduling deadline at 12:00 noon, day prior to start. At this point all firm schedules are known and the hourly non-firm request window opens for the next day. Then, SPP calculates hourly ATC for HE 14 of the current day through HE 24 of the next day. This process continues dropping the current hour each resynchronization until 12:00 noon the next day when the cycle starts again.

#### **4.2 Use of the KCP&L Open Access Transmission Tariff**

SPP functions as KCP&L's Transmission Service Provider under the SPP OATT. Grandfathered transmission service schedules that used the KCP&L Open Access Transmission Tariff have been converted to the SPP OATT.

As of March 2009, GMO continues to operate as a Transmission Service Provider for network service the MPS and SJLP OATTs. All point-to-point transmission service is provided under the SPP OATT.

## **5.0 KCP&L OVERLOAD POLICY FOR TRANSMISSION FACILITIES**

KCP&L shall design and operate the transmission network in a safe and reliable manner. In order to accomplish this goal, one must first determine safe-operating limits of the equipment involved. This document provides a general discussion of the practices used in developing ratings for the equipment used on the transmission system as well as a description of KCP&L's practices for developing loading limitations for the facilities (transmission lines and transformers), based upon these ratings.

SPP Criteria Section 12 describes the rating criteria for all types of transmission equipment based on IEEE and ANSI standards. This criteria was designed to ensure that all circuits operated at 69 KV and above in the SPP region are rated on a consistent basis for reliable planning and operation of the transmission network. The KCP&L overload policy on transmission facilities meets or exceeds the SPP transmission equipment rating criteria follows the SPP practice of rating transmission facilities as though all equipment were in service and capable of normal operation.

### **5.1 Development of Equipment Ratings & Loading Limits**

A maximum current capacity rating is assigned to all equipment on the KCP&L bulk power transmission system. The development of the ratings for each type of equipment is discussed below

#### **5.1.1 Overhead Conductors**

Maximum current ratings are calculated for ACSR (aluminum conductor steel reinforced) overhead conductors based upon maintaining conductor temperature limits of 90°C (SPP uses 85 °C) and 100°C. The current ratings developed for these conductor temperatures represent the Normal and the Emergency ratings of the conductors, respectively. Each of these ratings is developed for the Summer Peak, Winter Peak, and Spring/Fall seasons of the year.

Beginning in 2003, KCP&L began using ACSS (aluminum conductor steel supported) overhead conductor in certain situations where contingent overloads on ACSR conductors would limit transfer capability. For this conductor, the normal and emergency ratings will be based on allowing a maximum conductor temperature of up to 200 °C dependent upon adequate clearance levels.

Ratings for the St. Joseph – Cooper 345kV line were developed by GMO while still a part of Aquila. Thus, Aquila's methodology for facility ratings at that time was utilized. Because those line ratings were specified by contract language in certain agreements, KCP&L will continue to use the Aquila facility rating methodology for this line in the future. In all other instances, unless specified,

the KCP&L facility rating methodology will apply to GMO facilities wherever adequate clearance exists.

The maximum current ratings for each of these conductor temperatures are calculated using EPRI's DYNAMP computer model. These ratings are static ratings based upon the following anticipated system conditions:

Table 2 System Design Variables Modeled in DYNAMP

| Data Items          | Input Conditions       |                        |                        |
|---------------------|------------------------|------------------------|------------------------|
|                     | Summer Peak Conditions | Winter Peak Conditions | Spring/Fall Conditions |
| Date                | June 15                | January 1              | April 1                |
| Time                | 12:00 Noon             | 12:00 Noon             | 12:00 Noon             |
| Latitude            | 38.5° N                | 38.5° N                | 38.5° N                |
| Longitude           | 94.0° W                | 94.0° W                | 94.0° W                |
| Inclination Angle   | 0°                     | 0°                     | 0°                     |
| Ambient Temperature | 37.7°C<br>100°F        | 0°C<br>32°F            | 20°C<br>68°F           |
| Line Axis Azimuth   | 90°                    | 90°                    | 90°                    |
| Elevation           | 950 feet               | 950 feet               | 950 feet               |
| Absorbtivity        | 1.0                    | 1.0                    | 1.0                    |
| Emissivity          | 0.85                   | 0.85                   | 0.85                   |
| Wind Direction      | 180°                   | 180°                   | 180°                   |
| Wind Speed          | 2 ft/sec               | 2 ft/sec               | 2 ft/sec               |

**Table One: System Design Variables Modeled in DYNAMP Model**

The normal and emergency ratings determined for overhead transmission conductors are treated in the following manner in planning and operating the transmission system.

**Normal Rating:** Under normal operating conditions, with no contingencies in effect, the normal rating of the conductor may not be exceeded.

**Emergency Rating:** Under contingency conditions, an overhead transmission line may be loaded to the emergency rating.

### 5.1.2 Underground Pipe-Type Cable

The KCP&L transmission system utilizes several sections of buried oil-filled, pipe-type cable operated at a voltage of 161 KV. The factor that limits the current-carrying capability is the maximum permissible insulation temperature, which was determined by the manufacturer. Their current-carrying capability is not affected by ambient air temperature due to the fact that the cable is located underground. Therefore, seasonal ratings are not assigned to the cables.

Due to the nature and location of the underground transmission cables, the maximum current ratings determined by the manufacturers are treated as firm limits and may not be exceeded under any circumstances.

### 5.1.3 Wavetraps

Wavetraps are assigned maximum current ratings by the manufacturers based upon design criteria. KCP&L has two types of wavetraps in service; 1) the older wavetraps in which the main coil is designed as a single phase, air-cored inductor of dry type, and 2) the newer designs that consist of a wire coil encapsulated in an epoxy resin. These wavetraps have no overload capability when the ambient temperature is 40°C (104°F) and the wavetraps have been carrying current. If the ambient temperature is less than 40°C or if the wavetraps have not been carrying rated current, some overload capacity does exist. KCP&L has adopted the SPP loading guidelines for wavetraps. To arrive at the seasonal ratings, multiply the designed ampere rating at 40°C by the loadability factor shown in Table 4 for dry type wavetraps, or Table 5 for epoxy wavetraps.

Table 3 Seasonal Loadability Factors for dry type Wavetraps

| <u>Ambient Temperature</u> | <u>Season</u> | <u>Loadability Factor</u> |
|----------------------------|---------------|---------------------------|
| 37.7°C/100°F               | Summer        | 1.0058                    |
| 20°C/68°F                  | Spring/Fall   | 1.05                      |
| 0°C/32°F                   | Winter        | 1.10                      |

Table 4 Seasonal Loadability Factors for epoxy type Wavetraps

| <u>Ambient Temperature</u> | <u>Season</u> | <u>Loadability Factor</u> |
|----------------------------|---------------|---------------------------|
| 37.7°C/100°F               | Summer        | 1.0058                    |
| 20°C/68°F                  | Spring/Fall   | 1.13                      |
| 0°C/32°F                   | Winter        | 1.25                      |

The seasonal maximum current ratings determined for wavetraps are treated as firm limits and may not be exceeded under any circumstances.

**5.1.4 Disconnect Switches**

Disconnect switches are assigned maximum current ratings by the manufacturers based upon design criteria. The switches are rated according to their Allowable Continuous Current Class (ACCC) designation (ANSI STD. 37.37-1979). KCP&L utilizes switches with an ACCC rating of A01 or D06. The design of the switches is such that they have no overload capability when the ambient temperature is 40°C (104°F) and the switch is carrying rated current. If the ambient temperature is less than 40°C or the switch has not been carrying rated current, some overload capability does exist. The loadability factors used in developing the seasonal ratings for the KCP&L system are taken from SPP Criteria and shown in Table 6. To arrive at the seasonal ratings, multiply the designed ampere rating at 40°C by the loadability factor.

Table 5 Seasonal Loadability Factors for Disconnect Switches

| <u>Ambient Temperature</u> | <u>Season</u> | <u>Loadability Factor A01</u> | <u>Loadability Factor D06</u> |
|----------------------------|---------------|-------------------------------|-------------------------------|
| 37.7°C/100°F               | Summer        | 1.04                          | 1.10                          |
| 20°C/68°F                  | Spring/Fall   | 1.29                          | 1.27                          |
| 0°C/32°F                   | Winter        | 1.53                          | 1.41                          |

The seasonal maximum current ratings determined for disconnect switches are treated as firm limits and may not be exceeded under any circumstances.

**5.1.5 Current Transformers and Relays**

The maximum current ratings for current transformers and relays have been specified by the manufacturers and are based upon design criteria. As these ratings are relatively independent of temperature, no seasonal ratings are developed for current transformers and relays.

Due to the operating characteristics of current transformers and relays, the maximum current ratings specified for this type of equipment are treated as firm limits and may not be exceeded under any circumstances.

**5.1.6 Bulk Power Transformers**

The bulk power transformers used by KCP&L consist of 345/161 KV autotransformers, and 161/69 KV and 161/34.5 KV transformers. Power transformer ratings are discussed in IEEE Standard C57.115-1991, IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers Rated in Excess of 100 MVA (65 °C Winding Rise). Every transformer has a distinct temperature rise capability used in setting its nameplate rating (either 55 °C or 65 °C). These

temperature rise amounts reflect the average winding temperature rise over ambient that a transformer may operate on a continuous basis and still provide normal life expectancy. Average ambient temperature is an important factor in determining the load capability of a transformer since the temperature rise for any load must be added to the ambient to determine operating temperature. Transformers designed according to ANSI standards use a 30 °C average ambient temperature (average temperature for 24 consecutive hours) when setting nameplate rating. Transformer overloads can be increased at lower average ambient temperatures and still experience the same loss of life. KCP&L has chosen to follow SPP rating criteria, which does not call for seasonal transformer ratings. Transformers can be loaded above 110% and experience no loss of life when the average ambient temperature is below 30 °C. By not having seasonal ratings, the four occurrences that contribute to loss of life are limited to days when the average ambient temperature exceeds 30 °C (86 °F).

The normal circuit rating for power transformers shall be its highest nameplate rating. The nameplate rating shall include the effects of forced cooling equipment if it is available. For multi-rated transformer (OA/FA, OA/FA/FA, OA/FOA/FOA, OA/FA/FOA) with all or part of forced cooling inoperative, nameplate rating used is based upon the maximum cooling available for operation. Normal life expectancy will occur with a transformer operated at continuous nameplate rating.

When operated for one or more load cycles above nameplate rating, the transformer insulation deteriorates at a faster rate than normal. The emergency circuit rating for power transformers shall be 110% of its highest nameplate rating. Under no circumstance shall a power transformer be operated in such a manner as to allow the top spot oil temperature to exceed 110 °C.

#### **5.1.7 Circuit Breakers**

Circuit breaker ratings are discussed in ANSI/IEEE C37.010-1979, IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis and in ANSI/IEEE C37.010b-1985, IEEE Standard for Emergency Load Current-Carrying Capability. These standards discuss the development of ratings from the standpoint of the manufacturers. From a practical standpoint, the application of the methods discussed in these standards to circuit breakers in operation will be very difficult, due to the fact that this application would require contacting the manufacturer for detailed design information for each circuit breaker being rated. Therefore, the nameplate rated continuous current will be used as the circuit breaker's normal and emergency circuit ratings.

#### **5.1.8 Series & Shunt Reactive Devices**

KCP&L utilizes series reactors, shunt reactors, and shunt capacitors in a number of locations in its transmission system. Normal and emergency ratings for these devices will be based on manufactures' continuous current rating. This rating should not be exceeded under any circumstance.

## 5.2 Transmission Facility Loading Limits

There are several different types of equipment that could limit the load-carrying capability of a single transmission line or bulk power transformer. The limiting element could be the transmission line's conductor, a wavetrapp, a disconnect switch, a current transformer, a relay, a transformer, or a circuit breaker. The current carrying limitation of a transmission line segment or bulk power transformer will be the most limiting element in the path of the flow. The limiting element must be determined separately for both normal and emergency conditions, as well as on a seasonal basis. The information on limiting element for transmission lines or transformers is maintained in the KCP&L system databook. Transmission facilities will be upgraded when the emergency rating is exceeded as determined from SPP or KCP&L planning studies. KCP&L will also upgrade circuit breakers when the short circuit interrupting capability exceeds 100% of its' rating.

## 6.0 Protective Relaying

Protective relaying, communications and instrumentation play an important role in maintaining the reliability of the bulk electric system. Protective Relay Systems (PRS) requirements shall be taken into account during the planning and design of generation, transmission and substation configurations. If configurations are proposed that require PRS that do not conform to SPP criteria or to accepted IEEE/ANSI practice, then the entities affected shall negotiate a solution. The principles for planning additions in these categories are set forth in SPP Criteria.

- a) The bulk power protective relay system design shall have as its objective rapid clearing of all faults, with no fault permitted to remain uncleared despite the failure of any single protective system component. To accomplish this, transmission protection systems shall be installed as specified in the SPP Transmission Protection Systems Criteria 7.2.
- b) Transmission Operators shall maintain communications systems to their generating stations, operation centers and to neighboring utilities, which shall provide adequate communication in the event of failure of any one element of the systems. In general, such communication systems should not be susceptible to failure during an interruption of the A.C. power supply in any part or all of their areas.
- c) Loading on the bulk electric system shall be monitored continually to insure that operation is within safe limits.
- d) Suitable instrumentation, and/or other devices, shall be installed to measure appropriate quantities at key points in the electric system with appropriate automatic alarms.
- e) Fault recording devices as described in SPP Criteria 7.1 shall be installed at appropriate points within KCP&L so that outages and short circuits can

be analyzed and protective relay performance studied. In addition, Disturbance Monitoring Equipment shall be provided to meet SPP Criteria 7.1 so those system disturbances may be analyzed.

- f) Underfrequency Load Shedding equipment shall be installed pursuant to SPP Criteria 7.3 for the purpose of maintaining a stable operating frequency.
- g) Given the requirements of SPP Criteria 7.6, Automatic Restoration of Load schemes may be installed by KCP&L to expedite load restoration. These systems shall be coordinated with all other schemes such as system protection, Underfrequency Load Shedding, Undervoltage Load Shedding, and Generation Control and Protection. These systems shall operate only after underfrequency and/or undervoltage events.
- h) Generation Control and Protection schemes shall be designed pursuant to SPP Criteria 7.7 to provide a reasonable balance between the need for the generator to support the interconnected electric systems during abnormal conditions and the need to adequately protect generator equipment from damage.

## **7.0 BLACKSTART CAPABILITY AND SYSTEM RESTORATION**

Section IV of the NERC Reliability Standards deal with system restoration. A blackout is a condition where a major portion or all of an electrical network is de-energized resulting in loss of electric supply to a portion or all of that network's customer demand. Blackouts will generally take place under two typical scenarios:

- Dynamic instability, and
- Steady-state overloads and/or voltage collapse.

Blackouts are possible at all loading levels and all times in the year. Changing generation patterns, scheduled transmission outages, off-peak loadings resulting from operations of pumped storage units, storms, and rapid weather changes among other reasons can all lead to blackouts. Systems must always be alert to changing parameters that have the potential for blackouts.

Actions required for system restoration include identifying resources that will likely be needed during restoration, determining their relationship with each other, and training personnel in their proper application. Actual testing of the use of these strategies is seldom practical. Simulation testing of restoration plan elements or the overall plan is essential preparation toward readiness for implementation on short notice.

From a planning standpoint, it is critical that any overall system restoration plans include adequate generating units with system blackstart capability. It is also

important that adequate facilities are planned for the interconnected transmission systems to accommodate the special requirements of system restoration plans such as switching and sectionalizing strategies, station batteries for dc loads, coordination with under-frequency and undervoltage load shedding programs and Regional or area load restoration plans, and facilities for adequate communications.

SPP Criteria 8 describes the Regional load shedding and restoration plan and Criteria 9 describes the Regional black start plan that KCP&L adheres to. KCP&L has also developed its' own more specific plans titled Load Preservation Program Manual and System Restoration Plan.

## **7.1 Blackstart Capability**

Following the complete loss of system generation (blackout), it will be necessary to establish initial generation that can supply a source of electric power to other system generation and begin system restoration. These initiating generators are referred to as system blackstart generators. They must be able to self-start without any source of off-site electric power and maintain adequate voltage and frequency while energizing isolated transmission facilities and auxiliary loads of other generators. Generators that can safely reject load down to their auxiliary load are another form of blackstart generator that can aid system restoration.

From a planning perspective, a system blackstart capability plan is necessary to ensure that the quantity and location of system blackstart generators are sufficient and that they can perform their expected functions as specified in overall coordinated Regional system restoration plans.

In the event that the KCP&L Load Preservation Program Operative Procedures are unsuccessful in reducing customer load to maintain system voltage and frequency, KCP&L may be faced with a situation where generating units are isolated serving only its own auxiliaries or units are not on line and all customer loads has been interrupted. Interruption of service may encompass the KCP&L service territory or possibly the entire region and many utilities. A KCP&L System Restoration Plan has been developed to systematically restore generation and customer load to the KCP&L service territory (including GMO). The System Restoration Plan is referenced in the KCP&L Load Preservation Program Manual because both procedures are similar in steps to be taken and load preservation efforts will probably precede a system-wide service interruption. Detailed generating unit startup procedures and transmission switching instructions can be found in the KCP&L System Restoration Plan.

## 7.2 System Restoration

After automatic load shedding (by either underfrequency or undervoltage relays) has occurred, use of automatic restoration of load after the electric systems have recovered sufficiently (systems stabilized, frequency near nominal, and voltages within appropriate limits) can speed the reenergization of customer demands and minimize delays in restoring the electric systems.

KCP&L procedures for the orderly restoration of service to customers following load shedding or a system blackout are documented in the Load Preservation Program Manual and the System Restoration Plan.

These procedures allow for the restoration of load that has been shed by underfrequency relay actions, but only after system frequency has been restored to a normal level.

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**Appendix–1 Table I. Transmission System Standards –  
Normal and Emergency Conditions**

**Adopted by NERC Board of Trustees: October 29, 2008**

**Table I. Transmission System Standards – Normal and Emergency Conditions**

**Standard TPL-001-0.1 — System Performance Under Normal Conditions**

**Table I. Transmission System Standards – Normal and Emergency Conditions**

| Category   | Contingencies  | System Limits or Impacts  |  |                      |
|--|--|---|--|----------------------|
|  | Initiating Event(s) and Contingency Element(s)   | System Stable and both Thermal and Voltage Limits within Applicable Rating <sup>a</sup> | Loss of Demand or Curtailed Firm Transfers                               | Cascading Outages    |
| <b>A</b><br>No Contingencies   | All Facilities in Service  | Yes   | No   | No                   |
| <b>B</b><br>Event resulting in the loss of a single element.                   | Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing:<br>1. Generator<br>2. Transmission Circuit<br>3. Transformer<br>Loss of an Element without a Fault   | Yes<br>Yes<br>Yes<br>Yes  | No <sup>b</sup><br>No <sup>b</sup><br>No <sup>b</sup><br>No <sup>b</sup> | No<br>No<br>No<br>No |
|  | Single Pole Block, Normal Clearing <sup>e</sup> :<br>4. Single Pole (dc) Line  | Yes   | No <sup>b</sup>  | No                   |
| <b>C</b><br>Event(s) resulting in the loss of two or more (multiple) elements. | SLG Fault, with Normal Clearing <sup>e</sup> :<br>1. Bus Section   | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
|  | 2. Breaker (failure or internal Fault)   | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
|  | SLG or 3Ø Fault, with Normal Clearing <sup>e</sup> , Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing <sup>e</sup> :<br>3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
|  | Bipolar Block, with Normal Clearing <sup>e</sup> :<br>4. Bipolar (dc) Line Fault (non 3Ø), with Normal Clearing <sup>e</sup> .   | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
|  | 5. Any two circuits of a multiple circuit towerline <sup>f</sup>   | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
|  | SLG Fault, with Delayed Clearing <sup>e</sup> (stuck breaker or protection system failure):<br>6. Generator  | Yes   | Planned/<br>Controlled <sup>f</sup>                                      | No                   |
| 7. Transformer   | Yes  | Planned/<br>Controlled <sup>f</sup>   | No   |                      |
| 8. Transmission Circuit  | Yes  | Planned/<br>Controlled <sup>f</sup>   | No   |                      |
| 9. Bus Section   | Yes  | Planned/<br>Controlled <sup>f</sup>   | No   |                      |

**Standard TPL-001-0.1 — System Performance Under Normal Conditions**

|   |   |              |                |                         |                |  |
|---|---|--------------|----------------|-------------------------|----------------|--|
| <p><b>D<sup>d</sup></b><br/>Extreme event resulting in two or more (multiple) elements removed or Cascading out of service.</p> | <p>3Ø Fault, with Delayed Clearing<sup>e</sup> (stuck breaker or protection system failure):</p> <table border="0"> <tr> <td>1. Generator</td> <td>3. Transformer</td> </tr> <tr> <td>2. Transmission Circuit</td> <td>4. Bus Section</td> </tr> </table> <hr/> <p>3Ø Fault, with Normal Clearing<sup>e</sup>:</p> <hr/> <p>5. Breaker (failure or internal Fault)</p> <hr/> <p>6. Loss of towerline with three or more circuits<br/>7. All transmission lines on a common right-of way<br/>8. Loss of a substation (one voltage level plus transformers)<br/>9. Loss of a switching station (one voltage level plus transformers)<br/>10. Loss of all generating units at a station<br/>11. Loss of a large Load or major Load center<br/>12. Failure of a fully redundant Special Protection System (or remedial action scheme) to operate when required<br/>13. Operation, partial operation, or misoperation of a fully redundant Special Protection System (or Remedial Action Scheme) in response to an event or abnormal system condition for which it was not intended to operate<br/>14. Impact of severe power swings or oscillations from Disturbances in another Regional Reliability Organization.</p> | 1. Generator | 3. Transformer | 2. Transmission Circuit | 4. Bus Section | <p>Evaluate for risks and consequences.</p> <ul style="list-style-type: none"> <li>▪ May involve substantial loss of customer Demand and generation in a widespread area or areas.</li> <li>▪ Portions or all of the interconnected systems may or may not achieve a new, stable operating point.</li> <li>▪ Evaluation of these events may require joint studies with neighboring systems.</li> </ul> |
| 1. Generator  | 3. Transformer  |              |                |                         |                |  |
| 2. Transmission Circuit   | 4. Bus Section  |              |                |                         |                |  |

- a) Applicable rating refers to the applicable Normal and Emergency facility thermal Rating or system voltage limit as determined and consistently applied by the system or facility owner. Applicable Ratings may include Emergency Ratings applicable for short durations as required to permit operating steps necessary to maintain system control. All Ratings must be established consistent with applicable NERC Reliability Standards addressing Facility Ratings.
- b) Planned or controlled interruption of electric supply to radial customers or some local Network customers, connected to or supplied by the Faulted element or by the affected area, may occur in certain areas without impacting the overall reliability of the interconnected transmission systems. To prepare for the next contingency, system adjustments are permitted, including curtailments of contracted Firm (non-recallable reserved) electric power Transfers.
- c) Depending on system design and expected system impacts, the controlled interruption of electric supply to customers (load shedding), the planned removal from service of certain generators, and/or the curtailment of contracted Firm (non-recallable reserved) electric power Transfers may be necessary to maintain the overall reliability of the interconnected transmission systems.
- d) A number of extreme contingencies that are listed under Category D and judged to be critical by the transmission planning entity(ies) will be selected for evaluation. It is not expected that all possible facility outages under each listed contingency of Category D will be evaluated.
- e) Normal clearing is when the protection system operates as designed and the Fault is cleared in the time normally expected with proper functioning of the installed protection systems. Delayed clearing of a Fault is due to failure of any protection system component such as a relay, circuit breaker, or current transformer, and not because of an intentional design delay.
- f) System assessments may exclude these events where multiple circuit towers are used over short distances (e.g., station entrance, river crossings) in accordance with Regional exemption criteria.