Planning Coordinator and/or Transmission Planner

TRANSMISSION SYSTEM PLANNING GUIDELINES

Effective Date: October 29, 2019

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Revision History

Date	Version	Description
October 29, 2019	18.0	Clarified language for identifying 90/10 projects. Revised language for the Generation Replacement scenarios. Various other sections were modified to enhance clarity.
September 28, 2018	17.0	Revised language for material change in the 10 year stability model requirement to accommodate the RC request from the 2018 TEP. Added language for technical rationale in selecting contingencies which result in more severe impacts to the BES. Removed maximum TSR import and export studies per change to OATT Attachment C. Change from BCS models to starting point models. Added switch shunt outages since new 138 kV capacitor will be added. Added language for identifying 90/10 projects.
September 11, 2017	16.0	Various sections were modified to enhance clarity; pointed reader to NERC Glossary terms; added filtering criteria in Section 6.1; made changes to the off-peak model; removed NITS capacity sensitivity scenario. Effective for the 2018 TEP and Planning Assessment performed in 2017 and 2019 TEP and Planning Assessment performed in 2018
September 28, 2016	15.0	Make changes for MOD-032 data requests. Change identification of Cascading/Instability; Correct error in 7.7.1 that says “single line to ground”. Clarify which 69 kV buses are monitored for voltage (Section 8.2); corrected angular stability in Section 8.3.1; made criteria for generator synchronism match TPL-001-4 (Section 8.3.5 through 8.3.7).
September 15, 2015	14.0	Section 1: applicability to 2015 TEP removed; section 5.4 details of load scenarios described; section 5.6 DNR changed to NITS capacity; added section 5.8 to described ratings in off-peak models; removed unnecessary paragraph 5.10.1; section 5.12 added language in case ERAG models are late; section 6and 6.7 removed flowgate analysis requirement; added section 6.2.1.1 details of sensitivity study requirements; section 6.6 added language to match TPL-001-4 2.5; section 6.7 added NITS capacity sensitivity study; previous section 8.2 “Corrective Action Plan” moved to new section 10; section 8.2 added clarification for TPL-001-4 footnote 12; revised stability criteria to accommodate load inductor model section 8 and 9.2; RC requested changes to Instability Identification Section 9.1 and 9.2.
October 30, 2014	13.0	Make corrections; section 5.8, 5.10, 6.4, 7.2, 7.5.2, 8.2, Attachment A
July 30, 2014	12.0	Changes required to address new TPL-001-4 standard
December 30, 2013	11.0	Correct error in footnote 13 on page 8
December 20, 2013	10.0	General Update; added detail to multiple sections to provide clarification
September 1, 2012	9.0	General Update; Added detail to stability analysis section

Date	Version	Description
November 30, 2010	8.0	Changed Company name from E.ON to LG&E/KU; edited to match other guidelines; added detail to stability section
August 14, 2009	7.0	Added statement reiterating comparable treatment of service requests per FERC Order.
July 1, 2008	6.0	Updated performance requirements and incorporated SOL Methodology
May 1, 2008	5.0	Added effective date, signatures, Revision History, Contingency Selection criteria, updated Tables 2 & 3 and updated certain references
September 11, 2007	4.0	Added section describing how Guidelines exceed NERC requirements
May 7, 2007	3.0	Better quantified thermal overload and voltage violations and added Section 4 – Impacted Facilities
March 1, 2007	2.0	Added NERC Categories to Table 1 and expanded
March 11, 2005	1.0	Expanded Table 1
June 6, 1998	0.0	Initial LGEE document to establish guidelines applicable to both LG&E/KU

Table of Contents

1 Purpose

This *Transmission System Planning Guidelines* Document (this "Document") describes the requirements for planning Louisville Gas & Electric Company and Kentucky Utilities Company's (collectively "LG&E/KU") Transmission System and related Transmission Expansion Plan ("TEP"). This Document is developed in accordance with NERC Reliability Standard TPL-001-4. LG&E/KU is registered as both a Planning Coordinator ("PC") and Transmission Planner ("TP"). The LG&E/KU Transmission Planning Group performs the functions for both the PC and TP. This Document establishes the minimum planning criteria for the LG&E/KU Transmission System, including equipment and facilities operated at 69 kV and above.

2 Overview

The primary purpose of LG&E/KU's Transmission System is to reliably transmit electrical energy from Designated Network Resources to Network Loads. Interconnections to other transmission systems have been established to increase the reliability of LG&E/KU's Transmission System and to provide access to emergency generation sources for Network Customers.

The Federal Energy Regulatory Commission ("FERC") requires all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce have a non-discriminatory Open Access Transmission Tariff ("OATT"). LG&E/KU have an OATT on file with FERC to provide Point to Point Transmission Service and Network Integration Transmission Service.

3 NERC Reliability Standards Compliance

NERC Reliability Standard TPL-001-4 governs the requirements for planning the interconnected Bulk Electric System (BES) such that the network can be operated to supply real and reactive forecasted loads and projected Firm (non-recallable reserved) Transmission Services. LG&E and KU's Transmission System Planning Guidelines is intended to meet or exceed the requirements of TPL-001-4.

4 Definitions

The following is a list of NERC definitions used in these Planning Guidelines and can be found in the NERC Glossary or the TPL-001-4 Standard:

Balancing Authority (BA)
Bulk Electric System (BES)
Bus-tie Breaker
Cascading

Capacity Benefit Margin (CBM)
Consequential Load
Contingency
Corrective Action Plan(s)
Demand Side Management (DSM)
Element
Extra High Voltage (EHV)
Facility
Facility Rating
Fault:
Firm Transmission Service
High Voltage (HV)
Load
Load Serving Entity (LSE)
Long-Term Transmission Planning Horizon
Near-Term Transmission Planning Horizon:
Network Integration Transmission Service
Non-Consequential Load Loss
Off-Peak
On-Peak
Operating Reserve
Planning Assessment
Planning Authority
Planning Coordinator (PC)
Point to Point Transmission Service
Protection System
Real-time Assessment
Resource Planner
Scenario
Special Protection System (SPS) or Remedial Action Scheme
Stability
System
Transmission
Transmission Reliability Margin (TRM)
Transmission Planner (TP)
Year One

The following are LG&E/KU defined terms:

50/50 Load Forecast: On Peak Demand which represents a 50% probability of Load being higher than forecast and 50% probability of Load being lower than forecast

90/10 Load Forecast: Loads for more extreme weather and On-Peak Demand have a 90% probability of being below this forecast and a 10% probability of being higher than this forecast.

Starting Point Models: A set of models which includes year two for summer peak, winter peak, off-peak; year five for summer peak, winter peak; and year ten for summer peak, winter peak. The models are developed using the MOD-032 data received using a 50/50 and 90/10 Load Forecast. The Starting Point Models do not include revisions for Long Lead items, Sensitivities as described in TPL-001-4 2.1.4 and 2.4.3 or Other Models as described in these Planning Guidelines.

NITS Capacity: Maximum net capacity for each resource over the 10 year horizon as submitted by the Network Customer in their annual 10 year forecast submitted in compliance with MOD-032. See *LG&E/KU Business Practices* for additional information.

Extreme Event Report: Report of the results for the extreme events studies for TPL-001-4 Table 1 extreme events.

5 Models

This section describes the models that are built for compliance with TPL-001-4. NERC has defined Year One as, *"The first twelve month period that a Planning Coordinator or a Transmission Planner is responsible for assessing. For an assessment started in a given calendar year, Year One includes the forecasted peak Load period for one of the following two calendar years. For example, if a Planning Assessment was started in 2011, then Year One includes the forecast peak Load period for either 2012 or 2013."* Based on this, LG&E/KU has elected to utilize year two and year five for the near-term models and a year ten model for the Long-Term Transmission Planning Horizon.

5.1 Normal System Condition Models

In accordance with TPL-001-4 R1, LG&E/KU maintains normal System condition models for its respective area in order to perform the studies needed to satisfy TPL-001-4. The models use data consistent with data collected via MOD-032 (which has superseded the now retired MOD-010 and MOD-012 standards), supplemented by other sources as needed, and shall represent projected System conditions. The process for developing the steady state and stability models are described in this section. Normal System condition models shall include:

- Existing Elements[1]: model of 69 kV and above lines, transformers, substations etc. Some 34.5 kV will be modeled.
- Known Outage (s) of generation or Transmission facilities described in Section 5.2 below.
- New planned Elements and Facilities and changes to existing Elements and Facilities as described in Section 5.3 below.
- Real and Reactive Forecasted Load as described in Section 5.4 below.

[1] TPL-001-4 1.1.1

- Known commitments for Firm Transmission Service as described in Section 5.5 below.
- Resources (supply or demand side) required for Load as described in Section 5.6 below.

The models represent normal System conditions and must meet the performance requirements of TPL-001-4 Table 1 Category P0.[2] The applicable Facility Rating for TPL-001-4 Table 1 Category P0 is the seasonal Normal Rating also known as Rate A in the PSS/E software. For purposes of these Planning Guidelines the Normal System Condition Models are called Starting Point Models and include Forecasted Loads that represent 50/50 and 90/10 peak Load Forecast defined above as well as Off-Peak models. The models using the 90/10 peak Load Forecast meet the sensitivity study requirements per TPL-001-4 part 2.1.4 and 2.4.3.

5.2 Known Outages

Known outages in the Near -Term Transmission Planning Horizon of either generation or transmission Elements and Facilities with an outage duration of at least six months will be modeled in separate cases as necessary for the seasons and years in which the outage is scheduled in both the System Peak and Off-Peak models[3]. Models will be developed, and an assessment of the System with these outages will be completed by analyzing P0 and P1 planning events in Table 1 of TPL-001-4[4]. A list of facilities with an outage duration longer than six months are supplied by the GO and TO to the PC through the MOD-032 data submittal.

5.3 New and Existing Elements and Facilities

The steady state and stability models developed will include projects as documented in the Planning Assessment including new planned Elements and Facilities and changes to existing and planned Elements and Facilities.[5] All projects that were completed after the completion of the previous year's TEP will be included in the Starting Point Models. Prior TEP projects under construction are included in the Starting Point Models.

Since the group that performs the functions for the LG&E/KU TP also performs the functions for the LG&E/KU PC, there is no need for a MOD-032 data submittal from the LG&E/KU TP to PC for new planned Elements and Facilities.

[2] TPL-001-4 R1
[3] TPL-001-4 1.1.2
[4] TPL-001-4 2.1.3
[5] TPL-001-4 1.1.3

5.4 Real and Reactive Forecasted Load

Load Serving Entities (LSEs) and Distribution Providers submit delivery point load forecast for real power and power factor per the MOD-032 data submittal. The reactive load is calculated with the real power and power factor by the TP. The LSE load forecast for network load levels are included in the models.[6]

Load forecasts are typically provided for the following conditions:

- Summer and Winter Peak – 50/50 peak forecast
- Summer and Winter Peak – 90/10 peak forecast
- Off-Peak[7] –
    - 60% of the 50/50 summer scalable peak Load Forecast or forecasted load for a 60 degree ambient temperature; ratings of Facilities are based on a 60 degree Fahrenheit ambient temperature. Some customers have non-scalable loads which are the same during On-Peak or Off-Peak seasons
    - Light Load – Lowest loads typically observed in the middle of the night or early morning on a spring day (e.g., Easter morning)
    - Summer Shoulder – 70% to 80% of summer peak load

Additional forecasts may be requested on an as needed basis. The alternative delivery points are not considered guaranteed (firm) delivery points and should not be included in the load forecast.

5.5 Transmission Service Request (TSR)

For both steady state and stability models, firm transmission service requests that are annual, confirmed, and have a contract period of five or more years are included[8] in the models when there is enough generation resources to support the TSR. A list of the TSRs included in the Starting Point Models are documented in the Planning Assessment report. Confirmed Firm TSRs with a contract period of five or more years that are not included in the models will be evaluated per Section 6.8 “Other Studies” of this Document.

TSR information is supplied to the LG&E/KU PC from the MOD-032 data submittal and OASIS.

5.6 Real Power Resource Modeling

[6] TPL-001-4 1.1.4

[7] TPL-001-4 2.1.2; not all Off-Peak models are analyzed in the Planning Assessment but are required for SERC and other groups.

[8] TPL-001-4 1.1.5

This section applies to real power resource modeling of units connected to the LG&E/KU transmission system.

The real power resource modeling, for generating units connected to the LG&E/KU transmission system, for steady state and stability models is provided by GO and/or RP, and includes capabilities for both On-Peak and Off-Peak Scenarios[9]. Off-Peak Scenarios are described in Section 5.4 "Real and Reactive Forecasted Load". The generation that is on-line initially comes from a merit order that is also provided to the TP by the RP. Operating Reserves are modeled if sufficient generation is available. The process of modeling Operating Reserves dispatches large units (20 MW or greater) to some value less than their maximum output, so that the sum total of available output for online units meets or exceeds the reserve requirements.

Maximum output will be the value provided by the Generator Owner (GO) in their MOD-032 data submittal or the Network Integrated Transmission Service (NITS) Capacity value posted on the LG&E/KU OASIS plus firm point to point transmission, whichever is lower except in the case of Solar Generating units. Units are dispatched using the Merit Order (MO) provided by the RP in their MOD-032 data submittal.

Solar Generating units attached to the LG&E/KU transmission system will be modeled at output expected for the time of day represented by the load forecasted in the model. Solar units will be modeled at 100% output during the off-peak models, 80% output in the summer peak models, and 0% output in the winter peak and light load models.

There coud be instances where there are not enough generation resources identified in MOD-032 submittals to cover the load for any LSE of the LG&E and KU Transmission System, particularly in the Long-Term Transmission Planning Horizon. In those instances, the TP may choose to model a future expected generating unit, fictitious generating Facility, energy imports, or the use of any other generation resources to serve LSE load. The TP will not utilize these options solely to meet Operating Reserves.

5.7 Reactive Power Resource Modeling[10]

This section applies to reactive power resource modeling of units connected to the LG&E/KU transmission system.

The reactive power resource capability for the steady state and stability models is supplied by the Generator Owner (GO) and/or RP to the LG&E/KU PC per the MOD-032 data submittal. The transmission level voltage at the power plants will be regulated in the Starting Point Models to the target voltage in Table 1 of the LG&E/KU *Voltage and Reactive Power Schedule (VAR-001)* document. The Voltage and Reactive Power Schedules are supplied to the PC from the TOP per the MOD-032 data submittal.

[9] TPL-001-4 1.1.6
[10] TPL-001-4 1.1.6

Capacitor banks will be modeled with the actual control voltages (or typical settings for future installations) at which the capacitor bank turns on and off for voltage regulation.

5.8 Facility Ratings

Facility Ratings are based on the ambient temperature in the seasonal models. The TP models Facility Ratings based on the following ambient temperatures:

- Summer Peak: 104°F
- Winter Peak: 23°F
- Light Load: 60°F
- Off-Peak: 60°F

The LG&E/KU PC has access to the LG&E/KU Transmission Owner Facility Ratings through LOAD database. Generator Owner Facility Ratings are provided to the TP/PC through a MOD-032 data submittal.

5.9 Starting Point Models

Steady state Starting Point Models are developed for Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon.

Each model in the Starting Point Models contains a detailed representation of the LG&E/KU PC Area from 69 kV through 500 kV.

Portions of the models outside the LG&E/KU model area are taken from the most recent NERC Eastern Interconnection Reliability Assessment Group (ERAG) Base Case Series. The specific ERAG model used will be the same time-frame as, or a model nearest the time-frame of the target model being built. LG&E/KU may coordinate models with neighboring TPs, and may alter their Systems in the ERAG models to reflect that coordination.

Steady State models are developed for winter On-Peak, summer On-Peak and Off-Peak Load conditions. Transmission Starting Point Models for steady state analysis are developed on an annual basis to reflect the most current information and assumptions available concerning the modeling of future years' System load level and load distribution (provided by the LSE) and generation (provided by the GO). Generation levels must not exceed the NITS Capacity levels. The forecasted loads must not exceed 5 MW higher than the previous year’s forecast for the same season and year without a confirmed TSR for a 69 kV load or 10 MW on a BES load per the business practices posted on OASIS. Generation and/or load will be capped, if MOD-032 data exceeds what is allowed in the business practices.

The Starting Point Models contain existing system topology and ratings with added changes for projects under construction.

Steady state models in the Near-Term Transmission Planning Horizon will include summer and winter On-Peak load models for year two and year five[11]; a single Off-Peak model in year two. Long-term Transmission Planning Horizon On-Peak Load models will generally include year ten only. A year ten model is considered more severe since it is expected that the loads will be higher in year ten than in years six through nine[12].

Starting Point Models with an upto date list of projects under-construction and completed projects since the prior TEP will be provided to the ITO for review as soon as available after all data checks are complete.

Starting Point Models are the starting point for the annual Planning Assessment, and are used for the development of the TEP.

5.10 Final Planning Assessment Models

At the completion of the annual Planning Assessment, TEP projects are identified and timed. A set of final models are created which includes the projects in the TEP for use in future studies. Both steady state, stability and short circuit final models are created. At the completion of the Planning Assessment process, the final models are delivered to both the Reliability Coordinator (RC) and the ITO.

5.11 Stability Models

Stability models are developed using the final steady state models described in Section 5.10 “Final Planning Assessment Models” which include the steady state projects identified in the current Planning Assessment. Stability models are developed for summer On-Peak and Off-Peak conditions. Year two and year five On-Peak models and one Off-Peak model in the Near-Term Transmission Planning Horizon will be developed. A single year ten stability On-Peak model will be built for the Long-Term Transmission Planning Horizon.

A minimum of at least one stability model with maximized generation, utilizing the generation interconnection capacity (GIC) values (posted on OASIS), within the LG&E/KU BA will be developed. The LG&E /KU Business Practices document posted on OASIS defines GIC. Other stability models may be developed as necessary. The GIC maximized generation model is the sensitivity meeting requirements of TPL-001-4 R2.4.3 related to 2.4.1. An Off-Peak stability model in the Near Term Transmission Planning Horizon with changes in generation dispatch is developed to meet requirements of TPL-001-4 R2.4.3 related to 2.4.2. Corrective Action Plans will be identified to meet the performance requirements of TPL-001-4 in the GIC Maximized Model. The GIC maximized model is described in the business practice posted on OASIS.

[11] TPL-001-4 2.1.1
[12] TPL-001-4 2.2.1

The LG&E/KU dynamics parameters are also updated to the latest available data. Per MOD-026 and MOD-027, dynamics data can be revised as a result of actual tests performed on the generator owners' equipment providing this does not violate the GO's LGIA for that particular unit. Test results revising the stability data as a result of MOD-026 and MOD-027 tests must be received by the PC no later than the MOD-032 due date for stability data in order to be incorporated into the models during that Planning Assessment.

All dynamics models are tested under no-fault conditions to ensure that voltage and rotor angles have no oscillation (flat line) for twenty seconds.

The stability models for areas outside LG&E/KU transmission System for the Planning Assessment come from the ERAG MMWG set of models. Currently, ERAG is the designee for model development in the eastern interconnection (MOD-032-1 R4). The ERAG stability models have roots in a previous year's ERAG steady state models. The ERAG dynamic models from the previous year will be utilized for the outside world.

The ERAG stability models are updated within the LG&E/KU BA with the most recent load forecast. Generation levels use merit order and also incorporate Operating Reserves as described in Section 5.6 "Real Power Resource Modeling".

The final stability models will match the topology of the steady state models for the LG&E/KU PC Area. Due to the ERAG Dynamic Model Building process, the outside world may not match between the stability and steady state models.

5.12 Short Circuit Models

LG&E/KU maintains a perpetually updated short circuit model that reflects the current topology of the LG&E/KU Transmission System with Elements and Facilities in their normal status. LG&E/KU participates in the SERC Short Circuit Database Working Group (SCDWG) process in which a SERC regional model is developed annually, in accordance with the SCDWG procedure manual. The procedure manual requires models be developed for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon and the SCDWG coordinates its schedules with the SERC Multi-Regional Modeling Working Group (MMWG) process. In conjunction with SCDWG process, LG&E/KU incorporates a reduction of the most recent SCDWG near-term model each year to represent the Transmission Network outside LG&E/KU, and also incorporates a current detailed model of East Kentucky Power Cooperative (EKPC) short circuit model during the annual update.

The current short circuit model is used to perform the annual breaker duty study of the current Transmission System[13]. It will be modified as needed to perform other ad hoc studies, including, where appropriate, replacing the outside world model with a reduced SCDWG long-term model.

[13] TPL-001-4 2.3

The short circuit model is limited to one model in the Near-Term Transmission Planning Horizon and one model in the Long-Term Transmission Planning Horizon.

6 Annual Planning Assessment per TPL-001-4 R2

LG&E/KU conducts an annual Planning Assessment in order to plan the Transmission System to meet performance requirements in TPL-001-4. The annual Planning Assessment includes analysis of both the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. The Planning Assessment simulates contingencies for steady state, Stability analysis, and short circuit studies[14]. Due to load differences between the near term and long term, a Stability analysis will be performed on a ten year On-Peak model.[15]

6.1 Non-BES Annual Assessment

The *LG&E/KU BES Definition* document does not include any 69 kV Facilities. BES transformers are those transformers with a primary and at least one secondary voltage operated above 100 kV. An annual planning assessment of the 69 kV facilities is performed for the Near-Term and Long-Term Transmission Planning Horizon. The 69 kV facilities are planned to meet performance requirements for P0, P1 and P3 of TPL-001-4 Table 1. The 69 kV facilities are not monitored and faults on 69 kV is not performed in the stability analysis. There are no 69 kV contingencies analyzed in steady state analysis of P2, P4-P7 and extreme events nor are 69 kV facilities monitored for these events.

The non-BES annual Planning Assessment may utilize a qualified past study or a current study to meet the requirements of TPL-001-4 Table 1 P0, P1 and P3. If a qualified past study is used, it must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include whether the past study reasonably represents the system today. If a qualified past study is used, the study reports will be included as attachments in the Planning Assessment.

6.2 Steady State BES Assessment for the Near-Term Transmission Planning Horizon

The Planning Assessment in the Near-Term Transmission Planning Horizon will include steady state analysis of the BES based on computer simulations of contingency events[16]. The study is performed using computer simulations of planning and extreme events to determine whether the BES meets the performance requirements of TPL-001-4 Table 1[17]. The contingency selection for the planning events is discussed in section 7

[14] TPL-001-4 2.3
[15] TPL-001-4 2.5
[16] TPL-001-4 R3
[17] TPL-001-4 3.1

"Contingencies" of this document. The annual Planning Assessment for the Near-Term Transmission Planning Horizon may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. If used, a qualified past study must meet the requirements of TPL-001-4 part 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study. If a qualified past study is used, the prior study reports will be included as attachments in the Planning Assessment report. The Near-Term Transmission Planning Horizon assessment will simulate P1 through P7 planning events and extreme events for BES Facilities using the performance requirements of TPL-001-4 Table 1[18]. In the event that the Contingency analyzed does not meet the respective performance requirements of TPL-001-4 Table 1 P1 through P7, a Corrective Action Plan(s) will be developed. The Corrective Action Plan(s) are documented in the Planning Assessment report.

The extreme event analysis for Near-Term Transmission Planning Horizon will use the identification of System instability for conditions such as Cascading, voltage instability, or uncontrolled islanding criteria described in section 9 "System Instability Criteria Methodology." If the extreme event shows potential for System instability, then an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences is conducted and documented in the Extreme Event Report.

6.2.1 Steady State Sensitivity Studies for Near-Term Transmission Planning Horizon

The Near-Term Transmission Planning Horizon portion of the steady state analysis will include an assessment of at least one of the following varying conditions[19]:

- Real and reactive forecasted Load
- Expected transfers not included in the Starting Point Models
- Expected in service dates of new or modified Transmission facilities that may or may not have all required approvals.
- Reactive resource capability.
- Generation additions that have not yet completed a large generation interconnection agreement and/or anticipated retirement of generation not yet announced.
- Controllable Loads and Demand Side Management (modeled in selected Off-Peak).

[18] TPL-001-4 3.2
[19] TPL-001-4 2.1.4

- Duration or timing of known Transmission outages (when outages are known to occur in the Near-Term or Long Term Transmission Planning Horizon).

For the sensitivity portion, the Planning Assessment may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study. If a qualified past study is used, the lack of material changes justifying the past study will be documented in the Planning Assessment. If a qualified past study is used, the study reports from the previous Planning Assessments will be included in the current Planning Assessment report. The Near-Term Transmission Planning Horizon steady state analysis sensitivities described above will include P0, P1 and P3 for non-BES Elements. The Near-Term Transmission Planning Horizon steady state analysis sensitivities will include P0 through P7 and extreme events for BES Facilities. Corrective Action Plan(s) may be developed but are not required in accordance with Requirements TPL-001-4 parts 2.1.4, 2.4.3 and 2.7.[20]

6.2.2 Unavailable Long Lead Item BES Assessment

A list of BES equipment with a lead time of one year or more will be identified by the appropriate LG&E/KU department. A year two On-Peak, year five On-Peak model for both summer and winter and an Off-Peak will be used. Other equipment with long lead times and no spares will be included, if such exist. A steady state assessment is performed on models with long lead item equipment out of service for TPL-001-4 Table 1 Categories P0, P1 and P2[21]. The impact of this possible unavailability of certain equipment on System performance shall be studied as a portion of the Near-Term Transmission Planning Horizon Planning Assessment. The result of the analysis of potential unavailable equipment is included in the Planning Assessment report. Corrective Action Plans will be developed, if performance requirement violations are identified.

6.3 Steady State BES Assessment for Long-Term Transmission Planning Horizon

The Planning Assessment in the Long-Term Transmission Planning Horizon will include steady state analysis of the BES based on a computer simulation of contingency events[22]. The study is performed using a computer simulation of planning and extreme events to determine whether the BES meets the performance requirements of TPL-001-4 Table 1[23]. The contingency selection for the planning events is described in section 7 “Contingencies” of this document.[24] The annual Planning Assessment for the Long-Term Transmission

[20] TPL-001-4 2.7
[21] TPL-001-4 2.1.5
[22] TPL-001-4 R3
[23] TPL-001-4 3.1
[24] TPL-001-4 2.2

Planning Horizon may be supported by a current study and supplemented with a qualified past study to meet the performance requirements of TPL-001-4. At least one winter On-Peak model and one summer On-Peak steady state model will be developed for the Long-Term Transmission Planning Horizon. The model is used to simulate P1 through P7 planning events and extreme events for BES Facilities using the performance requirements of TPL-001-4 Table 1[25]. In the event that the Contingency analyzed does not meet the respective performance requirements of TPL-001-4 Table 1 P1 through P7, Corrective Action Plan(s) will be developed to ensure that the System meets the required performance requirements. The Corrective Action Plan(s) are documented in the Planning Assessment report.

The extreme event analysis for Long-Term Transmission Planning Horizon will use the identification of System instability for conditions such as Cascading, voltage instability, or uncontrolled islanding criteria described in section 9 "System Instability Criteria Methodology". If the extreme event shows potential for system instability, then an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences is conducted and documented in the Extreme Event report which is a portion of the Planning Assessment report.

6.4 Steady State NITS Capacity Assessment

The NITS Capacity for specific generating units in the LG&E/KU System will be represented in at least one of the models discussed in Section 5 "Models". If the GO MOD-032 data for a unit determines the NITS capacity in a season or year which is not one of the models developed, an earlier model will be used to test the NITS capacity for that unit. To test the NITS capacity of each plant site, generation dispatch Scenarios in which individual plant sites are maximized to their NITS capacity plus firm point to point levels will be developed. These dispatch Scenarios will be tested with the transmission system intact against normal facility ratings, and with a transmission outage (P1) against emergency facility ratings. The NITS Capacity for generation is tested in the annual Planning Assessment and will not be treated as a separate sensitivity study.

6.5 Short Circuit Analysis

The short circuit analysis portion of the Planning Assessment shall be conducted annually utilizing one model in the Near-Term Transmission Planning Horizon and one model in the Long-Term Transmission Planning Horizon[26]. The short circuit analysis may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study. If a qualified past study is used, the prior study reports will be included in the current year's Planning Assessment report.

[25] TPL-001-4 3.2
[26] TPL-001-4 2.8

The interrupting requirements of LG&E/KU circuit breakers must remain within circuit breaker interrupting capabilities. LG&E/KU calculates circuit breaker interrupting duty utilizing a recognized industry standard software application for short circuit analysis. The software calculates the breaking currents using procedures recommended by ANSI/IEEE.

Breaker duty studies are performed with all Transmission Facilities, and all generators in service. Studies are performed on the Transmission System in its current topology at least annually, and internal ad hoc studies are performed as necessary to determine short circuit impacts of projects under consideration. For ad hoc studies, the model will be modified to simulate as accurately as possible the Transmission System configuration when the project is expected to go into service.

In service circuit breakers with fault duties in excess of interrupting capabilities will have a TEP project for breaker replacement. The project schedule will follow the rules of TEP project schedule considering lead times necessary to complete breaker replacements. When the scheduled date is beyond the need date for a breaker replacement, the first Corrective Action Plan tested will be to disable automatic reclosing. If the breaker duty still exceeds the breaker interrupting capability additional Corrective Action Plan measures will be tested. A Corrective Action Plan which mitigates all criteria violations will be documented in the Planning Assessment report. The Planning Assessment report will list short circuit study deficiencies and the associated actions needed to achieve the required System performance[27]. The TEP projects identified in the short circuit analysis will include a list of breaker replacements required so as not to overload the breaker duty rating. The list of breaker replacements will be reviewed in subsequent annual Planning Assessments for continued validity and implementation status of identified System Facilities and Operating Procedures[28].

6.6 Near Term Transmission Planning Horizon Stability BES Analysis

Per TPL-001-4 R4, the Near-Term Transmission Planning Horizon Stability Planning Assessment will only be analyzed for BES Facility disturbances. Only BES Facilities will be monitored for the performance requirements of TPL-001-4. The Stability Planning Assessment will include TPL-001-4 P1 through P7 planning events and extreme events[29]. For the Stability portion of the Planning Assessment, the Near-Term Transmission Planning Horizon may utilize a qualified past study, five calendar years old or less, or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study. If a qualified past study is used, the prior study reports will be copied in the Planning Assessment report. Documentation to support the technical rationale for determining material changes will also be included in the Planning Assessment.

[27] TPL-001-4 2.8.1
[28] TPL-001-4 2.8.2
[29] TPL-001-4 4.1 and 4.2

TPL-001-4 Table 1 P1 through P7 faults on the near-term models shall be analyzed. The respective performance requirements of P1 through P7 will be used as well as the performance requirements of section 8 "Performance Requirements" in these planning guidelines. Where a fault does not pass the respective performance requirements, Corrective Action Plan(s) will be developed to ensure the problem is mitigated and therefore meeting the performance requirements. The Corrective Action Plan(s) are documented in the Planning Assessment.

Stability analysis will be performed on the following models:

- At least one near-term Off-Peak Load model[30]
- At least one near-term On-Peak Load model

These models will represent the expected dynamic behavior of Loads that could impact the study area, considering the behavior of induction motor Loads[31]. The model uses an aggregate System Load model which represents the overall dynamic behavior of the Load.

6.6.1 BES Stability Sensitivity Studies for Near-Term Transmission Planning Horizon

The annual assessment for the Near-Term Transmission Planning Horizon portion of the Stability analysis shall be performed for at least one of the following varying conditions[32]:

- Load level, Load forecast, or dynamic Load model assumptions
- Expected transfers not previously included in the stability models
- Expected in service dates of new or modified Transmission Facilities that may or may not have all required approvals.
- Reduced reactive resource capability.
- Generation additions that have not yet completed a large generation interconnection agreement and/or anticipated retirement of generation not yet announced.

For the sensitivity portion, the Planning Assessment may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study. If a qualified past study is used, the study reports will be copied in the current Planning

[30] TPL-001-4 2.4.2
[31] TPL-001-4 2.4.1
[32] TPL-001-4 2.4.3

Assessment report. The near-term Stability analysis sensitivity will include P1 through P7 and extreme events for BES Facilities only. Corrective Action Plan(s) do not need to be developed solely to meet the performance requirements for a single sensitivity study analyzed in accordance with TPL-001-4 2.1.4 and 2.4.1.[33] Corrective Action Plan(s) may be developed but are not required in accordance with Requirements TPL-001-4 2.1.4 and 2.4.3.[34]

6.7 Stability BES Assessment for the Long-Term Transmission Planning Horizon

Per TPL-001-4 R4 the Long-Term Transmission Planning Horizon Stability portion of the Planning Assessment will only be analyzed for BES Facility disturbances. Only BES Facilities will be monitored for the performance requirements of TPL-001-4. At least one model in the Long-Term Transmission Planning Horizon will be used in the Stability studies. The Stability assessment may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study.[35] The material changes may or may not include proposed generation that does not have a signed large generation interconnection agreement. The long-term model will include proposed transmission elements and Facilities. The Stability analysis will include TPL-001-4 Table 1 P1-P7 and extreme events. Where analysis does not pass the performance requirements of TPL-001-4 Table 1 P1 through P7, a Corrective Action Plan will be developed to ensure the problem is mitigated meeting the performance requirements. Additionally, extreme event analysis will be performed using the criteria detailed in Section 9.2 “Identification of Instability for Dynamics Simulations”. If the extreme event shows a potential for System instability, then an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences is conducted and documented in the Extreme Event Report.

6.8 Other Studies

The study Scenarios described in sections 6.2.1 “Steady State Sensitivity Studies for Near-Term Transmission Planning Horizon” and 6.6.1 “BES Stability Sensitivity Studies for Near-Term Transmission Planning Horizon” are performed on models for the Near-Term Transmission Planning Horizon only. There are other studies, described below, performed on both the Near-Term Transmission Planning Horizon and the Long-Tem Transmission Planning Horizon models. If counter flows are modeled, justification for the modeling of counter flows will be documented in the Planning Assessment. Other studies include but are not limited to:

- TSR Study: This study ensures that confirmed firm TSRs can be served by the LG&E/KU Transmission System. Only steady state analysis for P0, P1, P2 (EHV

[33] TPL-001-4 2.7
[34] TPL-001-4 2.7
[35] TPL-001-4 2.6

only), P3, P4 (EHV only) category events are simulated. The TSR study will be performed using the off peak and the 50/50 summer and winter peak models only. Corrective Action Plan(s) will be developed for criteria violations identified on the LG&E/KU Transmission System. If performance requirements are not met for the additional TSR study, Corrective Action Plan(s) will be developed and documented in the annual Planning Assessment. This will include operating guides for criteria violations associated with TSRs with a contract period of less than five years. Confirmed firm export or import TSRs that were not included at the maximum level in the Starting Point Models are modeled in the appropriate time frame. The TSRs must be firm and have a contract period of at least one year. TSRs linked to DNR resources utilized to serve LSE load on the LG&E/KU Transmission system will only be re-dispatched if a single generator outage would remove the full DNR resource.

7 Contingencies

The contingencies of TPL-001-4 Table 1 P1 through P7 and extreme events simulated for the assessment will only include those that are expected to produce more severe System impacts on the LG&E/KU portion of the BES[36]. The list of Contingencies being simulated is included in the appropriate Planning Assessment report.

Category P1-5, P3-5, P6-4, and P7-2 refer to HVDC outages. There are no HVDC lines within or near the LG&E/KU PC area that affect the LG&E/KU System. The Planning Assessment does not evaluate HVDC contingencies and no P1-5, P3-5, P6-4, or P7-2 contingencies are simulated in either the steady state or Stability analyses.

7.1 Contingency List Coordination

Per TPL-001-4 3.4.1 and 4.4.1, LG&E/KU TP will coordinate with adjacent PCs and TPs to ensure that Contingencies on adjacent Systems which may impact the LG&E/KU System are included in the Contingency list. The LG&E/KU BES Contingency list will be shared with the LG&E/KU neighbor TP with a request for the neighbor TP to recommend contingencies in its System that should also be evaluated in the LG&E/KU Planning Assessment. All contingencies recommended by neighboring TPs and/or PCs will be assessed for inclusion in the LG&E/KU Contingency list for evaluation in the LG&E/KU annual Planning Assessment.

7.2 Generation Replacement Scenarios

Generation unit outages require an increase in generation in order to replace the lost unit to accurately study the system under a generator contingency.

[36] TPL-001-4 3.4

To maintain the capability to serve LSE load after loss of a LSE's affiliate generator within the LG&E/KU PC area, replacement generation shall be initially selected from available dispatchable LSE affiliate generation resources within the LG&E/KU PC area based on the merit order in the year two summer peak model. Any deficit in replacement generation not covered from affiliate resources within the LG&E/KU PC area shall be replaced with an import from Tennessee Valley Authority (TVA), Midcontinent Independent System Operator (MISO) or PJM unless customer discussions indicate that some of these scenarios are not required.

For other generator contingencies outside the LG&E/KU PC area, generation will be replaced from the contingent generator's PC area.

7.3 Maximizing Generation at a Plant Site

In addition to simulating generator outages, the maximum output of each generation plant site within the LG&E/KU PC area is studied. Each unit at the plant site shall be increased to the unit's seasonal maximum capacity as provided by the annual MOD-032 submittal, not to exceed the associated NITS capacity. Other resources within the plant site's PC area are reduced to offset this increase in generation. For LG&E/KU affiliate generation, the reduction shall be accomplished by proportionally scaling other affiliate generation in the LG&E/KU PC area. For non-LG&E/KU generation in the LG&E/KU PC area, the largest Transmission Service Reservation (TSR) affiliated with the unit shall be reduced as appropriate or generation is exported to the non-affiliate PC area.

7.4 Automatic Control Inclusion

[37]The simulated contingencies must remove all elements that the Protection System and other automatic controls are expected to disconnect for each Contingency without operator intervention. Information from LG&E/KU protection group supplies transmission planning with clearing times, breakers which will open to clear a fault and other data required to accurately analyze a contingency.

The LG&E/KU System does not currently have any Special Protection Systems. Simulations of Protection System responses during a fault or Contingency are analyzed with that Contingency. The LG&E/KU PC area does not currently have any generation tripping or run back scheme other than what would be tripped as a result of clearing a fault. If generation is tripped as a result of fault clearing, then that tripping scheme will be studied as part of the Contingency analyzed.

Per TPL-001-4 3.3.1.1, LG&E/KU will build a project to ensure that generators do not trip due to low voltage on the generator bus after a P1 or P3 planning event. Information on generator relay tripping is obtained by the protection group to ensure that requirements of PRC-024 are achieved.

[37] TPL-001-4 3.3.1 & 4.3.1

7.4.1 Steady State Automatic Control Inclusion

If the results of the steady state analysis show an overload of Facility (ies) above the criteria outlined in NERC standard PRC-023-3, prior to loss of load if allowed by TPL-001-4 Table 1, the steady state simulation will include the outage of that Facility(ies) unless verification of the relay loadability values indicate the Facility(ies) would not trip on the resulting flow. Verification is done via the CASCADE database or through communication with the Protection department.

The LG&E/KU transmission System does not contain any phase-shifting transformers. There are switched capacitors on the LG&E/KU transmission System and those facilities are modeled with the voltage levels at which they are switched on and off[38]. Transmission capacitor status (on/off) are simulated consistent with automatic voltage control (on/off) settings and operating practice during normal transmission System conditions. Therefore, when the solution of the power flow analysis has capacitor bank switching enabled, the automatic switching of capacitor banks is simulated.

7.4.2 Stability Assessment Protection System Inclusion

Per TPL-001-4 4.3.1.1 the Stability simulation will include successful high speed (less than one second) reclosing and unsuccessful high speed reclosing into a Fault where high speed reclosing is utilized.

Per TPL-001-4 4.3.1.2 the Stability simulations will include the tripping of generators where the GO has indicated that generators will trip as a result of either low/high voltage or frequency. The relay protection models shall be provided by the GO. If assumptions are made they will be included in the Planning Assessment report.

Generation is not tripped as a result of low/high voltages or low/high frequency unless the GO has provided relay models. However, the generator must meet the LGIA/LGIP/SGIA/SGIP and PRC-024-2 low/high voltage ride through (LVRT and HVRT) and low/high frequency ride through (LFRT and HFRT) requirements.

7.5 Load Restoration and Switching Procedure.

During breaker to breaker outages, some Consequential Load loss is possible. The simulation of the load restoration and switching procedure is performed as part of the Planning Assessment. Post-fault conditions and conditions after load restoration, switching, or transmission re-configuration are evaluated. Post-contingency operator-initiated actions including switching may be simulated. Load that is off-line as a result of the Contingency (consequential load loss) being evaluated may be switched to alternate

[38] TPL-001-4 3.3.2

sources during the load restoration assessment. However, load is not taken off-line to perform switching.

7.6 Steady State Planning Events

The steady state Planning Assessment studies are performed based on a Contingency list created to meet requirements of TPL-001-4 R3. The Contingency list includes those planning events in TPL-001-4 Table 1 that are expected to produce more severe System impacts on its portion of the BES. The Contingency list is documented in the Planning Assessment. This section of the Planning Guidelines will document the methodology used to develop the Contingency list which will produce the most severe System impacts.

The Extreme Event Report will also list those contingencies analyzed and expected to produce more severe System impacts. The extreme event analysis may utilize a qualified past study or a current study to meet the requirements of TPL-001-4. A qualified past study must meet the requirements of TPL-001-4 2.6. Material changes in determination of a qualified past study would include substantial changes to the System represented in the study.

7.6.1 TPL-001-4 Table 1 Category P1 Contingency Selection

TPL-001-4 Table 1 Category P1 are single contingencies including loss of generator, transmission circuit, transformer, or shunt device. The LG&E/KU Planning Assessment includes all single transmission circuits and transformers that are operated at 69 kV (secondary voltage) and above. Shunt devices operated at 69 kV are not included in the contingency list. In order to achieve the removal of all elements that the Protection System and other automatic controls are expected to disconnect for each Contingency without operator intervention all breaker to breaker contingencies for transmission circuits and transformers are simulated for Category P1 events[39].

The single generator Contingency includes single generator units connected to the LG&E/KU System which are 50 MW or higher. When more than one generator is connected to the same transmission bus, only the largest generator unit outage is simulated at each transmission bus. The largest generator at a bus is considered to produce more severe System impacts than smaller units connected to the same bus, since larger units have the largest amount of reactive power loss to support the transmission system. Similarly, single generator contingencies not connected to the LG&E/KU System, but that are in close proximity are also simulated by taking the outage of only the largest unit at the point of interconnection.

All single lines, transformers and BES shunt equipment within the LG&E/KU PC area are analyzed as a P1 event.

[39] TPL-001-4 3.3.1

7.6.2 TPL-001-4 Table 1 Category P2 Contingency Selection

- Opening a line section without a fault: All line section outages of BES Facilities will be simulated to ensure the performance requirements of TPL-001-4 Table 1. A technical rationale for determining a set of contingencies for opening a line section without a fault is not required, since all BES line sections are opened without a fault for this analysis.

- Technical rationale for identifying bus section faults which produce more severe impacts to the BES: Many LGE&E/KU BES substations are designed with a breaker and a half or ring bus design. A bus section fault for a ring bus results in the same Contingency as P1, while a bus section fault of a breaker and a half design results in no transmission circuit outage or a P1 outage depending on the location of the bus. Therefore, bus section faults which produce more severe impacts to the BES are buses with a straight bus design. All BES Facilities in a straight bus configuration are simulated for Category P2-2.

- Technical rationale for internal Breaker Faults (non-Bus-tie Breaker) which result in more severe impacts to the BES: An internal breaker fault means a breaker failing internally, thus creating a System fault which must be cleared by protection on both sides of the breaker. An internal breaker fault on a ring bus design is a double Contingency of the two Facilities that share a breaker in the ring. An internal breaker fault on a breaker in a breaker and a half design, results in a double Contingency of the two Facilities that share a breaker in the same bay. The contingency which results in more severe impacts to the BES are internal faults of breakers which result in two BES Facilities that share a breaker for either a ring bus or breaker and a half design. Additionally, an internal breaker fault for a breaker on a straight bus will be simulated when the fault causes more than just a disconnected bus, for example, an internal breaker fault where the breaker connected to a BES straight bus protects a three terminal line.

- Internal Breaker Fault (Bus-Tie Breaker): An internal breaker fault means a breaker failing internally, thus creating a System fault which must be cleared by protection on both sides of the breaker. This contingency results in opening all breakers connected to both buses connected by the bus-tie breaker. For the annual Planning Assessment, all internal breaker faults for bus-tie breakers are simulated. Since all of the internal faults of bus-tie breakers are included, a technical rationale for selecting a reduced set of internal faults of bus-tie breakers is not required.

7.6.3 TPL-001-4 Table 1 Category P3 Contingency Selection

Category P3 includes the loss of a single generator unit, as described in section 7.2, followed by system adjustments. After system adjustments, all P1 contingencies are simulated. This includes generator, transmission circuit, transformer, and shunt device (BES only) contingencies. For P3 events, LG&E/KU runs all single contingencies of 69

kV and above combined with a generator outage as described in section 7.2. LG&E/KU also runs combinations of two generator outages.

Technical rationale for determining which P3 contingencies which result in more severe impacts to the BES:

The initial generator outage (units 50 MW or higher) is analyzed on the largest unit at the same point of interconnection. After the generator outage and system adjustments described in Section 7.2, all P1 contingencies are analyzed.

Additionally, "Outside World" generator Contingencies are determined using the same criteria as LG&E/KU PC area plants if the generator plant is connected to the BES system within five busses of the LG&E/KU PC area. The following generator Contingencies are selected outside the LG&E/KU PC area:

1. TVA's Bull Run
2. SIGE's Cannelton
3. OVEC's Clifty Creek
4. BREC's Coleman
5. EKPC's Cooper
6. AEP's Clinch River
7. DOE&K's East Bend
8. DEI's Gibson
9. BREC's Green
10. AEP's Industrial Drive
11. EKPC's JK Smith
12. EEI's Joppa
13. Dayton P&L Killen
14. OVEC's Kyger
15. EKPC's Laurel Lake
16. AEP's Lawrenceburg
17. DOE&K's Miami Fort
18. DEI's Markland Dam
19. TVA's Norris
20. TVA's Paradise
21. AEP's Rockport
22. TVA's Sequoila
23. TVA's Shawnee
24. EKPC's Spurlock
25. Dayton P&L Stuart
26. AEP's Virginia City
27. TVA's Watts Bar
28. BREC's Wilson
29. TVA's Wolf Creek
30. AEP's V3-007 (New unit, name subject to change)
31. Dayton P&L AB1-169 C OP (new unit, name subject to change)

Outages of all solar generation within 5 miles radius will be studied as a single generator unit to accommodate clouds or storm which results in loss of solar generation in the same area.

7.6.4 TPL-001-4 Table 1 Category P4 Contingency Selection

Category P4 contingencies in steady state are multiple contingencies caused by a stuck breaker where backup and/or delayed clearing is required to clear a fault. A fault followed by a breaker failure where the breaker is attached to a straight bus is the same disturbance as a fault on the bus itself which is analyzed as a P2 disturbance. Therefore, these are not analyzed as a P4 disturbance.

Technical rationale for identifying P4 contingencies which result in more severe impacts to the BES: BES Facilities that share a common breaker in a ring bus or breaker and a half design result in two BES Facilities taken out of service at the same time in order to clear the fault. A fault and a subsequent loss of two BES Facilities without system adjustments result in more severe impacts to the BES.

7.6.5 TPL-001-4 Table 1 Category P5 Contingency Selection

The contingencies for TPL-001-4 Table 1 Category P5 are simulated using Stability results. The Stability analysis identifies which breakers will open for a category P5 event and subsequent tripping of generation. The contingency selection is determined by the Stability analysis described in Section 7.8.2 " for P5 events. If the Stability results for the Planning Assessment identifies additional outaged Facilities to eventually clear the fault, for a P5 event, then the steady state analysis is performed by tripping all facilities that trip in the stability analysis.

7.6.6 TPL-001-4 Table 1 Category P6 Contingency Selection

The following technical rationale for contingencies selected for Category P6 that produce more severe System impacts to the BES: All tested BES contingencies are analyzed to determine impacts on BES Facilities remaining in-service. When a BES Contingency shows an impact on any BES Facility, that Contingency will be paired with all other BES Contingencies that impact the same BES Facility. Category P6 contingencies include transmission circuits, transformer, and shunt devices (BES only). This contingency list of two BES Facilities are tested using an automatic program and the resultant contingency file is developed by the same program. The resultant contingency list contains both internal and external BES Facilities.

7.6.7 TPL-001-4 Table 1 Category P7 Contingency Selection

LG&E/KU maintains a list of adjacent circuits greater than one mile in length that reside on a common structure. Loss of all BES double circuit Facilities that reside on a common

structure longer than a mile are simulated for Category P7. Since all Category P7 contingencies are analyzed, a technical rationale for selecting a smaller list of contingencies is not required.

7.7 Steady State Extreme Events

LG&E/KU simulates the System performance for TPL-001-4 Table 1 extreme events. The extreme events are selected that are expected to produce more severe System impacts. When LG&E/KU evaluates in steady state the performance of Category P6, there are no System adjustments after the first Contingency. Therefore, the P6 planning event is the same as the extreme event for steady state part 1. The extreme events that are simulating in the TPL performance assessment include:

- Loss of a tower line that has three or more BES circuits when the common structure lines are more than one mile in length. Since all BES Facilities on a common structure are simulated, no technical rationale for determining a smaller list of contingencies is required.

- Loss of all BES transmission lines on a common Right-of-Way when the common right of way is longer than one mile in length. All BES Facilities on a common right-of-way are simulated, therefore no technical rationale for determining a smaller list of contingencies is required.

- Loss of a substation (one BES voltage level plus transformers) which are analyzed in the Planning Assessment process. A list of substations selected for this extreme event will be included in the Planning Assessment report including a technical rationale for selecting the group of substations.

- The technical rationale for selecting loss of all generating units at a station includes the largest generation sites greater than 500 MW total generation capability in the LG&E/KU System. Loss of the largest generation site also results in loss of the largest amount of reactive power which is used to support the BES, therefore, this results in more severe impacts to the BES.

- Loss of a large load or major load center which is analyzed in the Planning Assessment process includes tripping the load from the LG&E/KU largest single customers. This also includes large municipal loads. Loss of these largest customers are analyzed as part of the Planning Assessment.

- Loss of all gas-fired generation (two plants) served by a common large gas pipeline. The technical rationale for determining loss of which two plant sites result in more severe impacts to the BES: The two largest generation sites serviced from the same natural gas pipeline will be analyzed. The largest amount of generation loss is more severe since it is also the largest amount of reactive power available to support the

BES. The study assumes the loss of generation can be replaced by existing off-line generation and importing power from TVA, PJM and MISO.

7.8 Stability Planning Events

The contingencies selected that produce the most severe impacts to the BES in steady state are not always the same as those selected for Stability analysis. LG&E/KU's Contingency Selection Criteria describes the rationale for Contingency selection that is consistent with TPL-001-4 R3 and is considered to produce more severe System impacts. The Stability portion of the Planning Assessment shall be performed for planning events to meet performance requirements in TPL-001-4 Table 1. The Stability portion of the Planning Assessment will only include analysis of disturbances on BES Facilities. The Stability analysis may use a current or qualified past study per TPL-001-4 2.6.

FAC-010-3 require stability analysis that is similar to analysis required in TPL-001-4. Therefore, the annual Planning Assessment will include language required by FAC-010-3.

7.8.1 Category P1 Stability Disturbances Analyzed

Category P1 disturbances are selected to comply with NERC reliability standards including faults on generators, Transmission Circuits, Transformers and BES switched shunt devices. Three phase faults with normal clearing (assumed six cycles) are initially analyzed for breaker to breaker BES Facilities in the stability model. A clearing time of six cycles is an assumed conservative clearing time. In the event that a Category P1 disturbance does not meet the performance requirements of TPL-001-4 Table 1, the Protection group is contacted to acquire the actual clearing time. The disturbance is then re-simulated with the actual clearing time.

A test or study is done in the prior year's TEP on the near term maximized model to determine the list of P1 disturbances that results in more severe impacts to the BES. The test including the technical rationale is described in the annual Planning Assessment report.

7.8.2 Categories P2 through P7 Stability Disturbances Analyzed

TPL-001-4 Table 1 Categories P2 through P7 disturbances are selected such that only the disturbances that produce the more severe System results or impacts are analyzed.[40] A test or study is done in the prior year's TEP on the near term maximized model to determine the list of P2 through P7 disturbances that result in more severe impacts to the BES. The test including the technical rationale is described in the annual Planning Assessment report.

For Category P2.1 selections are made from the near term maximized model from the previous years TEP.

[40] TPL-001-4 4.4

All BES lines that are on a common tower are simulated for a P7 event. Therefore, a technical rational for determining which P7 events produce more severe impacts to the BES is not required.

7.9 Stability Extreme Event Assessment

The Stability portion of the Planning Assessment will perform studies to assess the impact of extreme events detailed in TPL-001-4 Table 1[41]. The events selected for evaluation are those that are expected to produce more severe System impacts. This section describes the rationale for the Contingencies selected for extreme events analyzed in the stability portion of the Planning Assessment. If the Stability portion of the Planning Assessment for extreme events concludes there is instability (see section 9.2 "Identification of Instability for Dynamics Simulations") caused by the occurrence of extreme events, an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences of the event will be conducted. This evaluation will be documented in the Extreme Event Report.

Technical Rationale for Extreme Event Contingency Selection: Extreme events that are expected to produce more severe System impacts will be identified. These extreme events are selected based on analyzing a three phase fault on large generators, transmission circuits above 300 kV, transformers with high side voltage above 300 kV, straight line bus sections followed by a stuck breaker, or relay failure resulting in delayed clearing. These disturbances are analyzed in models from the prior year's Planning Assessment using very long clearing times. Those disturbances which result in the most severe impact to the BES are identified using long clearing times. The Contingency list is included in the Planning Assessment report. The extreme event assessment analyzes these disturbances using actual clearing times in the current Planning Assessment. The performance of the extreme events are checked for potential instability (see section 9.2 "Identification of Instability for Dynamics Simulations").

8 Performance Requirements

This section documents acceptable System steady state voltage limits, thermal limits, and the transient Stability performance requirements for the LG&E/KU System[42]. Additionally performance requirements for P0 through P7 and extreme events described in TPL-001-4 Table 1 are included in the Planning Assessment report.

Specific criteria in the stability portion of the Planning Assessment for P1 planning events will be tested for TPL-001-4 part 4.1.1; P2 through P7 performance requirements in TPL-001-4 part 4.1.2 and P1 through P7 performance requirements in TPL-001-4 part 4.1.3.

8.1 Special Protection System

[41] TPL-001-4 4.5
[42] TPL-001-4 R5

LG&E/KU transmission does not currently own or operate any Special Protection System (SPS) or Remedial Action Scheme (RAS). Neither SPS(s) nor RAS(s)) remedial action schemes should be considered when developing the Corrective Action Plan(s).

8.2 Steady State Voltage Performance Criteria

Per TPL-001-4 R5, the following is the steady state voltage criteria: A steady state System voltage violation will occur when the percent nominal voltage, rounded to one decimal place, is outside the applicable performance requirements.

The following are detailed voltage criteria for each of the TPL-001-4 Table 1 Categories.

1. Category P0 with all Elements and Facilities in service, the LG&E/KU Elements and Facilities of 69 kV and above shall perform within the following:

    - The minimum acceptable voltage criteria for Facilities of 69 kV (load serving buses) and above are 0.94 pu of their nominal value. The maximum voltage criteria of any 500 kV System bus should not exceed 1.10 pu of the nominal value. All other transmission Elements and Facilities 69 kV to 345 kV should not exceed 1.05 pu of the nominal value.

2. Category P1and P3 voltage criteria:

    - The minimum acceptable voltage criteria for Elements 69 kV (load serving buses) and above are 0.90 pu of their nominal value. The maximum voltage criteria of any 500 kV System bus should not exceed 1.10 pu of the nominal value. All other transmission Elements and Facilities 69 kV to 345 kV should not exceed 1.05 pu of the nominal value.

    - Load shed using TPL-001-4 footnote 12 is not used as a mitigation for categories P1 and P3.

3. Category P2, P4 through P7: Additional voltage criteria for P2, P4 through P7 and limits to Non-Consequential Load Loss when load shed is allowed in TPL-001-4 Table 1.

    - A maximum load shed of ten percent in the LG&E/KU PC area as modeled for P2 and P7 planning events. A maximum load shed of five percent for P4, P5 and P6 planning events.

    - After allowed Non-Consequential Load Loss and interruption of Firm Transmission Service, the minimum acceptable voltage criteria for BES Facilities is 0.90 pu of their nominal value.

- Load shed using TPL-001-4 footnote 12 is not used as a mitigation for P1 through P7 planning events.

4. Steady state extreme events: Extreme events are only checked against the criteria in section 9.1 "Identification of Instability for Steady State Simulations" of these planning guidelines.

8.2.1 Steady State Thermal Facilities Limits

The applicable Facility Rating for TPL-001-4 Table 1 Category P0 is the seasonal normal Facility Rating (Rate A). The applicable Facility Rating for TPL-001-4 Table 1 Categories P1 through P7 is the seasonal emergency rating (Rate B).

8.3 Transient Stability Performance Requirements

Transient Stability studies shall be performed to meet TPL-001-4 Table 1 performance requirements. The System must remain stable per identification of System instability per Section 9 "System Instability Criteria Methodology" for TPL-001-4 Table 1 Categories P1 through P7 events.

8.3.1 Angular Stability

The angular Stability criteria for a generator are defined as: a generator rotor angle must remain less than 180 degrees with respect to the relative angle. LG&E/KU chooses the TVA's Brown Ferry, a nuclear unit, as the relative machine.

8.3.2 Damping Criteria

For TPL-001-4 Table 1 Categories P1-P7 Power Oscillations shall exhibit acceptable damping as established by the PC and TP[43]. This damping criteria is: The angular variation of a machine must be tested showing visual damping for a five second simulation. If the angular variation is not visually damped after the five second simulation, a 20 second simulation will be completed. If after the 20 second simulation, the angular variation is still not visually damped, then the System will be determined to be unstable. LG&E/KU examines the Stability plots as part of the Stability analysis.

8.3.3 Voltage Ride Through Criteria

Tripping of a generator will be simulated when the GO has indicated that generators will trip as a result of either low/high voltage or frequency. The acceptable limit of LG&E/KU

[43] TPL-001-4 4.1.3

BA generator tripping is 3500 MW per Section 9 "System Instability Criteria Methodology".

8.3.4 TPL-001-4 Table 1 Categories P1 Generator Synchronism

For TPL-001-4 Table 1 Category P1: No generating unit shall pull out of synchronism. A generator being disconnected from the System by fault clearing action or by a SPS) or RAS is not considered to be pulling out of synchronism[44]. LG&E/KU does not currently have an SPS or RAS.

8.3.5 TPL-001-4 Table 1 Categories P2-P7 Generator Synchronism

For TPL-001-4 Table 1 Category P2 through P7: Tripping of generating units will be simulated when the analysis indicates that a unit(s) is pulling out of synchronism. The acceptable limit for total generation loss is 3500 MW per Section 9 "System Instability Criteria Methodology".

8.3.6 TPL-001-4 Table 1 Categories P1 and P3 Transient Voltage Stability Performance Requirements:

Per TPL-001-4 R5, the following is the transient voltage Stability criteria for P1 and P3 events: LG&E/KU's transmission System voltage must recover to 0.8 p.u. within 4 seconds after the fault is cleared. TPL-001-4 Table 1 Categories P1 and P3 Stability faults must also pass the angular and damping Stability performance requirements described in this section. P1 disturbances must be in compliance with TPL-001-4 part 4.1.1.

8.3.7 TPL-001-4 Table 1 Categories P2, and P4-P7 Transient Voltage Stability Performance Requirements:

Per TPL-001-4 R5, the following is the Stability voltage criteria for P2 and P4-P7 events: These disturbances are less probable and may involve loss of non-consequential load (when allowed by TPL-001-4) and/or generation tripping within the LG&E/KU BA. These disturbances must pass the angular and damping Stability performance requirements described in this section. Within 4 seconds after a fault is cleared, there cannot be more than 6 BES substations with voltages less than 0.80 pu.

8.4 Extreme Events Stability Performance Requirements:

Stability disturbances for TPL-001-4 Table 1 extreme events are analyzed for those contingencies that would produce more severe System results or impacts[45]. If the analysis concludes there is potential instability per Section 9.2 "Identification of Instability for

[44] TPL-001-4 4.1.1

[45] TPL-001-4 3.5, 4.5

Dynamics Simulations", caused by the occurrence of the extreme events, an evaluation of the possible actions designed to reduce the likelihood of or mitigate the consequences and adverse impacts of the event(s) will be conducted.

9 System Instability Criteria Methodology

As required by TPL-001-4 R6 this section defines and documents the criteria or methodology used in the analysis to identify System instability for conditions such as Cascading, voltage instability, or uncontrolled islanding. It is the intent of the Planning Assessment to identify potential System instability before that instability actually occurs giving some margin in the assessment. The identification of potential instability in the power System simulation is different between the steady state study and the stability study.

9.1 Identification of Instability for Steady State Simulations

LG&E/KU has considered Cascading, voltage instability and uncontrolled islanding in the steady state power flow analysis. Instability could result if load loss in the LG&E/KU area load (area 363 in the model) is 10% or more.

9.2 Identification of Instability for Dynamics Simulations

For purposes of these planning guidelines, LG&E/KU has considered dynamic instability, Cascading, voltage instability, or uncontrolled islanding. For dynamics analysis, instability could result after one or more of the following occurs:

- The event is considered to be uncontrolled if, for a simulated disturbance in the LG&E/KU BA, the total generation loss is more than one plant located external to the LG&E/KU BA, or if the total loss of LGEE BA generation is greater than 3500 MW.

- 4 seconds after a fault is cleared, there exists more than six BES substations whose voltages are below 0.8 p.u.

- Violation of damping criteria per Damping Criteria in Section 8.3.2 "Damping Criteria".

- Increasing angular swings of some LG&E/KU generators lead to their loss of synchronism with other generators.

10 Corrective Action Plan(s)

For planning events shown in TPL-001-4 Table 1, when the analysis indicates an inability of the System to meet the performance requirements in TPL-001-4 Table 1, the Planning Assessment shall include Corrective Action Plan(s) addressing how the performance requirements will be met[46]. Revisions to the ITO approved projects in the Corrective Action Plan are allowed.but the planned System shall continue to meet the performance requirements of TPL-001-4 Table 1. Revisions to an ITO approved project will be communicated to the ITO as soon as feasible along with supporting documentation demonstrating the proposed project continues to meet the performance requiremetns of TPL-001-4. The ITO, after review, will post a notification of the revised project on OASIS and stakeholders will have 15 calendar days to comment on the revised project. The ITO will make its best effort to review and approve the revised project within 45 calendar days from initial notification from LG&E/KU, taking into consideration any stakeholder comments.

Corrective Action Plan(s) may be developed but are not required for sensitivity studies in accordance with TPL-001-4 2.1.4 and 2.4.3[47]. The Corrective Action Plan(s) are documented in the Planning Assessment report.[48] The Planning Assessment report lists the System deficiencies and the associated actions needed to achieve the required System performance.

The LG&E/KU Planning Assessment will NOT use Non-Consequential Load Loss when allowed per TPL-001-4 footnote 12 to satisfy the performance requirements of TPL-001-4.

The LG&E/KU BA does not have any automatic generation tripping or run back scheme other than what would be tripped as a result of clearing a fault. If generation is tripped as a result of the fault clearing, then that tripping will be studied as part of the Contingency analyzed. Automatic generator tripping or automatic generator run-back other than fault clearing should not be considered in the Corrective Action Plan(s) since this would be a RAS.

Some LSEs in the LG&E/KU PC area have DSM programs but not all. The majority of the loads for entities that have DSM programs contain reductions in load as a result of the DSM programs in the load forecast that was submitted. Therefore, since the majority of DSM was accounted for in the load forecast, DSM programs are not utilized in the Corrective Action Plan(s).

The previous year's Planning Assessment Corrective Action Plans are reviewed in subsequent annual Planning Assessments for continued validity and implementation status of identified of Systems Facilities or improvements to existing Systems Facilities[49].

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[46] TPL-001-4 2.7

[48] TPL-001-4 2.7.1

[49] TPL-001-4 2.7.4

10.1 Projects for Extreme Load Sensitivity

For the seasonal peak extreme load sensitivity analysis, projects will be developed for specific performance requirement violations of NERC TPL-001-4 category P0, P1, and P3. Projects will be developed to mitigate performance requirement violations for P0 and P1. Projects will be built for P3 when the violation exists in the year ten model and re-dispatch of Brown and Trimble Co CTs cannot mitigate the violation.

10.2 Operating Guides

Operating Guides may be an acceptable Corrective Action Plan in order to meet the performance requirements if the violation occurs in the Near-Term Planning Horizon but not in the Long-Term Planning Horizon. Operating guides will also be developed if a project will not be completed by the need date. In addition, there is a long standing operating guide, reviewed annually, to mitigate high voltage at Pocket North 500 kV, Pineville 500 kV and Pineville 345 kV stations. Operating guides may include; but not limited to, generation re-dispatch, transmission reconfiguration, Non-Consequential Load Loss, and loss of firm transmission service in accordance with TPL-001-4.

10.3 Corrective Action Plan(s) for P0

The Corrective Action Plans for TPL-001-4 Table 1 Category P0 may include:

- Building new transmission Elements and Facilities
- Upgrading existing transmission Elements and Facilities

10.4 Corrective Action Plan(s) for P1 thru P7

For events of TPL-001-4 Table 1 Categories P1 thru P7 which require a Corrective Action Plan in order to meet the performance requirements of Table 1, the Corrective Action Plans may include:

- Building new transmission Elements and Facilities.
- Upgrading existing transmission Elements and Facilities.
- Load Restoration and Switching Procedures (see Section 7.5 “Load Restoration and Switching Procedure). Operating Guides (see Section 10.2 “Operating Guides”).
- Non-Consequential Load Loss where specifically allowed in TPL-001-4 Table 1. However non-consequential load loss allowed per footnote 12 will not be used in the Corrective Action Plan.
- For P2, P4 thru P7, Generation re-dispatch and Transmission re-configuration.

10.5 Corrective Action Plans for Operational Issues

Additional TEP projects may be required to mitigate operational issues not identified elsewhere in the Planning Assessment. Projects will be considered for operational issues if a Real-time issue is identified or if a condition exists that prevents equipment maintenance from being performed during Off-Peak periods or other situations as determined by LG&E/KU.

If Transmission Planning analysis indicates that a Facility cannot be taken out of service without an adverse impact to the reliability of the LG&E/KU Transmission System, a TEP project may be developed. In order for the project to qualify as a potential TEP project under this scenario, a report must be developed to summarize the analysis and justify the need for a potential TEP project.

10.6 Project Timing

If situations arise that are beyond the control of the TP or PC that prevent the implementation of a Corrective Action Plan in the required timeframe, then the TP or PC is permitted to utilize Non-Consequential Load Loss and curtailment of Firm Transmission Service to correct the situation that would normally not be permitted in TPL-001-4 Table 1, provided that the TP or PC documents that they are taking actions to resolve the situation.[50] The TP or PC shall document the situation causing the problem, alternatives evaluated and the use of Non-Consequential Load Loss and curtailment of Firm Transmission Service.

Operating guides are used to document the mitigation steps when a construction project is not expected to be completed by the time the violation exists in the models per TPL-001-4 2.7.3. When necessary, an operating guide could include the use of Non-Consequential Load Loss and curtailment of Firm Transmission Service in accordance with TPL-001-4.

The goal of timing projects is to ensure that the project is completed before the loading reaches 100% of the appropriate seasonal rating. Due to varying conditions, this may not be possible. Therefore, utilization of TPL-001-4 2.7.3 may be used in the form of an operating guide when studies indicate there is an overload of 100% or more of the seasonal rating.

All existing projects that are not determined to be under construction are reviewed annually to determine if the current timing should be changed.

For P0, P1 and P3 thermal overload of a Facility, the following criteria will be used to determine the needed timing for the Corrective Active Plan to address the issue:

[50] TPL-001-4 2.7.3

1. In order to justify a capital project, the flow on the Facility must be equal to or greater than 100% of the applicable thermal rating of the Facility at the end of the Long-Term Transmission Planning Horizon (year ten). The mitigation for overloads that are identified in any of the Year One through year nine studies but not in year ten will have a Corrective Action Plan that is an operating guide if one is available, if not another corrective action plan will be developed.

2. Corrective Action Plans for new issues identified in the 50/50 On-Peak, or Off-Peak Load forecast will be timed to the year and season when the flow is equal to or exceeds 98% of the applicable thermal rating of the Facility.

3. Corrective Action Plans for new issues identified in the 90/10 Peak forecast will be timed to the year and season when the flow is equal to or exceeds 100% of the applicable thermal rating of the Facility.

The timing of new projects (construction) will not be any earlier than the year two model of the Planning Assessment. However, the Corrective Action Plan will contain potential actions, if needed, which can be taken to mitigate the identified constraint in the Planning Horizon prior to the expected completion of construction.

Voltage performance driven projects will be timed with a need date based on the performance criteria of Section 8 “Performance Requirements”. There will not be a timing date associated with these projects.

Until January 1, 2021, Corrective Action Plans applying to the following Categories of Contingencies and events identified in the TPL-001-4, Table 1 are allowed to include Non-Consequential Load Loss and curtailment of Firm Transmission Service (in accordance with Requirement R2, Part 2.7.3) that would not otherwise be permitted by the requirement of TPL-001-4:

- P1-2 (for controlled interruption of electric supply to local network customers connected to or supplied by the Faulted element)
- P1-3 (for controlled interruption of electric supply to local network customers connected to or supplied by the Faulted element)
- P2-1
- P2-2 (above 300 kV)
- P2-3 (above 300 kV)
- P3-1 through P3-5
- P4-1 through P4-5 (above 300 kV)
- P5 (above 300 kV)

11 Responsibility Coordination TPL-001-4 R7

Each PC, in conjunction with the TP, shall determine and identify each entity's individual and joint responsibilities for performing the required studies for the Planning Assessment. LG&E/KU is registered as a PC and TP. The LG&E/KU PC area consists only of the LG&E/KU Transmission Owned Facilities. All responsibilities for the studies required by TPL-001-4 and the Planning Assessment are the sole responsibility of the LG&E/KU Transmission Planning.

The required studies are performed in two parts. Part 1, the Planning Assessment uses the study results for planning events (TPL-001-4 Table 1 P0 through P7) and corresponding Corrective Action Plan(s) to demonstrate compliance with TPL-001-4 planning events. The annual Planning Assessment may utilize a qualified past study when allowed by TPL-001-4 and requirements of TPL-001-4 part 2.6.

Part 2 is the extreme event report which documents the results of the study for extreme events of TPL-001-4 Table 1. The extreme event report may not be performed annually, and may use a qualified past study provided no material changes have been documented in the Planning Assessment.