PPL companies

Transmission Planning Coordinator

Data for Power System Modeling and Analysis (MOD-032-1 R1)

Effective: February 1, 2017

MOD-032-1, Requirements R1 Data for Power System Modeling and Analysis
Program Title
February 1, 2017
Version Effective Date

Required Approval Signature

Delyn Kilpack, Manager – Transmission Strategy and Planning
Prepared by Delyn Kilpack 1/27/2017 Signature and Date
Chris Balmer, Director – Transmission Strategy and Planning
Approved by Chr Balmer 1/27/2017 Signature and Date
Tom Jessee, VP – Transmission Services
Approved by Tom Jessee 1/27/2017 Signature and Date

Revision History

Version No.	1.0 Effective – July 1, 2015
Document Creation after FERC Approval of new standard	
Version No.	1.1 Effective – March 11, 2016
Correct stability and short circuit sections; add specific language how demand side management should be handled in load forecast. Section 4.1.1.2: clarify how DSM should be considered in load forecast; Section 4.2.1.5 remove LSE requirement to supply dynamic load inductor model data; Added Section 4.3.1.3 GO short circuit data; Revised Section 4.3.1.4 clarifying generator step-up transformer short circuit data; Revised 4.3.1.7 clarified transformer short circuit data; removed section 4.3.1.6.1 on transformer wye-wye short circuit data; Revised Section 4.3.2 made requirement suitable for ASPEN not requiring ASPEN.	
Version No.	2.0 Effective – September 2, 2016
On generator data, replaced winter and summer seasons with exact ambient temperatures that data is being requested. Clarified that some TO functions are performed by the same LG&E and KU group that performs PC functions, therefore, a request from the TO is not required since PC already has this data.	
Version No.	3.0 Effective – February 1, 2017
Stability data: revise aggregate load model data collection.	

PPL companies

TABLE OF CONTENTS

1 Introduction

MOD-032-1: The purpose of NERC Reliability Standard MOD-032-1 is to establish consistent modeling data requirements and reporting procedures for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system.

2 Definitions

The following are from the "Glossary of Terms Used in the NERC Reliability Standards".

Balancing Authority (BA): The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Load Serving Entity (LSE): Secures energy and transmission service (and related Interconnected Operations Services) to serve the electrical demand and energy requirements of its end-use customers.

Long-Term Transmission Planning Horizon: Transmission planning period that covers years six through ten or beyond when required to accommodate any known longer lead time projects that may take longer than ten years to complete.

Near-Term Transmission Planning Horizon: The transmission planning period that covers Year One through five.

Planning Coordinator (PC) and/or Planning Authority (PA): The responsible entity that coordinates and integrates transmission facility and service plans, resource plans, and protection systems.

Resource Planner (RP): The entity that develops a long-term (generally one year and beyond) plan for the resource adequacy of specific loads (customer demand and energy requirements) within a Planning Authority Area.

Transmission Operator (TOP): The entity responsible for the reliability of its "local" transmission system, and that operates or directs the operations of the transmission facilities.

Transmission Owner (TO): The entity that owns and maintains transmission facilities.

Transmission Planner (TP): The entity that develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority Area.

Transmission Service Provider (TSP): The entity that administers the transmission tariff and provides Transmission Service to Transmission Customers under applicable transmission service agreements.

Year One: 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 forecasted peak Load period for either 2012 or 2013.

LG&E/KU further defines Year One in the example above as: When the Planning Assessment was started in 2011, then Year One includes the forecasted Peak Load period for 2013.

3 Scope

LG&E/KU is registered as Balancing Authority (BA), Transmission Planner (TP), Transmission Owner (TO), Planning Coordinator (PC), Planning Authority (PA), Generator Owner (GO), Resource Planner (RP), Transmission Service Provider (TSP) and Load Serving Entity (LSE) which are the functional entities that have some responsibility for compliance with MOD-032-1. There are other non-affiliate entities which have load and generation on the LG&E/KU transmission system. Those entities also have responsibility for supplying data to the LG&E/KU PC for compliance with MOD-032-1.

This document is intended to document the procedures and responsibilities of the entities for compliance with MOD-032-1.

4 Responsibilities and Procedures

MOD-032-1 R1 has some applicability to the PC, TP, TO, BA, GO, TSP, LSE, and RP.

MOD-032-1 Requirement R1

MOD-032-1 Requirement R1 is applicable to the TP and PC.

R1. Each Planning Coordinator and each of its Transmission Planners shall jointly develop steady-state, dynamics, and short circuit modeling data requirements and reporting procedures for the Planning Coordinator's planning area that include:

1.1 The data listed in MOD-032-1 Attachment 1;

1.2 Specifications of the following items consistent with procedures for building the interconnection –wide case(s):

1.2.1 Data format

1.2.2 Level of detail to which equipment shall be modeled

1.2.3 Case types or scenarios to be modeled; and

1.2.4 A schedule for submission of data at least once every 13 calendar months.

1.3 Specifications for distribution or posting of the data requirements and reporting procedures so that they are available to those entities responsible for providing the data.

The LG&E/KU PC is responsible for the development of steady state, dynamics, short circuit modeling requirements to meet the requirements of MOD-032-1.

4.1 R1 Steady State Model Data Reporting Requirements

4.1.1 Part 1.1 Data Reporting Requirements for Steady State (MOD-032-1 Attachment 1)

4.1.1.1 Bus Data Required from the TO

The TO is responsible for supplying the bus data with bus numbers, nominal voltage, area number, zone number, and owner number. Since the TO at LG&E and KU, who is responsible for the bus data, is the same group that performs PC functions, there is no need for the TO to supply bus data to the PC.

Bus area, zone and owner designations adhere to values prescribed by SERC. The LG&E/KU area number is 363. Zone numbers allotted to LG&E/KU are 375 through 384. Owner numbers allotted to LG&E/KU are 325 through 327.

4.1.1.2 Aggregate Demand Required from the LSE

Loads at delivery points within the LG&E/KU PC area are modeled as constant MW and power factor[1], using forecast data provided from the LSEs within the LG&E/KU PC area. Each LSE is required to submit a ten year demand forecast, for various ambient temperatures and years.

Data templates will be provided to each LSE with the annual data request from the PC, which specify the details to be submitted from each LSE in their demand forecast data submittal. These templates are Excel workbooks, and include separate tabs for each seasonal scenario.::Typical Scenarios include Summer Peak (50/50), Summer Peak (90/10), Summer Shoulder, Fall, Winter Peak (50/50), Winter Peak (90/10), Spring and Light Load. Other scenarios may be requested depending on the modeling needs of the PC..: Actual scenarios will be included in the letter attached to the annual data request.

A 50/50 load forecast represents a 50% probability that the actual load will be above this forecast and 50% probability the load is below this forecast. A 90/10 load forecast represents more extreme weather and has a 10% probability that the actual load is above this forecast and 90% probability that the actual load is below this forecast.

Load forecast for the shoulder model are loads that are expected to occur on the peak hour of a mild summer day with approximately 70 to 80 % of load in the Summer Peak (50/50) scenario.

The load forecast for the fall model is a peak expected to occur during the fall months. The load forecast for the spring model is a peak expected to occur during spring months.

The load forecast for the spring light load model is the lowest load expected. It represents loads at 2:00 am on a mild spring day.

[1] Reactive power is calculated from the supplied MW and power factor.

For each delivery point included in an LSE forecast, the following data is required:

- Real power (MW) for each of the years specified in the template
- Power Factor[2], which can be a common value for all years, or for individual years if needed, but should represent expected seasonal values.
- A yes/no flag to indicate whether the load can be scaled[3].

See Attachment 1 for an example Load Template worksheet.

4.1.1.3 Generating Units Required from the RP or GO

Several data elements associated with generating units are required for accurate modeling. These include:

- Real power capabilities – gross maximum and minimum
- Reactive power capabilities – maximum and minimum values at real power capabilities in previous bullet.
- Auxiliary load for normal plant configuration, which includes:
    - Unit auxiliary load(s) at all connection points
    - Balance of Plant load(s) at all connection points
- Machine MVA base

The auxiliary load connection points in above list include both the units and balance of plant need to be a description of the connection point at the transmission bus. For example “load on the tertiary of the GSU, or “load on the 138 kV bus” or “load on the 345 kV bus” etc.

The data described above is obtained from the GO, and/or the RP for future planned resources. Data request forms which detail the information required will be sent to the GO and/or RP in the fall of each year from the LG&E/KU PC. The data has to be submitted to the email distribution list (NERC.mod-32-steadystate@lge-ku.com) as described in the data request per the schedule in the data request.

See Attachment 2 for an example Generation Data Request Forms.

4.1.1.3.1 Generator Regulated Bus and Voltage Set Point Required from the TOP

A voltage schedule, for units required to have a voltage schedule, specifying the voltage set point and bus at which the voltage is monitored determined by each TOP per VAR-001. At times there are temporary changes to the voltage schedule due to different operation conditions that can occur. For the requirements of MOD-032-1, the TOP must supply the voltage schedule to the PC prior to the effective date of the voltage schedule for voltage schedules expected to be in effect for at least six months. The TOP is not required to supply the PC with temporary changes to the voltage schedule lasting less than six months or is not in effect for the Near-Term Transmission Planning Horizon.

[2] Reactive power is calculated from MW and power factor.
[3] A scalable load is a load that would increase for extreme weather, or decrease for off-peak load levels. A non-scaled load is like an industrial load that stays constant regardless of the ambient temperature.

4.1.1.3.2 Generating Unit In-Service Status and Generator Type Required from the GO

The in-service dates of new or materially modified generators are to be supplied from the GO and/or RP to the LG&E/KU PC. The generator type (hydro, wind, coal fired, gas, solar, etc.) is also supplied to the LG&E/KU PC along with other generator data for new or materially modified generators.

Planned generator outages lasting longer than six months in the Long-Term Transmission Planning Horizon are to be supplied from the GO or RP to the LG&E/KU PC. The GO and/or RP must supply a list of generation outages lasting longer than six months and planned in either the Near-Term Transmission Planning Horizon or Long-Term Transmission Planning Horizon. The planned schedule of the outage must be included in the data submittal. If there are no scheduled generation outages lasting longer than six months in either the Near-Term or Long-Term Transmission Planning Horizons, the GO and/or RP must send an email indicating that there are no planned generation outages lasting longer than six months. Emergency or unplanned outages are not included in this generator outage data. The schedule for this data request will be included in the PC's annual request for data.

4.1.1.3.3 Generator Step Up Transformers Data Required from the GO

When a new generator is being interconnected to the transmission system, data for generator step up (GSU) transformers are to be supplied from the GO and/or RP to the LG&E/KU PC.

A replacement GSU or materially modified existing GSU must have revised GSU data supplied to the PC from the GO and/or RP prior to energizing the modified or replaced GSU.

The requirements for transformer data for the short circuit model must be supplied along with steady state model include:

- Nominal voltages of windings
- Tap ratios
- Minimum and maximum tap position limits
- Number of tap positions
- Tap setting at which the transformer will be operated
- Regulated bus (where applicable)
- Ratings (normal and emergency at 104^0F, 70^oF, 23^oF, 60^oF and 50^0F)[4]
- In-Service status (in-service dates for new or replaced GSUs)
- Test Report for the transformer

4.1.1.3.4 In-Service Status of Generator Step-Up Transformers from the GO

[4] See the LG&E/KU Generator Owner FAC-008 Methodology for details of rating definitions and LG&E/KU Planning Guideline for how ratings are used.

For new generator step-up transformers expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

If an outage of a generator step-up transformer is expected lasting longer than six months and is scheduled within the Near-Term or Long-Term Transmission Planning Horizon, the dates of the scheduled outages must accompany the data request.

4.1.1.4 AC Transmission Line or Circuit Required from the TO

The group that performs LG&E and KU TP functions are the same group that performs LG&E and KU PC functions. Therefore, LG&E/KU PC has access to all the same data for AC Transmission lines owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities, and other companies with facilities connected to the LG&E/KU system (excluding tie lines), is required.

A data request to update the AC transmission line data is sent to the TO from the PC. The updated data must include:

- Positive sequence impedance parameters
- Susceptance (line charging)
- Ratings (normal and emergency at ambient air temperatures at 104^0F, 70^oF, 23^oF, 60^oF and 50^0F)

All impedance data is in per unit, and the voltage and volt-ampere base of the per unit impedances must be specified, unless otherwise noted.

If there are no changes to the AC Transmission Line data, an email from the TO to the PC must indicate that there are no changes to the AC Transmission Line data.

4.1.1.4.1 In-Service Status of Transmission Lines Required from the TO

A list of the scheduled transmission outages lasting longer than six months planned in either the Near-Term or Long-Term Transmission Planning Horizons must be supplied annually to the PC. The transmission facilities include transmission lines, transformers, protection system and reactive compensation (shunt capacitors and reactors). Emergency or unplanned outages should not be included in this data submittal. If there are no scheduled transmission outages lasting longer than six months in the Near-Term or Long-Term Transmission Planning Horizons, the entity must respond that there are no planned transmission line outages lasting longer than six months.

For new transmission lines expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the expected in service dates of the new facilities must be supplied with the data submittal.

4.1.1.5 DC Transmission systems Required from the TO

LG&E/KU has no DC facilities within the LG&E -PC. For new DC transmission systems expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

4.1.1.6 Transmission Transformers (voltage and phase shifting) Required from the TO

The group that performs LG&E and KU TP functions are the same group that performs LG&E and KU PC functions. Therefore, LG&E/KU PC has access to all the same data for transmission transformers owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

The PC will send a data request annually requesting an update of the transmission transformer data. Transmission transformers are those transformers with a low-side voltage greater than 50 kV. The data required must include:

- Nominal voltages of windings including high side, low side and tertiary windings.
- Positive Sequence Impedances
- Tap ratios
- Minimum and maximum tap position limits
- Number of tap positions
- Tap setting at which the transformer will be operated
- Regulated bus is required for Automatic Load Tap Changing (LTC) Transformers
- Ratings (normal and emergency at 104^0F, 70^oF, 23^oF, 60^oF and 50^0F)

All impedance data is in per unit, and the MVA base of the per unit impedances must be specified, unless otherwise noted. Manufacturer Test Reports may be provided instead of calculated impedance data.

4.1.1.6.1 In-Service Status of Transmission Transformers from the TO

For new transmission transformers expected to be in service within the Near-Term or Long-Term Transmission Planning Horizon, the in service dates of the new facilities must be supplied with the data submittal.

If an outage of a transmission transformer is expected lasting longer than six months and is scheduled within the Near-Term or Long-Term Transmission Planning Horizon, the dates of the scheduled outages must accompany the data request. If there are no scheduled transmission outages lasting longer than six months in the Near-Term or Long-Term Transmission Planning Horizons, the entity must respond that there are no planned transmission transformer outages lasting longer than six months.

4.1.1.7 Reactive Compensation (shunt capacitors and reactors) Required from the TO

The group that performs LG&E and KU TP functions are the same group that performs LG&E and KU PC functions. Therefore, LG&E/KU PC has access to all the same data for reactive compensation devices owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

The TO is required to supply data for the reactive compensation equipment that is connected to the transmission system in the LG&E/KU BA. The reactive compensation data required includes:

- Admittances
- Regulated voltage band limits
- Mode of operation
- Voltage set points (turn on/off voltages)
- Regulated bus

4.1.1.7.1 In-Service Status of Reactive Compensation Devices from the TO

For new reactive compensation devices expected to be in service within the Near-Term or Long-Term Transmission Planning Horizon, the in service dates of the new facilities must be supplied with the data submittal.

In an outage of a reactive compensation device is expected lasting longer than six months and is scheduled within the Near-Term or Long-Term Transmission Planning Horizon, the dates of the scheduled outages must accompany the data request.

4.1.1.8 Static VAR Systems Required from the TO

LG&E/KU has no static VAR systems within the BA. For new static VAR systems expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

4.1.1.9 Other information Requested by the PC for Steady State Models

Additional information not specified in MOD-032-1 Attachment 1 is also required.

- **Expected generation dispatch order (Economic merit order) Required from the RP**
  An Excel workbook template will be provided with the PC data request to the RP annually. The schedule required for the data will be supplied in the annual data request. The request will address each seasonal scenario required including winter peak, summer peak, off-peak and spring light load throughout the Near-Term and Long-Term Transmission Planning Horizons.

- **Scheduled transactions (Firm) Required from the RP**
  A list of the TSRs associated with purchases of resources must be submitted from the RP to the PC annually. An Excel template will be provided from the PC to the RP with the annual data request. A schedule for the required data is included in the data request. The request will address each seasonal scenario, in the Near-Term and Long-Term Transmission Planning Horizons in the load data request made to the RP. The scheduled firm transactions for this data request only include transmission of generation into, out of, or within the LG&E/KU PC.

  See Attachment 4 for an example Scheduled Firm Transactions template.

4.1.2 Part 1.2.1 Steady State Data Format

The annual data request to the LSE, GO, TO and RP will include forms or templates provided from the PC with the data request as described in 4.1.1 above. Examples of the forms and/or templates are shown in Attachments 1 through 4 of this document.

System topology, line impedance and transformer parameters (other than ratings) are maintained by the TP in a PSS/E model which represents up-to-date current system configuration. Data represented in the model is taken from electronic and hard copy records maintained by the TO and PC. When revised or new facilities are expected to occur within the Near-Term or Long-Term Transmission Planning Horizons, a list of those changes must be supplied to the PC from the TO/TP with the expected in-service or revision dates.

4.1.3 Part 1.2.2 Steady State Model Level of Detail

Networked Transmission System data described in 4.1.2 at 69 kV and above, are required for all transmission substations within the LG&E/KU PC. In some areas, 34.5 kV system may be modeled. Load delivery point buses will typically be represented at the point of connection to the transmission network, however delivery points that are very near to each other may be combined and represented as an equivalent bus. Generation data in required for all generators expected to supply power to the transmission system above 50 kV.

4.1.4 Part 1.2.3 Steady State Model Case Types or Scenarios

As a minimum the forecasted steady state model data required includes the following:

- 104°F for Year One
- 23°F for Year One
- 70% of 104°F for one of the Near-Term Planning Horizon years[5]
- light load for
- 104°F for year five
- 23°F for year five
- 104°F year ten
- 23°F for year ten

[5] The exact year detail will be included in the annual data request

- Spring and fall models may also be requested if the NERC Eastern Interconnect model building group requests those seasons.

The exact years will be included in the annual request for data sent by the LG&E/KU PC to the entities.

The off-peak model is any time that is not a peak as defined by NERC. The off-peak model can be either the shoulder, fall, spring, spring light load scenarios etc. The exact requirements of the off-peak data required will be included in the annual request for data sent by the LG&E/KU PC to the entities.

Additional scenarios can include an extreme weather model which will be included in the annual data request sent by the LG&E/KU PC to the entities.

A 50/50 load forecast represents a 50% probability that the actual load will be above this forecast and 50% of the time it is below this forecast. A 90/10 load forecast represents more extreme weather and has a 10% probability that the actual load is above this forecast and 90% probability that the actual load is below this forecast.

A shoulder model are70% of the 104ºF 50/50 loads.

Fall model is a peak expected to occur during the fall months. A spring is a peak expected to occur during spring months.

A spring light load forecast is the lowest load expected. It represents 2:00 am on a mild spring day.

4.1.5 Part 1.2.4 Steady State Model Schedule for submission of data

The schedule for submitting steady state data is discussed in each section above. In general there is an annual data request which contains the schedule required from the PC. The data request also includes an email distribution list (NERC.mod-32-steadystate@lge-ku.com) for supplying the data to the LG&E/KU PC. All data submittals for MOD-032 steady state data must be sent to this email distribution list.

4.1.6 Part 1.3 Steady State Specifications for Distribution or Posting of the Data Requirements and Reporting Procedures

This LG&E/KU PC MOD-032-1 Procedure document is posted on OASIS prior to the effective date. Additionally, all annual data requests for MOD-032 are emailed and posted on OASIS with the schedule and/or due dates of the required data.

4.2 R1 Dynamics Model Data Reporting Requirements

4.2.1 Part 1.1 Data Reporting Requirements (MOD-032-1 Attachment 1) Dynamics

The annual dynamics data request will be sent to the GOs in the spring of each year with a request to update the data per the schedule in the data request. A spreadsheet showing the existing dynamics data for each generator is supplied along with the data request. An example of the spreadsheet is shown in Attachment 5.

4.2.1.1 Dynamics Generator Data Requirements from the GO

The dynamics data as listed in MOD-032-1 Attachment 1 must have a valid generator model which includes the following:

Unit Ratings:

- kVA
- Voltage
- Power Factor
- Speed (RPM)
- Short circuit ratio
- Stator Amperes at Rating kVA
- Max Turbine MW
- Connection (e.g. Wye)
- Frequency, (Hz)
- Field Volts

Combined Turbine-Generator-Exciter Inertial Data

- Inertial Constant
- Moment-of-Inertia,

Reactance Data (PER UNIT RATED KVA)

- Synchronous - saturated
- Synchronous - unsaturated
- Transient - saturated
- Transient – unsaturated
- Subtransient - saturated
- Subtransient - unsaturated
- Zero Sequence – saturated
- Zero Sequence – unsaturated
- Leakage Reactance

FIELD TIME CONSTANT DATA (SEC)

- Open Circuit
- Three-Phase Short Circuit Transient
- Line to Line Short Circuit Transient
- Line to Neutral Short Circuit Transient
  - Short Circuit Subtransient
  - Open Circuit Subtransient

ARMATURE TIME CONSTANT DATA (SEC)

- Three Phase Short Circuit
- Line to Line Short Circuit
- Line to Neutral Short Circuit

NOTE: If requested information is not applicable, indicate by marking "N/A."

MW CAPABILITY AND PLANT CONFIGURATION

LARGE GENERATING FACILITY DATA

ARMATURE WINDING RESISTANCE DATA (PER UNIT)

- Positive R_1
- Negative R_2
- Zero R_0

- Rotor Short Time Thermal Capacity
- Field Current at Rated kVA, Armature Voltage and PF
- Field Current at Rated kVA and Armature Voltage, 0 PF
- Three Phase Armature Winding Capacitance
- Field Winding Resistance
- Armature Winding Resistance (Per Phase)

CURVES

Provide Saturation, Vee, Reactive Capability, Capacity Temperature Correction curves. Designate normal and emergency Hydrogen Pressure operating range for multiple curves.

4.2.1.2 Dynamics Excitation System Data Requirements from the GO

Identify appropriate IEEE model block diagram of the excitation system for computer representation in power system stability simulations and the corresponding excitation system constants for use in the model.

If a user-defined model is being used, a .flx code, object file, and diagram with associated constants must be provided.

4.2.1.3 Dynamics Governor Data Requirements from the GO

Identify appropriate IEEE model block diagram of the governor system for computer representation in power system stability simulations and the corresponding governor system constants for use in the model.

If a user-defined model is being used, a .flx code, object file, and diagram with associated constants must be provided.

4.2.1.4 Dynamics Power System Stabilizer Data Requirements from the GO

Identify appropriate IEEE model block diagram of power system stabilizer (PSS) for computer representation in power system stability simulations and the corresponding PSS constants for use in the model.

If a user-defined model is being used, a .flx code, object file, and diagram with associated constants must be provided.

4.2.1.5 Dynamics Demand Data Required from the LSE

Per MOD-032-1 Attachment 1 under the dynamics column requirement 5: The LSE is to provide demands or load in MW and MVAR values. This is also required for the steady-state column requirement 2. The LSE is not required to re-submit demand data if the LSE provided this for the steady state model.

Per MOD-032-1 Attachment 1 dynamics column requirement 8: If the LSE has Static VAR Systems or FACTS devices, dynamics data will be required. However, there are no Static VAR systems or FACTS devices in the LG&E/KU PC area.

Per MOD-032-1 Attachment 1 dynamics column requirement 10: At this time no other dynamics data is being requested of the LSE.

4.2.1.6 Dynamics Wind Turbine Required from the GO

The following are dynamic data required for wind turbines:

- Quantity of generators to be interconnected at the same interconnection point on the transmission system.
- Elevation
- Single Phase or Three Phase
- Inverter manufacturer, model name, number, and version
- List of adjustable set points for the protective equipment or software

Note: A completed Siemens PSS/D data sheet must be supplied with the data. If other data sheets are more appropriate to the proposed device, then they shall be provided to the PC as part of the data request.

4.2.1.7 Dynamics Photovoltaic Required from the GO

The following photovoltaic systems modeling data should be provided in Siemens PSS/E dyre format. If other data sheets are more appropriate to the proposed device, then they shall be provided.

- PVGU: Power converter/generator module
- PVEU: Electrical control module
- PANEL: Linearized module of a panel's output curve
- IRRAD: Linearized solar irradiance profile
- Diagrams for PVGU and PVEU

4.2.1.8 Dynamics Static Var Systems and Facts Required from the LSE

There are no Static Var Systems and/or Facts devices within the LG&E/KU PC area, therefore this data is not required.

4.2.1.9 Dynamics DC System Required from the TO

There are no DC Systems within the LG&E/KU PC area, therefore this data is not required. For new DC transmission systems expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

4.2.1.10 Other Information Required for Dynamics Models

For Induction Generators, additional data is required.

- Field Volts
- Field Amperes
- Motoring Power (kW)
- Neutral Grounding Resistor (If Applicable)
- I_2^2t or K (Heating Time Constant)
- Rotor Resistance
- Stator Resistance
- Stator Reactance
- Rotor Reactance
- Magnetizing Reactance
- Short Circuit Reactance
- Exciting Current
- Temperature Rise
- Frame Size
- Design Letter
- Reactive Power Required In Vars (No Load)
- Reactive Power Required In Vars (Full Load)
- Total Rotating Inertia in Per Unit on KVA Base

4.2.2 Part 1.2.1 Dynamics Data Format

The dynamics data must be supplied in Siemens PSS/E data format. The annual data request will include the previous year's dynamic data. With a request to update the data or indicate that there are no changes to the dynamics data. Spreadsheets with existing dynamics data is supplied to each GO with the annual data request.

4.2.3 Part 1.2.2 Dynamics Level of Detail Equipment Should Be Modeled

All generators interconnect to the LG&E/KU BA that will deliver power to the transmission system must supply dynamics model data to the LG&E/KU PC.

4.2.4 Part 1.2.3 Dynamics Case Types or Scenarios to be Modeled

In general the dynamics data does not change as a result of seasons or load scenarios. Dynamics models are built for the following seasons and forecasted periods.

- 104°F for Year One
- 23°F for Year One
- spring light load for one of the Near-Term Planning Horizon years[6]
- generation maximization for Year One
- 104°F for year five
- 23°F for year five
- generation maximization for year five
- 104°F year ten
- 23°F for year ten

A generation maximization model turns all generation on within the LG&E/KU BA and excess generation is exported out of the LG&E/KU BA.

In general the dynamics data does not change unless there are material modifications to the generator and associated equipment. When material modifications of generation are forecasted resulting in changes to the dynamics data, those must be submitted to the PC with the dates of the expected changes.

4.2.5 Part 1.2.4 Dynamics Data Schedule for Submission of Data

The request for updates of the dynamics data will be sent to the entities in the spring of each year. The dynamics data request will include the exact date the data is due but in general it will be two months after the data request is sent to the GOs. If there are no forecasted changes to the dynamics data, the entity must notify the PC using the NERC.mod-32-stab@lge-ku.com distribution list that there are no changes to the dynamics data in the Near-Term or Long-Term Transmission Planning Horizons. The data submittal has to be sent to the distribution list specified in the data request which is NERC.mod-32-stab@lge-ku.com.

[6] The exact year detail will be included in the annual data request

4.2.6 Part 1.3 Dynamics Specification for Distribution or Posting of Data Requirements and Reporting Procedures

This LG&E/KU Planning Coordinator MOD-032-1 Procedure document is posted on OASIS prior to the effective date. Additionally, all annual data requests for MOD-032 are emailed and posted on OASIS with the schedule and/or due dates of the required data.

4.3 R1 Short Circuit Model Data Reporting Requirements

4.3.1 Part 1.1 Data Reporting Requirements (MOD-032-1 Attachment 1) Short Circuit

The annual short circuit data request will be sent to the entities each year with a request to update the data per the schedule in the data request. The short circuit model is provided along with the data request. After the entity has reviewed the existing short circuit model and if there are no changes required, the entity must send a response before the scheduled due date that the data was reviewed and there are no required changes. If there are changes required, the changes must be supplied to the PC per the data request.

4.3.1.1 Bus Data Required from the TO

The group that performs LG&E and KU TP functions are the same group that performs LG&E and KU PC functions. Therefore, LG&E/KU PC has access to all the same data for bus data as the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

The TO is responsible for supplying the bus data with bus numbers and nominal voltage. A list of the existing short circuit bus data is supplied to the TO in the annual data request, with a request to update this data. If there are no changes to the bus data, a response from the TOto the PC must indicate that there are no changes to the existing data. The bus number for the short circuit model is different from the steady state model.

4.3.1.2 Aggregate Demand Required from the LSE

The short circuit modeling is not dependent on the aggregate demand. Therefore, no aggregate demand data is required for the short circuit model.

4.3.1.3 Generator Data Required from the GO

The GO must supply generator data for short circuit models to the LG&E/KU PC. These records include:

- Subtransient resistance and reactance
- Transient resistance and reactance
- Synchronous resistance and reactance
- Negative sequence resistance and reactance
- Zero sequence resistance and reactance

All impedance data is in per unit, and the voltage and volt-ampere base of the per unit impedances must be specified.

4.3.1.4 Generator Step Up Transformers Data Required from the GO

The GO must supply generator step up transformer data for short circuit models to the LG&E/KU PC. These records include:

- Nominal voltages of windings
- Winding configuration (e.g. delta/wye, wye/wye, auto)
- Positive sequence resistance and reactance between all loadable windings, in accordance with IEEE Standard C57.12.90-2006
- Zero sequence resistance and reactance, in accordance with IEEE Standard C57.12.90-2006
- Available tap ratios
- Minimum and maximum tap position limits
- Number of tap positions
- In-Service status (in-service dates for new or replacement transformers)
- Transformer test report

All impedance data is in per unit, and the voltage and volt-ampere base of the per unit impedances must be specified.

4.3.1.5 AC Transmission Line or Circuit Required from the TO

The group that performs LG&E and KU TP functions are the same group that performs LG&E and KU PC functions. Therefore, LG&E/KU PC has access to all the same data for AC Transmission lines owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

The TO must supply AC transmission line data for short circuit models to the LG&E/KU PC. These records include:

- Positive and zero sequence resistance and reactance
- Mutual impedance data where there is more than one line in close proximity,
  - The to and from buses for each line involved
  - Mutual zero sequence resistance and reactance
  - Beginning and ending point of the mutual coupling for each line in percent of total for each line

All impedance data is in per unit, and the voltage and volt-ampere base of the per unit impedances must be specified, unless otherwise noted.

4.3.1.6 DC Transmission systems Required from the TO

LG&E/KU has no DC facilities. For new DC transmission systems expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

4.3.1.7 Transmission Transformers Required from the TO

The LG&E/KU PC has access to all the same data for transmission transformers owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

For the short circuit model, the following is required from the TO to the LG&E/KU PC.

- Nominal voltages of windings
- Winding configuration (e.g. delta/wye, wye/wye, auto)
- Positive sequence resistance and reactance between all loadable windings, in accordance with IEEE Standard C57.12.90-2006
- Zero sequence resistance and reactance, in accordance with IEEE Standard C57.12.90-2006
- Available tap ratios
- Minimum and maximum tap position limits
- Number of tap positions
- In-Service status (in-service dates for new or replacement transformers)
- Transformer test report

All impedance data is in per unit, and the voltage and volt-ampere base of the per unit impedances must be specified, unless otherwise noted.

4.3.1.8 Static Var Systems Required from the TO

LG&E/KU has no static Var systems. For new static Var systems expected to be in service within the Near-Term or Long-Term Transmission Planning Horizons, the in service dates of the new facilities must be supplied with the data submittal.

4.3.1.9 Other Information Requested by PC Necessary for Short Circuit Modeling

4.3.1.9.1 Circuit Breakers Required from the TO

The LG&E/KU PC has access to all the same data for transmission transformers owned by the LG&E/KU TO. Therefore, LG&E/KU PC has access to all the same data for circuit breakers owned by the LG&E/KU TO. Therefore, a data request from the PC to the LG&E/KU TO is not required. The data request from LG&E/KU PC to the municipal utilities is required.

Circuit breaker data is required for the development of the short circuit models. This data includes:

- Rating method (symmetrical or total current).

- Rated short circuit amps or MVA.
- Maximum design voltage.
- Operating voltage.
- Interrupting time in cycles.
- K factor.
- Reclosing settings.
- Interrupting medium.

4.3.2 Part 1.2.1 Short Circuit Data Format

The short circuit model is maintained in ASPEN. Data submission must be in a format suitable for entry into ASPEN; a native .olr binary file, an ASPEN .dxt text data file, or a human readable text based document with the required data parameters.

4.3.3 Part 1.2.2 Short Circuit Level of detail to which equipment will be modeled

The short circuit model data is required for facilities operated 69 kV and higher within the LG&E/KU BA. Data is required for all generators contributing fault current to the Transmission System, regardless of connection voltage, as well as the Generator Step Up transformers (GSU's) and connection facilities. Short circuit data is required for all Transmission lines operated at 69 kV and higher. Data is required for any transformer with high and low side voltages of 69 kV and higher, and any transformers with low side voltages lower than 69 kV with a path for zero sequence current in their models.

4.3.4 Part 1.2.3 Short Circuit Case Types or Scenarios to be Modeled

Short circuit models are developed annually for Year One and year five. These need to include updates to any of the equipment listed in Section 4.3.1 for the forecasted period of Year One and year five.

4.3.5 Part 1.2.4 Short Circuit Schedule for submission of data

An annual data request will be sent in the spring to the entities required to submit short circuit data. Included in the data request will be an ASPEN short circuit model. The entities are requested to review the short circuit models and make any required changes. A list of the changes made to the models must accompany the short circuit data submittal and sent to the NERC.mod-32-sc@lge-ku.com distribution list. If there are no changes to the short circuit model, an email to must be sent to NERC.mod-32-sc@lge-ku.com stating that there are no changes to the short circuit model.

4.3.6 Part 1.3 Short Circuit Specifications for Distribution or Posting of Data Requirements and Reporting Procedures

This LG&E/KU PC MOD-032-1 Procedure document is posted on OASIS prior to the effective date. Additionally, all annual data requests for MOD-032 are emailed to the entities and posted on OASIS with the schedule and/or due dates of the required data.

5 Internal Controls

A checklist maintained by the LG&E/KU PC is used to ensure that all data requests have been sent out at least once every 13 calendar months. The checklist includes the dates at which each entity supplied the required data. If the data received required clarifications or revisions using a written request per MOD-032-1 R3, the date of the written request from the PC or TP is noted on the check list. The dates of any responses from the entity per MOD-032-1- R3 are included in the checklist. An example of the MOD-032-1 Internal Control Checklist is included as Attachment 6.

Attachment 1

Example Load Data Worksheet

PPL companies

Delivery Point Description (note 1)	KV	NERC Model Bus Number	NERC Model Bus Identification	NERC Model ID	Estimated Power Factor at Given Load (note 2)	Is Load Scalable? Yes or No (note 5)	Summer Peak Forecast - 50/50 probability (MW) (see note 3) (see note 4)											Comment
							2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	

Notes:

(1) Provide data at the connection point to the LG&E and KU Transmission System (Transmission Voltage Level).

(2) If Power factor is expected to change over requested time horizon, insert columns (left of applicable year column) and power factor as appropriate.

(3) If the forecasted load includes DSM, indicate the amount in MW on separate tab.

(4) Indicate how much load is interruptible in MW during emergency or peak conditions on separate tab.

(5) Indicate if the load can be scaled to simulate special conditions.

Attachment 2

Example Generation Data Request Forms

PPL companies

Example of ambient temperature related Generator Data

							Gross MW Maximum Capability											Gross MVAR Maximum Capability (@ MW Maximum Capability)											Gross MW Minimum Capability											Gross
Known Available Units	EIA Plant Code	NERC Model Bus Number	NERC Model Bus Identification	NERC Model ID	Unit Type	MVA Base	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2016	2017	20
Brown #1	1355	324000	1BROWN 1 13.800	1																																					
Brown #2	1355	324001	1BROWN 2 18.000	2																																					

Example of Auxiliary Load Data

	Insert more rows where needed	MW Auxiliary Load (Normal Operations)											MVAR Auxiliary Load (Normal Operations)										
Known Available Units	Auxiliary Load(s) Connection Point(s)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Brown #1																							
Brown #2																							

Example of Balance of Plant Load Data

	Insert more rows where needed	MW Auxiliary Load (Normal Operations)											MVAR Auxiliary Load (Normal Operations)										
Plant Site	Balance of Plant Connection Point(s)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Brown Plant																							

Attachment 4

Example Scheduled Firm Transactions Template By Season

Description	OASIS Reference Number	Source	Sink	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026

Attachment 5

Example of Dynamics Data Spreadsheet

Generator Name:
Mbase = 133.7

Example of a Generator Model Data

GENROU Model

CONs	#	Value	Description	New Value from Generation	Comments on why making the change
J		8.512	T'do (>0) (sec)		
J + 1		0.062	T''do (>0) (sec)		
J + 2		0.946	T'qo (>0) (sec)		
J + 3		0.096	T''qo (>0) (sec)		
J + 4		4.58	H, Inertia		
J + 5		0	D, Speed damping		
J + 6		1.7235	Xd		
J + 7		1.6696	Xq		
J + 8		0.2101	X'd		
J + 9		0.319	X'q		
J + 10		0.1207	X''d = X''q		
J + 11		0.12	Xl		
J + 12		0.225	S(1.0)		
J + 13		0.682	S(1.2)		

Example of an Exciter Model

ESDC2A Model

CONs	#	Value	Description	New Value from Generation	Comments on why making the change
J		0.01	TR (sec)		
J + 1		300	KA		
J + 2		0.01	TA (sec)		
J + 3		0	TB (sec)		
J + 4		0	TC (sec)		
J + 5		4.95	VRMAX or zero		
J + 6		-4.95	VRMIN		
J + 7		1	KE or zero		
J + 8		1.33	TE (>0) (sec)		
J + 9		0.1	KF		
J + 10		0.675	TF1 (>0) (sec)		
J + 11		0	Switch		
J + 12		3.05	E1		

J + 13		0.279	SE(E1)		
J + 14		2.29	E2		
J + 15		0.117	SE(E2)		

TGOV1 Model

Example of a Governor Model

CONs	#	Value	Description	New Value from Generation	Comments on why making the change
J		0.05	R		
J + 1		0.49	T1 (>0) (sec)		
J + 2		1.01	VMAX		
J + 3		0	VMIN		
J + 4		3	T2 (sec)		
J + 5		9	T3 (>0) (sec)		
J + 6		0.02	Dt		

Attachment 6

Example of Internal Control Checklist

Transmission Expansion Plan Year:	

Company	Registered Entity	Data Type	Data Request Date	Date of Data Receipt	Any Technical Concerns (y/n)	Date of Written Notice of Technical Concern	Date of Response of Technical Concern
LG&E/KU	LSE	Temperature Demand					
LG&E/KU	RP	Temperature Generator					
LG&E/KU	GO	Auxiliary Load/ Balance of Plant					
LG&E/KU	RP	Dispatch Order					
LG&E/KU	RP	Firm Transaction					
LG&E/KU	GO	Generator Outage Data					
LG&E/KU	TO – Lines	Line Outage Data					
LG&E/KU	TO – Subs	Transformer Outage Data					
LG&E/KU	TO – Protection and Controls	Protection Outage Data					