Attachment H: Power System Modeling Data

Power System Modeling Data

Accurate power system modeling data is a key component of quality power system analysis. PJM System Planning uses a variety of models and analytical techniques to create and maintain the models used for the RTEP. The intended use of this Attachment is to supplement existing documentation by PJM and other entities that govern modeling data quality requirements. PJM will continue to follow the data quality guidelines and standards set forth by NERC as part of the MOD standards and the Eastern Interconnection Reliability Assessment Group (ERAG) Multiregional Modeling Working Group (MMWG) Procedural Manual.

Load Flow Analysis Models

Basecase creation is a collaborative process between PJM and its members. From a technical standpoint PJM follows the regulations set forth in the ERAG MMWG Procedural Manual. In the following sections, the logistics and transfer of information between PJM and its members are detailed.

Annual Updates

In the fourth quarter of each year, PJM will distribute to the Transmission Owners a current year +5 summer peak network model based on the most up to date MMWG case combined with the previous year's RTEP case. This draft case will contain all upgrades identified during the previous year's RTEP cycle. Within 4 weeks of receiving the initial draft network model, Transmission Owners will provide:

- Network updates to the model that will advance the case to represent a current year + 5 base case with respect to the 1st Quarter of the following year. This update should be reviewed for correctness and compatibility with the final version of the base case under development
- Complete NERC category B and C contingency file updates that correspond to the updated network model
- Maximum credible disturbance (NERC Category D) contingencies
- Any other significant changes such as new load or block load additions
- TO's may be asked to support the development of network models for additional years and demand levels for both near term (years 1 through 5) and longer term (beyond 5 years) analyses.
- Verification that all baseline, network and supplemental upgrades are included in the updated case along with a written description of any case modifications.

- Notification of any changes to tie lines whether they are ties internal to PJM or to external companies.

Generation Owner Requirements:

- Specific information regarding generator capability per MOD 10 and MOD 12

Load Flow Modeling Requirements

In addition to the guidelines set forth by NERC and the ERAG MMWG procedural manual, PJM uses several specific procedures in establishing the base case so that it represents the best starting point for the annual RTEP analysis.

Generator step-up transformers

Generator models should represent the physical plant lay-out to the extent possible, explicitly modeling generator step-up transformers (GSUs) and Station Service (aka Auxiliary loads) loads. This applies to units above 20 MW and connected to 100+ kV, consistent with BES requirements. Plants consisting of multiple units aggregating to 75 MW or more also require explicit representation of GSUs and station service loads.

Interchange

The PJM net interchange in the summer peak case is determined by the firm interchanges that are represented in the PJM OASIS system. The interchange in light load cases follows the light load criteria as defined in the Light Load Reliability Analysis in section 2.3.10 of this manual.

Generator Reactive Capability

Annually, PJM updates the model for the generator reactive capability (GCAP) of each generator based on data coordinated with PJM operations, this includes default limits obtained from the most up to date d-curves used in operations analysis as well as data provided by the Generator Owners.

Interconnection Projects With Interconnection Service Agreements (ISAs)

PJM includes queue projects with a signed ISA into the base case as well as verifying the accuracy of queue projects that have not yet signed their ISA. PJM also includes the interconnection, ratings and associated upgrades for each of these projects. Transmission Owners will verify the accuracy of the points of interconnection and the associated upgrades in their zones.

Real and Reactive Load

Each TO is responsible for modeling the real and reactive load profile in their zone. PJM will scale the load in the base case to the targeted values reported in the latest annual PJM load forecast report.

Real loads will be scaled uniformly in each zone to meet the PJM 50/50 load forecast less any Demand Response (DR), Energy Efficiency (EE), or Behind the Meter (BTM) generation as necessary. Real loads will also be scaled uniformly within each zone for off-peak analysis. Reactive load in each area will be scaled at a constant power factor along with the real load for peak load analysis. For off-peak analysis including light-load, PJM will provide a case for which each TO is responsible for updating the load profile for reactive load at their own discretion.

Any deviation from the above method of load modeling will be defined specifically in other sections of this document that describe specific test procedures such as the PJM Load Deliverability Procedure or the PJM Light Load Reliability Test Procedure.

PJM will coordinate with TOs on an individual basis to ensure that non-conforming loads are properly modeled and not uniformly scaled.

Voltage Schedules

The setting of voltage schedules is crucial to the robustness of cases. PJM allows Transmission Owners to supply generator voltage schedule data. If the data is not provided in accordance to the ERAG MMWG procedure manual, PJM will use the default voltage schedules as defined in PJM Manual 03.

Submittal of Load Flow Data

Acceptable Data Formats

- For PSS/E users, cases should be submitted to PJM in a ".SAV" format in a PSS/E version that is readable by the current version of PSS/E that MMWG is using.
- For users of PSLF or other modeling software, cases shall be submitted to PJM in a ".RAW" format that is PSS/E compatible and is readable by the current version of PSS/E that MMWG is using.
- PJM's migration of PSS/E versions may slightly lag MMWG, in that case it is acceptable to provide updates formatted for the current version that PJM is using.

Timing

Transmission Owners must comply with the schedule dictating the timeliness of the case creation process which will be included in the initial email sent to kick off the process. This schedule will include a minimum of 4 weeks to provide updates to the case and corresponding files for the first iteration, and 2 weeks for the second iteration.

Load Flow Data Quality

- In the event that data provided by Transmission Owners does not pass all of the testing included in the MMWG data checker, PJM may request updated data.

- Transmission Owners must provide unique bus names or circuit ID's for each winding of all transformers.

- Bus numbers must be within the allocated bus number range for each company.

- Conventions used for the naming of Machine ID's vary for different TO zones. PJM will coordinate with each TO individually to align with their preferred convention.

- Certain specific modeling and naming conventions which must be followed by all TO's include:

    - High/Low Pressure units should be modeled on the same bus and designated with the corresponding machine ID "H" and "L".
    - No other machine ID should be named "H" or "L".
    - With the exception of High/Low Pressure units, multiple machines modeled on the same bus must have the same status. Offline machines should not be modeled on the same bus as machines which have a status of online.
    - Machines at the same plant with different statuses should be modeled on separate busses connected by a very low impedance line (X=.002) as defined in the MMWG manual.

Short Circuit Analysis Models

Short Circuit data procedures are documented in the Attachment G.7 of this manual, which references ANSI/IEEE 551. The intended use of this attachment is to supplement these procedures and outline the data requirements which PJM follows in creating the short circuit cases used for analysis.

- Short circuit models should be provided in Aspen ".olr" format, if possible.
    - At the time of this writing, CAPE and PSSE users can't accommodate this requirement.
- All the TO provided Aspen ".OLR" cases should model only their own TO area and their tie lines. No outside areas should be included in the submission.
- All area numbers in the TO provided cases should be consistent with MMWG designated area numbering convention. Area numbers such as 1, 2, 3, etc. are not acceptable.
- All TO provided Aspen ".OLR" cases should have all TO circuit breakers rated above 100 kV modeled in the case.
- Generation owners must submit to PJM all their breaker data for breakers rated above 100 kV.
- TOs must submit an excel sheet containing explanations for outaged and out-of-service equipment that is normally in-service

Timing

In the 1st quarter of each year, PJM will send the Transmission Owners an initial current year +5 impedance network model. This case is based on the most up to date PJM short circuit case combined with the previous year's RTEP case containing all upgrades, MTX projects, and generation queue projects in the Facility Studies Phase that have been identified during that RTEP cycle.

In the 4th quarter of each year, PJM will send the Transmission Owners an initial current year +1 impedance network model. This case is based on the most up to date PJM short circuit case combined with the previous year's RTEP case containing all upgrades, MTX projects, and generation queue projects in the Facility Studies Phase that have been identified during that RTEP cycle.

Transmission Owners must comply with the schedule dictating the timeliness of the case creation process which will be included in the initial email sent to kick off the process. This schedule will include a minimum of 4 weeks to provide updates to the case and corresponding files. Once all cases and corresponding files have been submitted to PJM, a +1 case is created and analysis performed to determine overdutied breakers. TOs are then given another 4 weeks to confirm any new overdutied breakers. After the +1 year short circuit case is finalized, the +1 year case is then used to create the+5 year short circuit case where analysis is performed and sent out to TOs with 4 weeks to address any new system issues.

Stability Analysis Models

The case used for stability and dynamic studies is developed by PJM based on information from the Regional Transmission Expansion Plan (RTEP) case prepared by PJM Interconnection and the MMWG case prepared by Powertech Labs for the Eastern Interconnection Reliability Assessment Group (ERAG).

When preparing the base case for stability and dynamics, the ERAG case provides the information for the areas outside PJM while the RTEP case provides the PJM information (e.g. load forecast, network configuration). When combining the ERAG and the RTEP cases, care should be taken to preserve the ties between the PJM areas and the rest of the Eastern Interconnection.

All of the projects active in the PJM queue process that have been studied must be included in the base case for stability and dynamics. In some instances, the RTEP model for the queue project may not be detailed enough for use in stability studies. In this situation, the case must be updated to make sure that all detailed components are included in the stability and dynamics power flow model (e.g. generator step-up transformer, loads).

In addition to updating the power flow case with the latest network information, the dynamic models must also be updated to reflect the changes introduced by the RTEP case and the stability and dynamic studies performed by PJM. In this regard, the dynamic data file from the ERAG MMWG case is updated so that the dynamic models for the machines in the PJM areas are matched against the new power flow information from the RTEP. The dynamic model for each queue project must also be added to the dynamic data file.

The resulting power flow case, the dynamic data file and supporting files required for a complete stability and dynamics base case need also to be correlated and reviewed to determine inconsistencies as well as missing or questionable data. A base case is considered to be finished when, after the review, it compiles, links the models to the PSS/E main structure and initializes correctly. An acceptable base case must also show no deviations from the initial conditions for any simulation setup with no disturbances applied to the system.

Timing

In the first quarter of each year, PJM will build stability cases based on the latest RTEP power flow model and the latest ERAG dynamic cases. In this period, PJM will request the Transmission Owners for load models for dynamic studies, and for other supporting data if necessary. Transmission Owners must comply with the schedule dictating the timeliness of the stability case creation process which will be included in the initial email sent to kick off the process.

Stability and dynamics base cases:

Stability is assessed using a summer peak load and a light load condition. The summer peak stability case has the load profile of the RTEP summer peak case and corresponds to the demand expected to be served in the specific planning year. The light load stability case represents 50% of the summer peak load and is developed by scaling down the summer peak load case at the same power factor.

For simplicity, it is recommended to first build the summer peak case and then update that case to reflect the second load condition (light load). This approach provides two cases that are common in bus numbers and network information. Updates to both cases, such as addition or removal of proposed lines or queue projects would be easy to handle due to the uniformity.

After the powerflow case has been finalized and revised, the dynamic data file from the dynamic data file will be updated to reflect the changes that were introduced by the addition of the PJM areas from the RTEP case and generation interconnection studies. It is important to note that the RTEP case and the ERAG case complement each other. RTEP case information is used for future generation queue projects and transmission upgrades which don't exist in the ERAG case and ERAG case information is used for existing units/

The light load case (50% peak) is derived from the summer peak case. This approach ensures consistent bus numbers and network information in both cases, making addition or removal of proposed lines or queue projects easy to handle. After the summer peak case is completed, the PJM load is scaled down to a load representing 50% of the 50/50 load. The areas outside PJM are updated with the light load case from the corresponding ERAG MMWG case. Note that generation and shunt capacitors may be turned off or disabled in order to achieve convergence of the power flow. In addition, all pumped storage hydro units are modeled in the pumping mode with their governors and power systems stabilizers deactivated or adjusted to reflect the appropriate operating condition.

TO Responsibilities:

- Provide necessary supporting data for stability case build upon PJM's request including but not limited to: topology information and dynamic modeling and station loads
- Provide station loads, including power factors and load representation data (CONL file) if the load representation is different from the one in the ERAG MMWG series
- Verify upgrades and generator modeling (MVA base & Topology)

If there is any discrepancy between the RTEP case and the ERAG MMWG case for existing units, PJM will follow up with the Transmission Owner to insure that the most current data is used.

A complete base case (summer peak or light load) must include at least:

- A power flow file: This file contains the network information and provides the initial conditions for the dynamic models.
- A dynamic data file: This file contains all the information necessary to simulate the dynamic response of the various system components.
- A gnet file: This file contains the information of those generators that do not have a dynamic model. Any generator listed in this file is considered as a negative MVA load.
- A conl file: This file indicates how loads will be modeled based on a combination of constant MVA, constant current and constant admittance. It is strongly recommended that each TO develop more accurate load representation for stability and dynamics studies

Dynamics Data Submittal Requirements and Guidelines:

The Multiregional Modeling Working Group (MMWG) provides the following topics pertaining to dynamics data submittal requirements and guidelines. This information is accessible in Appendix II of the MMWG Procedure Manual V5. A hyperlink to the manual is located at the bottom of this section.

- Power Flow Modeling Requirements
    - Bus name identifiers for synchronous condensers, Static VAr Compensators (SVCs) modeled as generators, switched shunts, relays, and HVDC terminals.
    - Step-up transformer representation requirements for both MMWG power flow cases and non-MMWG power flow cases.
    - Resistance and reactance data placements for step-up transformers represented in the power flow generator data records.
    - Xsource value representations in the power flow generator data record.
    - SVC representation requirements in power flows.

- Dynamic Modeling Requirements
    - Synchronous generator and condenser modeling / associated data requirements and exceptions.
    - Additional representation requirements and exceptions for synchronous generators and condensers modeled as described in Requirement II.1.
    - PSS/E modeling requirements for any other types of generating units and dynamic devices.
    - Exceptions to the use of standard PSS/E dynamic models.
    - Required written documentation and its submittal procedures for user-defined modeling in MMWG cases.
    - Generating unit, synchronous condenser, and other dynamic device requirements for netting.
    - Lumping conditions of similar or identical generating units at a plant.
    - Location requirements for per unit data.
    - Exception procedure for any requirements listed.
- Dynamics Data Validation Requirements
    - Dynamics data screening requirements
    - Preliminary procedures to undergo before regional data submittal to the MMWG coordinator.
    - Material required by each region to test the validity and stability of the dynamics model.
- Guidelines
    - Additional documentation that should be submitted with dynamics data.
    - Information pertaining to parameters for representing loads via the PTI PSS/E CONL activity that the regions should provide to the MMWG.

Location of MMWG Procedural Manual:

https://rfirst.org/reliability/easterninterconnectionreliabilityassessmentgroup/mmwg/Documents/