accelerated or modified and meet the Market Efficiency Benefit/Cost criteria as explained in accompanying sections of this Manual 14B.

Long-term Market Efficiency planning is also completed as part of the development of the RTEP to identify solutions that require longer lead times to implement. As part of the 24-month Market Efficiency planning cycle, PJM initially develops a base case for years 1, 5, 8, 11, and 15 that are used to evaluate congestion for the long-term planning horizon. A higher level base case is developed for year 15 and may require a less detailed model of the transmission system below the 500 kV level as explained in section 2.6.5 of this manual. Proposed solutions to address Market Efficiency projected congestion are developed by stakeholders and PJM staff during the first year of the 24-month planning cycle. As shown in Exhibit 3, during the second year of the 24-month cycle, the base cases used for the long-term analysis during the first year (i.e., now year 0, 4, 7, 10, and 14) will be updated, as appropriate, to reflect the latest assumptions regarding load, generation, demand response, energy efficiency, transmission topology, or other input assumptions.

Congestion issues identified during the first year are validated and the proposed solutions are refined during the second year of the 24-month cycle. An independent consultant may be used to develop a cost estimate and evaluate the constructability of proposed solutions. Results from these long-term analyses are reviewed with the Transmission Expansion Advisory Committee throughout the 24-month planning process, and, ultimately, presented to the PJM Board of Managers for approval.
2.3.6 Baseline Thermal Analysis

Baseline thermal analysis is a thorough analysis of the reference power flow to ensure thermal adequacy based on normal (applicable to system normal conditions prior to contingencies) and emergency (applicable after the occurrence of a contingency) thermal ratings specific to the Transmission Owner facilities being examined. It is based on a 50/50 load forecast from the latest available PJM Load Forecast Report (50% probability that the actual load is higher or lower than the projected load.) It encompasses an exhaustive analysis of all NERC P0-P7 events and the most critical common mode outages. Final results are supported with AC power flow solutions. The PJM Load Forecast uses a 50/50 distribution minus Energy Efficiency. Demand Response is not considered in the Load Forecast.

For normal conditions (NERC P0), all facilities shall be loaded within their normal thermal ratings. For each single contingency (NERC P1), all facilities shall be loaded within their emergency thermal ratings. After each single contingency and allowing phase shifter, re-dispatch and topology changes to be made, post-contingency loadings of all facilities shall be within their applicable normal thermal ratings.

For the more severe NERC P2, P3, P4, P5, P6 and P7 contingencies, along with only transformer tap and switched shunt adjustments enabled, post-contingency loadings of all facilities shall be within their applicable emergency thermal ratings as required by the PJM or the Transmission Owner planning criteria. The study procedure for the NERC P3 and P6 contingencies (N-1-1) is described in detail in section 2.3.8.

2.3.7 Baseline Voltage Analysis

Baseline voltage analysis parallels the thermal analysis. It uses the same power flow and examines voltage criteria for all the same NERC P0, P1, P2, P3, P4, P5, P6 and P7 events. Also, voltage criteria are examined for compliance. Analysis will simulate the expected automatic operation of existing and planned devices designed to provide steady state control of electrical system quantities when such devices impact the study area. Those devices may include equipment such as phase-shifting transformers, load tap changing transformers, and switched capacitors and inductors. PJM examines system performance for both a voltage drop criteria (where applicable) and a voltage magnitude criteria. The voltage drop is calculated as the decrease in bus voltage from the initial steady state power flow to the post-contingency power flow. The post-contingency power flow is solved with generators holding a local generator bus voltage to a pre-contingency level consistent with specific Transmission Owner specifications. In most instances this is the pre-contingency generator bus voltage. Additionally, all phase shifters, transformer taps, switched shunts, and DC lines are locked for the post-contingency solution. SVC’s are allowed to regulate and fast switched capacitors are enabled.

The voltage magnitude criteria is examined for the same contingency set by allowing transformer taps, switched shunts and SVC’s to regulate, locking phase shifters and allowing generators to hold steady state voltage criteria (generally an agreed upon voltage on the high voltage bus at the generator location.)

In all instances, specific Transmission Owner voltage criteria are observed. All violations are recorded and reported and tentative solutions will be developed. These study results will be presented to and reviewed with stakeholders.
C.5.3 General Procedures and Assumptions

C.5.3.1 Independent Study Area Generation Capacity Deficiency

For the purposes of analysis, each tested study area within the PJM control area is assumed to be experiencing a generation deficiency independently. Thus, the remainder of PJM and adjacent non-PJM areas are operating normally and are assumed to be able to supply the study area with emergency power up to the limit of their available reserves. Load in all other areas beyond the area under test will be modeled at 50/50 load level reduced by forecast energy efficiency. The amount of reserves considered available from any adjacent non-PJM area may be changed to reflect historical data. Generally the procedure first tests the limit based on PJM reserves. The resource supply is opened to areas external to PJM as necessary, based on a reasonable expectation of such external support.

C.5.3.2 Consistency with PJM Emergency Operations Procedures

In all cases, the study area CETL analysis should reflect actual PJM emergency operations procedures designed to make as much power available to the deficient study area as possible under the prevailing system conditions. This should include (but is not limited to):

- The operation of any available PJM generation regardless of system economics.
- The activation of any PJM Load Management (LM) schemes that may serve to unload limiting facilities to the extent that it does not reduce the load in the area under test below expected 50/50 load reduced by forecast energy efficiency levels.
- The modification of any transfers modeled in the base case.
- The adjustment of any Phase Angle Regulators (PARs) which PJM or PJM member companies control (within existing agreements for emergency operation).
- The activation of any approved PJM or PJM member company operating procedure (procedure descriptions are available in Manual 3.)
- Re-dispatch of capacity resources in PJM are allowed internal to the study area to relieve an overload provided that the CETO is increased by the amount of generation re-dispatch required to eliminate the internal overload.

C.5.3.3 Study Area Definitions—Zonal and Global

A study area may consist of a single PJM transmission owner’s transmission system (230 kV and below for the Mid-Atlantic system) with its connected load and generation. In this case, the study area is referred to as a **Zonal** study area. A study area may also consist of a geographical combination of various transmission systems (with all connected load and generation) sharing common bulk facilities for importing power. For this combination type of study area, a **Global** CETL analysis will be performed in which all load and generation in the area will be modeled internal to the study area. Assessment of both Global and Zonal Load Deliverability analyses will identify the most restrictive emergency import margins with respect to reliability criteria and deliverability of capacity resources.
C.5.4 Base Case Development

Two separate base case models are developed as may be necessary; a PJM summer peak case to study summer-peaking study areas and a PJM winter peak case to study winter-peaking study areas. The RTEP load flow case nearest to the study time period should be selected and modified as required (modeling the projected load, generation, and transmission system configuration for the target study period).

To calculate plausible generator outage scenarios, a file containing the installed MW capacity and the Generator Unavailability Subcommittee (GUS) five-year planning equivalent forced outage rate demand (EFORd) for every PJM capacity resource will be developed. Related data is available at [http://www.nerc.com/Pages/default.aspx](http://www.nerc.com/Pages/default.aspx).

C.5.4.1 Study Area Capacity Deficiency Assumptions

The study area being evaluated is assumed to be experiencing the generation deficiency due to a combination of higher-than-expected load demand (a 90/10 load forecast) and greater-than-expected generator unavailability. The 90/10 load forecast level is modeled by using the value of the 90/10 load contained in the latest LAS report along with generator outage scenario(s) that would lead to a generation deficiency which cause a transmission limitation.

C.5.4.2 Study Area CETL Base Case Modeling Summary

- Behind the Meter and energy only generation should be modeled at the average historic MW output during the previous year’s 10 highest load hours for the study area each hour being selected from a different day.
- No study areas will be defined less than a peak load of 1500 MW.
- Generator reactive output will be reduced in proportion to the MW scaling reduction for any generation that is modeled below the rated capability.
- The 90/10 load adder is assumed to be at 0.8 power factor.
- Normal and emergency ratings included in the power flow will be those applied in Operations (at 35°C).
- PAR setting should be 1000 MW to NJ at Ramapo, 1000 MW to NJ at Waldwick, and 1000 MW into ConEd at Goethals and Farragut. PARs located within PJM may be operated as needed subject to the appropriate agreements (if any) and PJM Operating Company practices. Except as follows.
- PAR settings during subsequent contingency analysis can decrease the 1000 MW delivery to ConEd at Goethals and Farragut to as low as 600 MW delivery as required to enhance deliverability to the eastern study areas.
- The forecast 90/10 MW load for the area under test will be reduced by the available energy efficiency and DR (both in MW). The greater of the 90/10 MW load in the area under test reduced by the total amount of energy efficiency and DR or the
50/50 load reduced by forecast energy efficiency, will be used as the MW load in the area being tested.

If the 50/50 load reduced by energy efficiency is used to model the load in the test area, the forecast 90/10 MW load reduced by the amount of energy efficiency and DR needs to be adjusted by a MW adder to reach the level of 50/50 MW load minus the energy efficiency. The MVAR load associated with the 50/50 load minus the energy efficiency also needs to be increased by an amount equal to the difference between the MVAR associated with the 90/10 load adder at an 80% power factor and at the power factor in the 50/50 load forecast. The MVAR adder is to account for the assumption that the incremental MW (90/10 load adder) between the 90/10 and 50/50 load forecast is at an 80% power factor.

Note that the above assumes that the 90/10 forecast contains only a MW value. If the 90/10 forecast contains both a MW and a MVAR value, the power factor of this forecast 90/10 load needs to be used for the adjustment instead of the 80% power factor.

C.5.4.3 Procedure for Determining Load Deliverability Facility List

The following procedures outline the process for determining which facilities will be monitored for the PJM Load Deliverability test. The first procedure provides the details for internal PJM facilities and the second procedure concentrates on external PJM facilities.

**Internal PJM Load Deliverability Facility List**

1. PJM monitors all transmission facilities for its load deliverability test and screens criteria violations for upgrades that pass a transfer distribution factor (TDF) cutoff test and are on PJM’s monitored facility list (Lists of PJM monitored lines and substations are available at [http://www.pjm.com/markets-and-operations/ops-analysis/transmission-facilities.aspx](http://www.pjm.com/markets-and-operations/ops-analysis/transmission-facilities.aspx)). PJM performs load deliverability for its entire region by individually studying each study area listed in § 3.3. A different subset of the Transmission Facilities is the focus for each study area.

2. The following defines the TDF cutoff for PJM facilities that will be included in the separate Load Deliverability test for each study area. If a 100 kV and up facility is excluded from all load deliverability analyses based on its unresponsiveness to load supply, that facility may be addressed in generator deliverability or it becomes subject to reliability screening under the standard NERC TPL 001-4 criteria.

   All non-radial facilities 345 kV or greater will be included regardless of OTDF.

   All facilities with an external OTDF (an “external OTDF” is based on a source point external to the study area and a sink point internal to the study area) greater than 10% will be included regardless of voltage class.

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4 Any 100 kV and above facility that is not subject to upgrade screening in the load deliverability analysis will be evaluated in a subsequent screening that evaluates the NERC TPL-001-4 criteria in the 50/50 peak load scenario. All facilities failing these standard NERC criteria will be identified for upgrade.
C.7 Generator Deliverability Procedure

C.7.1 Introduction
To maintain reliability in a competitive capacity market, resources must contribute to the deliverability of the Control Area in two ways. First, energy must be deliverable, from the aggregate of resources available to the Control Area, to load in portions of the applicable PJM region experiencing a localized capacity emergency, or deficiency. PJM utilizes the CETO / CETL procedure to study this “deliverability of load”. Second, capacity resources within a given electrical area must, in aggregate, be able to be exported to other areas of PJM that are experiencing a capacity emergency. PJM utilizes a Generator Deliverability procedure to study the “deliverability of individual generation resources”. This document provides the procedure for Generator Deliverability.

C.7.2 Study Objectives
The goal of the PJM Generator Deliverability study is to determine if the aggregate of generators in a given area can be reliably transferred to the remainder of PJM. Any generators requesting interconnection to PJM must be “deliverable” in order to be a PJM installed capacity resource.

C.7.3 General Procedures and Assumptions

Step 1: Develop Base case
The RTEP base case is developed for a reference year 5 years in the future. All RTEP identified system upgrades and Supplemental RTEP Projects are included in the system model. Load is modeled at a non-diversified forecasted 50/50 summer peak load level reduced by energy efficiency as per the latest load forecast. All approved firm interchange is included with roll-over rights. Generation and Merchant Transmission projects that have proceeded at least through the execution of the Facility Study Agreement stage of the interconnection process are considered in the model along with any associated network upgrades. The starting point dispatch is developed as explained in the next step. PJM uses a uniform reduction of generation in place of discrete forced outages for this test due to the significant bias any one specific outage pattern can have on the final overload results.

Step 2: Establish initial RTEP dispatch for unit under study
Place all in-service capacity resources (those that have procured capacity delivery rights) on-line at a generation value equal to their installed capacity x (1 – PJM average EEFORd). Wind units with capacity delivery rights are derated to their granted capacity rights (either 13% beginning with the “U” queue or 20% for prior queues) representing the combined effects of wind variation and outage characteristics. The target generation value is the projected load + losses + firm interchange. (See addendum 1 for treatment of transmission withdrawal and injection rights). If all in-service capacity resources de-rated by the PJM EEFORd are greater than the target generation value, then all in-service capacity resources should be uniformly reduced to meet the target generation value. If all in-service capacity resources de-rated by the PJM EEFORd is less than the target generation value, then place all capacity resources with an executed Interconnection Service Agreement (ISA) on-line at a generation value equal to the installed capacity x (1 – PJM average EEFORd). If all in-
3.0 General Procedures and Assumptions

**Step 1: Develop Base case**

The RTEP base case is developed for a reference year 5 years in the future. All RTEP identified system upgrades and Supplemental RTEP Projects are included in the system model. PJM load is modeled at 50% of a non-diversified forecasted 50/50 summer peak load level reduced by energy efficiency as per the latest load forecast. System Interchanges will be determined by PJM through the use of data, including statistical averages based on historical data for off-peak load periods for typical previous years. Generation and Merchant Transmission projects that have proceeded at least through the execution of the Facility Study Agreement stage of the interconnection process are considered in the model along with any associated network upgrades. The starting point dispatch is developed as explained in the next step. PJM uses a combination of uniform reduction of coal powered generation and discrete outages for this test.

**Step 2: Establish initial RTEP dispatch for unit under study**

Existing PJM Resources: Place all in-service nuclear resources on-line at a generation value equal to their installed capacity. Wind units are derated in the initial dispatch to 40% of their nameplate capability. Coal units are initially derated consistent with Table 1. Queued Units in the PJM queue that have an ISA will be placed on-line consistent with Table 1. The target generation value for each Transmission Owner (TO) zone in the model is the projected load + losses + historical interchange for the light load period, as calculated by PJM. If necessary, coal resources in each TO zone are then uniformly de-rated or increased from the initial dispatch until the target generation value is met.

Existing MISO Resources: Model all existing wind generation in the MISO area online at a 100% capacity factor. Sink all MISO generation uniformly to maintain the target interchange. MISO generation dispatch utilized to serve MISO load will reflect a typical yearly statistical average for off-peak periods for interchange between MISO West, Central, and East.

Queued Resources in PJM and neighboring systems: Model all non-ISA queued generation offline. Model all ISA queued generation online. If selected by the test procedure, queued MISO wind resources will have the potential to be dispatched to 100% capacity factor. Similarly, if selected by the test procedure, queued PJM wind resources will have the potential to be dispatched to 80%.

For queued interconnection studies, all queued resources in the study queue ahead of the unit under study are set at 0 MW but available to be turned on per the Generator Deliverability procedure and Common Mode Outage test procedure. The resource request under study is also set at 0 MW but available to be turned on. Resource requests queued after the unit under study are not modeled. The loading on each transmission line that results from this dispatch and the application of a contingency is the base loading of the facility. (See Addendum 2 for treatment of Common Mode Outage Procedures).
G.11 PJM Capacity Import Limit Calculation Procedure

Introduction

a. The purpose of PJM Capacity Import Limit Calculation Procedure is to establish the amount of power that can be reliably transferred to PJM from defined regions external to PJM.

b. The PJM Capacity Import Limit is calculated annually and is used to confirm that import capability into the PJM system is greater than the sum of the PJM Capacity Benefit Margin (CBM) and confirmed Long Term Firm Transmission Service.

2. General Procedures and Assumptions

a. The system power flow model will be based on the latest summer peak RTEP base case.

b. The base case will contain confirmed Long Term Firm Transmission Service for the study period as identified in the PJM OASIS.

c. The PJM dispatch will reflect a PJM generation deficiency situation independent of the defined regions external to PJM. Thus, non-PJM regions are operating normally and are assumed to be able to supply PJM with power up to the lower of the Capacity Import Limit or the limit of their available reserves. Load in PJM and all external regions will be modeled at a 50/50 load level and load in PJM will further be reduced by the forecasted energy efficiency. The amount of reserves considered available from any adjacent non-PJM area may be adjusted to reflect historical data.

d. For thermal analyses, all Eastern Interconnection BES facilities (100 kV and above) will be monitored. All PJM internal BES single contingency events and selected non-PJM BES contingency events will be considered.

e. For voltage analyses, all PJM BES facility voltage magnitude and drop limits will be monitored and selected non-PJM BES facility voltage limits will be observed. In addition, any part of the Eastern Interconnection that would experience voltage collapse will be evaluated. The voltage analyses are subject to all PJM internal BES single contingency events and selected non-PJM BES contingency events.

f. The following operating procedures will be employed as necessary.

   i. Adjustments of Phase Angle Regulators (PARS which PJM or PJM member companies control (within existing agreements for emergency operation)

   ii. The activation of any approved PJM or PJM member company operating procedure (procedure descriptions are available in Manual 3.)

   g. Redispachtch and implementation of load management schemes will not be considered as part of this study.


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 an 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 active (real) and reactive load profile in its zone. PJM will scale the load in each zone 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 to the Transmission Owners, at their discretion, for updating their zonal reactive load profile.

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

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 PJM will use the default voltage schedules as defined in PJM Manual 03.

H.1.3 Submittal of Load Flow Data

Attachment J contains the checklist for the new equipment energization process to be utilized by Transmission Owners and Designated Entities from inception to energization of upgrade projects.

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.

TO’s can submit data in an agreed to version if they are unable to export to the latest MMWG compatible version.