C.4 PJM Load Deliverability Procedure—Capacity Emergency Transfer Objective (CETO)

The Capacity Emergency Transfer Objective (CETO) analysis determines a target MW import value for a test area that ensures sufficient transmission capability to access available external capacity reserves. The import value determined is a measure of the transmission capability required by the test area so that the area does not experience a modeled, transmission induced loss of load event more frequently, on average, than 1 in 25 years. This test ensures comparability of transmission service to all areas within the PJM Region.

The CETO for each sub-area in PJM is determined separately using PJM's reliability software to perform a single area reliability study for each load area. The system models are based on the latest RTEP load and capacity data available at the time of the study. Only the load and capacity within the study area are modeled while the capacity supply from outside the study area is assumed unlimited. The transmission system is not modeled. The CETO is the import capability value that is necessary for the study area to achieve the CETO reliability standard. The CETO reliability standard is one event in 25 years.

More detail is available by referring to PJM Manual 20 – Resource Adequacy Analysis at http://www.pjm.com/documents/manuals.aspx

C.5 PJM Load Deliverability Procedure—Capacity Emergency Transfer Limit (CETL)

1.0 Introduction

PJM specifies a reliability objective regarding each study area's ability to import needed and available capacity assistance. The purpose of performing a Capacity Emergency Transfer Objective/Limit Study (CETO/CETL) also known as a Load Deliverability study is to verify that this objective is met. Load Deliverability analysis is therefore one of the tests applied to validate the deliverability of PJM capacity resources to PJM load. Load Deliverability analysis is performed for a study area. At present, load deliverability study areas consist of individual zones, sub-zones and the geographical combinations of zones. Eighteen zones and sub-zones have thus far been identified. The zones correspond to the present power flow areas of the PJM operating companies. Five global study areas which are geographical combinations of power flow zones have thus far been identified.

2.0 Study Objectives

The goal of a PJM Load Deliverability study is to establish the amount of emergency power that can be reliably transferred to the study area from the remainder of PJM and the areas adjacent to PJM in the event of a generation deficiency within the study area (the study area's CETL). This transfer limit, in combination with its corresponding CETO, is then used to determine if the import capability required to meet the reliability objective is sufficient. An indicator of the amount of reserve transfer capacity (if any) available is also provided.

3.0 General Procedures and Assumptions

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.

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.

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.

PJM Global CETL Study Areas

Eastern Mid-Atlantic Area – Comprises all load and generation connected 500 kV and lower in PECO, PSE&G, JCP&L, Delmarva, AE, and RECO.

Southern Mid-Atlantic Area – Comprises all load and generation connected 500 kV and lower in BG&E and PEPCO.

Western Mid-Atlantic Area – Comprises all load and generation connected 500 kV and lower in Penelec, Met-Ed and PP&L.

Mid-Atlantic Region – Comprises all load and generation connected 500 kV and lower in Penelec, Met-Ed, PP&L, BG&E, PEPCO, PECO, PSE&G, JCP&L, Delmarva, AE and RECO.

Western Region – Comprises all load and generation connected 765 kV and lower in ComEd, ATSI, AEP, Dayton, Duquesne and AP. Note that CPP is within the ATSI transmission Zone.

PJM Zonal CETL Study Areas

Penelec – All load and generation connected at 230 kV and below.

AP – All load and generation connected at 500 kV and below.

ATSI – All load and generation connected at 345kV and below.

Met-Ed - All load and generation connected at 230 kV and below.

PP&L - All load and generation connected at 230 kV and below.

BG&E - All load and generation connected at 230 kV and below.

PEPCO - All load and generation connected at 230 kV and below.

JCP&L - All load and generation connected at 230 kV and below.

PECO - All load and generation connected at 230 kV and below.

AE - All load and generation connected at 230 kV and below.

PSE&G - All load and generation connected at 230 kV and below.

Delmarva - All load and generation connected at 230 kV and below.

ComEd - All load and generation connected at 765 kV and below.

AEP - All load and generation connected at 765 kV and below.

Dayton - All load and generation connected at 345 kV and below.

Duquesne - All load and generation connected at 345 kV and below.

Dominion – All load and generation connected at 500 kV and below.

Delmarva South - All load and generation connected at 230 kV and below as defined in Figure E-1.

PSE&G North - All load and generation connected at 230 kV and below as defined in Figure E-2.

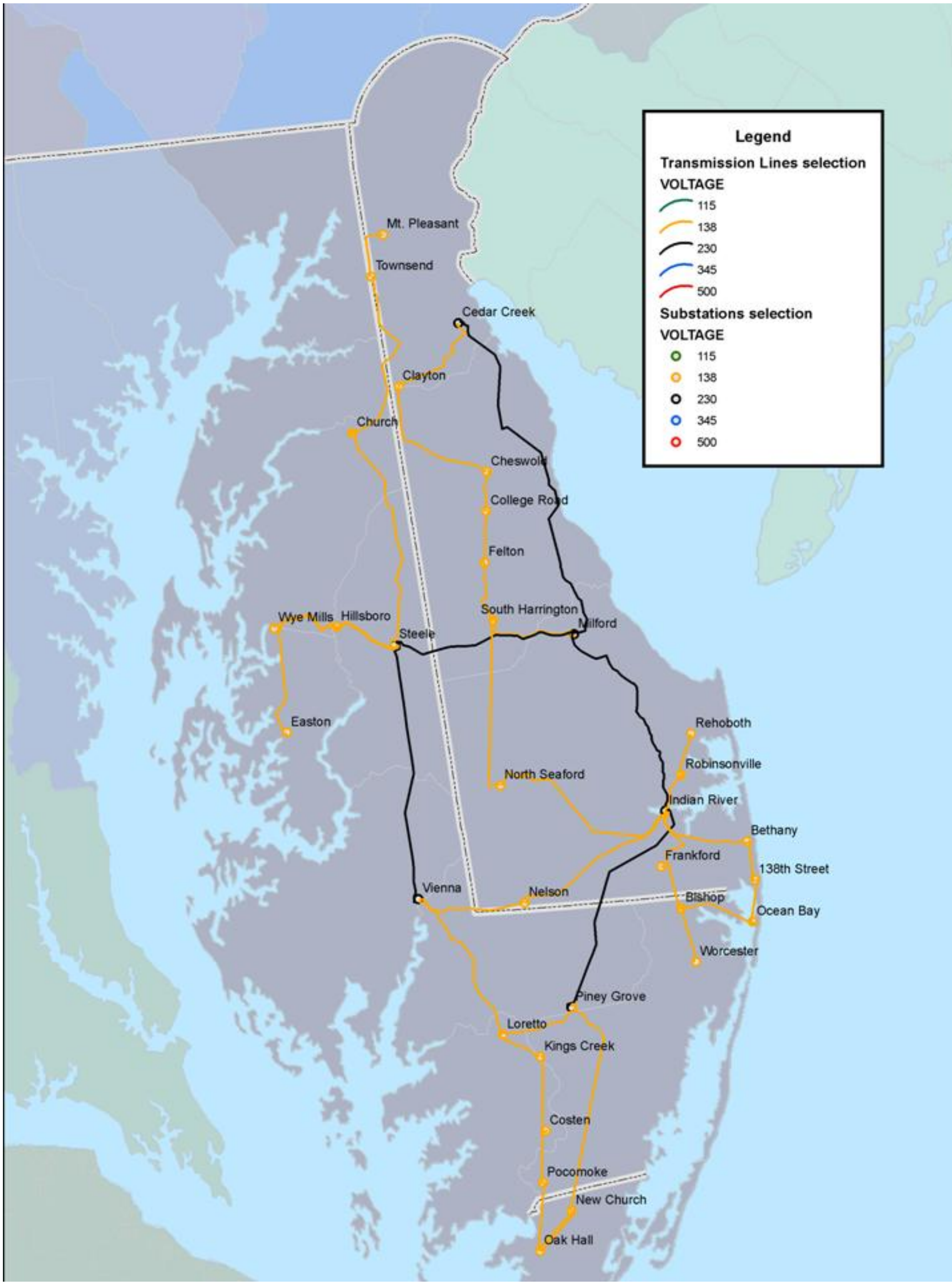

Figure E-1 (Delmarva South)

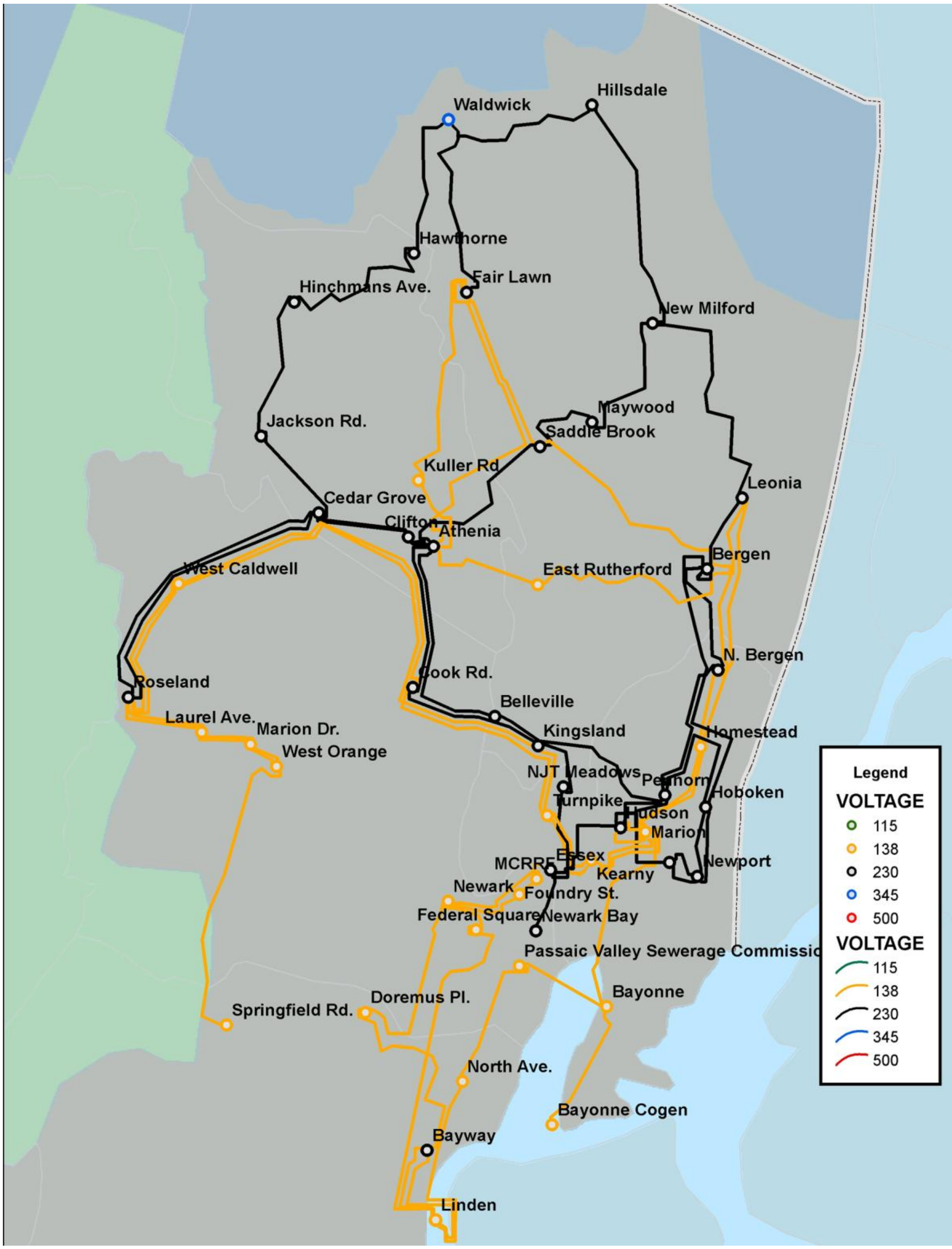

Figure E-2 (PSE&G North)

4.0 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 need for a winter case is assessed annually. Currently the only PJM winter peaking area has summer and winter peaks sufficiently close to enable the analysis on only a summer peak case). 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/page.php?cid=4|43|47.

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 ~~simulated by modeling 105% of the study area's load expected to be served at the time of the 50/50 peak~~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.

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 ~~5%~~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 ~~levels in~~ 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 ~~modeled~~ 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 this MW 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 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.

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/transmission-service/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 001-004 criteria[4].

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

[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 through 004 criteria in the 50/50 peak load scenario. All facilities failing these standard NERC criteria will be identified for upgrade.

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.

All facilities with an external OTDF between 5% and 10% will be included unless both PJM and the TO agree that the facility should not be subject to the load deliverability test.

All facilities with an external OTDF less than 5% will not be included unless the PJM and TO agree that the facility should be subject to the load deliverability test.

3. The Load Deliverability Facility List can be modified prior to each baseline analysis but cannot be changed between baseline studies.
4. All PJM monitored facilities will be included when determining any generation re-dispatch or PAR movements required for the base case development. However, only the facilities on the Load Deliverability Facility List will require system upgrade if overloaded for this load deliverability test.
5. The substations to be included for voltage analysis will be developed based on the Load Deliverability Facility List.
6. Additional substations to be included for voltage analysis as agreed to by PJM and the TO.

External PJM Load Deliverability Facility List

For study areas electrically close to PJM, PJM conducts joint coordinated interregional studies on a periodic basis that examines and addresses deliverability issues between PJM and adjacent external systems.

4.4 Dispatch for PJM Areas Not in Capacity Emergency

PJM generators should be dispatched as per existing RTEP base case procedures (see also ―Deliverability of Generation"). To simulate the average forced outage rate for generation in PJM, a uniform de-rate of all generation is done.

4.4.1 Dispatch for non-PJM Areas Not in Capacity Emergency

One of the base principles for the load deliverability test is that the study area is the only area that is in a capacity emergency. All adjacent external areas to PJM are assumed to be at a peak load but in a non-emergency condition. Increasing available generation (respecting Pmax) simulates exports from these areas to the study area.

The locations of generation increases and corresponding MW import level to the study area is typically optimized to provide the highest available imports to any given study area. The import amounts from each external area can be based on strength of ties or historical imports when the study area was capacity deficient. The amount of reserves considered available from any external system may be changed from the optimized scenario to reflect historical import data or to minimize constraints at the discretion of the engineer conducting the study.

4.5 Dispatch for Load Deliverability Study Area

4.5.1 Procedure to Determine Dispatch for Voltage Analysis

1. Derate all generators in the zone by their EFORd.
2. Rank generators by EFORd^(1/PMAX).
3. To model discrete generator outages, select generators in rank order until the next selected generator would exceed 105% of the target generator outage value.
4. Multiple generators at the same substation may be outaged unless the outaged MW to installed MW ratio is greater than 60%. (For example, if a station had 3-100 MW units, 1 unit would be outaged since 100 MW/300 MW = 33% but two units would not be outaged since 200 MW/300 MW = 66%)
5. Any remaining MW outages required to meet the target generator outage value will be obtained through a uniform scale of all on-line generation's MWs and MVARs in the study area.
6. The Transmission Owner(s) may request analysis of a different outage pattern. If this outage pattern results in more severe reliability problems it will be used in place of the original outage pattern only if both the Transmission Owner and PJM accept the new outage pattern.

4.5.2 Procedure to Determine Dispatch for The Mean Dispatch Case

1. All generators in the study area are sampled until 10,000 generation outage scenarios are found where the amount of generation selected is within +/- 2% of the amount needed to meet the target generator outage value required to model the import objective.
2. The 10,000 generation outage scenarios are determined by using a Monte Carlo simulation and randomly assigning a value between 1 and 0 to each generator in the study area. If the value is greater than the generator forced outage rate, then that generator is turned on. If the value is less than the generator forced outage rate, then that generator is turned off. There is no limit to the number of units that can be simultaneously outaged at a station.
3. Determine the average MW output of each generator in the study area by using its dispatched values in the 10,000 generator outage scenarios. These average MW output values for each generator are referred to as the Mean Dispatch.
4. The reactive capability of each unit is reduced by the ratio of each unit's average MW output from the preceding step to the unit's maximum MW output.
5. Create a base case modeling the average MW output of each generator determined in step 5 above. This case is referred to as the mean dispatch case. It models a generation outage scenario based on the average MW for each unit from the 10,000 generation outage scenarios determined in step 5 above. This case is used by the entities to study potential reinforcements required to resolve any overloaded flowgates. In addition,

since the case models an average generation outage scenario and therefore average losses for those outage scenarios, it is the best case to use when determining the impact on flowgates of the various discrete generation outage scenarios applied for the median loading.

6. Perform an AC contingency analysis on the mean dispatch case to obtain the percent loading for each flowgate. This percent loading is referred to as the reference loading.
7. Flowgates that have a reference loading greater than or equal to 90% of the appropriate (i.e., normal or emergency) rating (at 35°C) in the mean dispatch case are tested further as defined below.
8. To determine the discrete generation outage scenarios, all generators in the study area are sampled until 10,000 generation outage scenarios are found where the amount of generation selected is within +/- 2% of the amount needed to meet the target generator outage value required to model the import objective. (This process is described in steps 7 and 8 above).
9. The flowgate loading for each discrete generation outage scenario is determined as follows:
    a. For each generator in the study area, a distribution factor is established for each flowgate using the generator in the study area as the sink point and all generators external to the study area, being used to model the transfer as the source points.
    b. The impact on the flowgate due to the change in generation is determined for each generator by determining the change in MW output in the generation outage scenario from the output modeled in the mean dispatch case. The change in MW value is then multiplied by the distribution factor of each flowgate to determine the +/- impact on the flowgate.
    c. The AC MVA loading from the mean dispatch case is incremented or decremented by this MW result.
    d. This results in 10,000 percentage loadings being established for each flowgate (i.e., one flowgate percent loading for each of the generation outage scenarios studied).
10. If any overloads exist, any of the system adjustments noted in section 3.2 can be implemented and the procedure in section 4.5.2 is repeated.
11. Any overloads that still remain will require mitigation in order for the study area CETL to exceed the CETO.

4.6 Study Results

1. Five % points are selected (30-70% in 10% increments) to quantify the probability of a given % loading for each flowgate.
2. For example, a 90% flowgate loading in the column of the first point, 30%, means that in 3,000 of the 10,000 discrete generation outage scenarios the line loading was below 90%. Likewise, a 90% flowgate loading in the

column of the third point, 50%, means that in 5,000 of the 10,000 discrete generation outage scenarios the line loading was below 90%. This third point is the median flowgate loading.

3. Select 50% probability point such that any circuits with loadings exceeding their applicable rating for more than 50% of the dispatch scenarios will require upgrade.

4.7 CETL Determination

After steps 4.5.1 and 4.5.2 are completed and any required system upgrades are identified to eliminate any voltage problems or overloads, the study area CETL can be determined.

CETL for Voltage Problems

To determine the CETL for voltage problems, the imports into the study area will be increased in 50 MW increments starting from the dispatched base case identified in section 4.5.1. The import change will be modeled by increasing external generation and uniformly decreasing internal study area generation.

CETL for Thermal Problems

To determine the CETL for thermal problems, the transfer distribution factor on each of the flowgates will be calculated by using a source of generation external to the study area and a sink of generation internal to the study area. The transfer distribution factor multiplied by the increased imports will indicate which overload will limit the study area imports from a thermal perspective.

CETL for Study Area

The lower of the CETL identified for the voltage problems and the thermal problems will be used as the study area CETL.

5.0 Transitional Rules

This Load Deliverability Procedure will be applied for all future load deliverability analysis for planning years 2008 and beyond. Any existing projects identified through the RTEP for installation prior to June 2008 and approved by the PJM Board will remain requirements as identified in previous analysis.

C.6 Deliverability of Generation

The second deliverability test, the ability of an electrical area to export capacity resources to the remainder of PJM has historically been applied in situations where problems were expected to occur. Consistent with the move from IOU service territories to electrical areas, this test is applied to ensure that capacity is not "bottled" from a reliability perspective. This would require that each electrical area be able to export its capacity, at a minimum, during periods of peak load. Export capabilities at lower load levels would be based more on economic decisions and would not reflect on deliverability criteria and therefore the "certification" of resources as deliverable capacity.

Deliverability, from the perspective of individual generator resources, ensures that, under normal system conditions, if capacity resources are available and called on, their ability to provide energy to the system at peak load will not be limited by the dispatch of other