

Attachment C: PJM Deliverability Testing Methods

C.1 Introduction

C.1.1 Purpose of Deliverability Requirements

Schedule 10 of the PJM Reliability Assurance Agreement states that Capacity Resources must be deliverable, consistent with a loss of load expectation as specified by the Reliability Principles and Standards, to the total system load, including portion(s) of the system in the PJM Control Area that may have a capacity deficiency at any time. Certification of deliverability means that the physical capability of the transmission network has been tested by the Office of the Interconnection and found to provide service consistent with the assessment of transfer capability internal to PJM as set forth in the PJM Tariff and, for Capacity Resources owned or contracted for by a Load Serving Entity, that the Load Serving Entity has obtained Network Transmission Service or Firm Point-to-Point Transmission Service to have capacity delivered on a firm basis under specified terms and conditions.

PJM determines the installed Capacity Requirement requirements for the entire PJM footprint ~~to achieve this reliability objective~~ assuming sufficient network transfer capability will exist to ensure deliverability of these resources. In order to satisfy this assumption, the energy from generating facilities that are is ultimately committed to meet this capacity requirement must be deliverable within PJM to wherever they are it is needed, within PJM in a capacity emergency. Therefore, there must be sufficient transmission network transfer capability within PJM. PJM determines sufficiency of network transfer capability through a series of Deliverability tests.

Deliverability ensures that the transmission system within PJM can be operated within applicable reliability criteria and ensures within those criteria that regional load will receive energy, with no guarantee as to price, from the aggregate of Capacity Resources available to PJM- as demonstrated in the applicable planning studies.

C.1.2 Types of Deliverability Requirements

To maintain reliability in a competitive capacity market, capacity resourcesCapacity Resources must contribute to the deliverability of energy within PJM in two ways. First, within an area experiencing a localized capacity emergency, or deficiency, energy must be deliverable from the aggregate of the available capacity resourcesCapacity Resources to load. This type of deliverability is referred to as load deliverability. Failure of load deliverability tests will result in the initiation of appropriate mitigation actions, including securing additional capacity resourcesCapacity Resources or an enhancement to the Transmission System, in order to increase the area's ability to import power.

Second, capacity resourcesCapacity Resources within a given electrical area must, in aggregate, be able to be exported to other areas of PJM. This type of deliverability is referred to as generator deliverability. The generator deliverability test determines whether a generator qualifies for the status of a certified capacity resourceCapacity Resource with respect to the installed capacity obligations imposed under the

Reliability Assurance Agreement. It does not guarantee any rights to specific generators to deliver energy to specific loads within PJM. Nor does it guarantee any rights to generators to produce energy during any particular set of operational circumstances. Failure of the deliverability test for a new capacity resourceCapacity Resource will result in denial of full capacity rights for the generator until such generator deliverability deficiencies are corrected.

These deliverability tests ensure that the PJM Transmission System is adequate for delivery of energy from the aggregate of capacity resourcesCapacity Resources to the aggregate of PJM load. PJM has developed comprehensive testing methodologies to verify compliance with each of these deliverability requirements. It is important to point out that deliverability ensures that the PJM Transmission System is adequate for delivery of energy from the aggregate of capacity resources to the aggregate of PJM load. Additionally, the generator deliverability test determines whether a generator qualifies for the status of a "certified" capacity resource with respect to the installed capacity obligations imposed under the Reliability Assurance Agreement. It does not guarantee any rights to specific generators to deliver energy to specific loads within PJM. Nor does it guarantee any rights to generators to produce energy during any particular set of operational circumstances. Deliverability ensures that the Transmission System within PJM can be operated within applicable Reliability Criteria and, ensures within those criteria that regional load will receive energy, with no guarantee as to price, from the aggregate of capacity resources available to PJM.

Failure of the deliverability test for a new capacity resource will result in denial of full capacity rights for the generator until such generator deliverability deficiencies are corrected. Failure of load deliverability tests will result in the initiation of appropriate mitigation actions including securing additional capacity resources, reduction of peak load and/or an enhancement to the Transmission System to increase the load area's ability to import power.

C.2 Deliverability Methodologies

To maintain reliability in a competitive capacity market, capacity resources must contribute to the deliverability of energy within PJM in two ways. First, within an area experiencing a localized capacity emergency, or deficiency, energy must be deliverable from the aggregate of the available capacity resources to load. Second, capacity resources within a given electrical area must, in aggregate, be able to be exported to other areas of PJM. PJM has developed testing methodologies to verify compliance with each of these deliverability requirements.

C.2 Load Deliverability

C.3 Overview of Deliverability to Load

C.2.1 Overview of Load Deliverability

C.2.1.1 Purpose of Load Deliverability

The first of these deliverability tests, involves confirming that within accepted probabilities the Transmission System can support the delivery of energy from the aggregate of available PJM capacity resourcesCapacity Resources in one PJM electrical area to another PJM electrical area experiencing a capacity deficiency, is

~~the more common deliverability test that has been utilized within PJM for some time. It. This test is often discussed in the context of demonstrating the "deliverability to the load" as opposed to the "deliverability of individual generation resources". This ensures that, within accepted probabilities, energy can be delivered to each PJM load area from the aggregate of capacity resources available to PJM (regardless of ownership). These tests address reliability only and do not address the economic performance of the system.~~

~~For~~To ensure ~~the~~ adequacy of the generating capacity of the entire PJM footprint, the acceptable loss of load expectation (LOLE) is based on load exceeding available capacity, on average, ~~during only~~not more than one occurrence in ten years (1/10). This concept of deliverability to load coincides with the assumptions inherent in the determination of the PJM Installed Reserve Margin (IRM), i.e. the total amount of installed capacity necessary to be at the disposal of the PJM operator to ensure delivery of energy to load consistent with an LOLE of 1/10. The determination of the IRM is based on the assumption that the delivery of energy from the aggregate of available ~~capacity resources~~Capacity Resources to load within the PJM footprint will not be limited by transmission capability. This assumption depends on the existence of a balance between the distribution of generation throughout PJM and the strength of the Transmission System to deliver energy to portions of PJM experiencing capacity deficiencies.

C.2.1.2 Locational Deliverability Areas

To test the deliverability assumptions inherent in the development of the PJM Installed Reserve Margin, electrically cohesive load areas must first be defined. The historical implementation of this test based these areas on Transmission Owner service territories and larger geographical zones comprised of a number of those service territories. Current study areas also include the definition of smaller areas within service territory boundaries. Twenty-seven Locational Deliverability Areas (LDAs) have thus far been identified including five global LDAs, which are geographical combinations of Transmission Owner service territories, and three sub-LDAs, which are portions of Transmission Owner service territories.

Many of these Locational Deliverability Areas (LDAs) were defined based on the impacts of generators located within the area and on the contingencies known to limit operational transfers in the area. Similar techniques may be used to form future new LDAs to establish incentives for infrastructure that promotes reliability.

PJM will analyze the need for the addition of an LDA if such a need is identified through either the RTEP market efficiency or other RTEP long-term planning studies. Constrained facilities identified utilizing market efficiency studies that are not resolved by an existing approved RTEP upgrade are identified for further consideration. In addition, future constrained facilities identified utilizing the RTEP long-term planning studies may also result in the need for the addition of a new LDA. These future constrained facilities are screened using thresholds that are included in the RTEP long-term planning studies. This analysis is updated annually based on approved RTEP upgrades. 500 kV and above constrained facilities or other sets of critical facilities that advance more than three years between RTEP cycles are identified for further consideration. If the driver for such constraints advancing more

than three years is linked to a specific event (e.g. significant generation retirement), it may require further analysis and the creation of a new LDA.

Once a constrained facility or group of constrained facilities has been identified under these criteria, distribution factor analysis is performed to determine the specific busses to be included in the proposed LDA. The model used to determine the distribution factors will include all approved RTEP upgrades. The specific distribution factor cutoff to be used in the development of a new LDA will be dependent upon an analysis of the specific system topology, generation and load characteristics in the vicinity of the identified constrained facility(s).

C.2.1.3 General Assumptions

C.2.1.3.1 Independent Study Area Generation Capacity Deficiency

For the purposes of analysis, each LDA within PJM is assumed to be experiencing a generation deficiency independently. Thus, the remainder of PJM is assumed to be operating normally and able to supply the study area with emergency power up to the limit of its available reserves. Load in all other PJM areas beyond the area under test will be modeled at 50/50 load level.

C.2.1.3.2 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 and redispatch of any available PJM generation external to the LDA regardless of system economics. Redispatch of ~~capacity resources~~Capacity Resources are allowed internal to the study area as well to relieve an overload provided that the CETO is increased by the amount of generation reduction required to eliminate the internal overload.
- The activation of any PJM Load Management (LM) schemes within the LDA that may serve to unload limiting facilities to the extent that doing so does not reduce the load in the area under test below the expected 50/50 load.
- The adjustment of any Phase Angle Regulators (PARs) which PJM or PJM member companies control within existing agreements for emergency operation. The PJM/NYISO PAR flows will be set according to Attachment B Section (B.3)(VII)(P).
- The activation of any approved PJM or PJM member company operating procedure. Operating procedures are described in PJM Manual M03 - Transmission Operations.

C.2.1.4 General Procedures

The load deliverability procedures are consistent with the changing nature of load responsibility under wholesale and retail access and provide a wide range of information about the performance of the Transmission System as electrical areas of different sizes are evaluated. The sequence of evaluating areas of differing size involves nesting small sub-areas into larger areas and finally areas into larger geographical areas of PJM to help identify the interrelationships between local and large geographical area deliverability problems.

The specific procedures utilized to test deliverability from the load perspective involve the calculation of both Capacity Emergency Transfer Objectives (CETO) and Capacity Emergency Transfer Limits (CETL) for the various electrical areas of PJM. A CETO value represents the amount of energy that a given area must be able to import in order to remain within an LOLE of 1 event in 25 years (1/25) when that area is experiencing a localized capacity emergency. The LOLE calculation takes into account all generation within the study area including that which may not be a PJM ~~capacity resource~~ Capacity Resource. The CETL represents the actual ability of the Transmission System to support deliveries of energy to an electrical area experiencing such a capacity emergency. ~~Providing~~ Provided that the CETL for a given area exceeds the CETO for that area, the test is passed and, on a probabilistic level, the area will be able to import sufficient energy during emergencies. The Transmission System is tested at a LOLE of 1/25 so that the transmission risk does not appreciably diminish the overall target of a 1/10 LOLE for PJM.

~~To test the assumptions used in the development of the PJM Installed Reserve Margin, electrically cohesive load areas must first be defined. The historical implementation of this test based these areas on Transmission Owner service territories and larger geographical zones comprised of a number of those service territories. Current study areas include the definition of smaller areas, within service territory boundaries. These areas, known as Locational deliverability Areas (LDAs) were defined based on the impact of generators, potentially within the area and on the contingencies known to limit operations in the area. Similar techniques may be used to form future new areas to establish incentives for infrastructure that promotes reliability.~~

~~PJM will analyze the need for the addition of an LDA if either of the following criteria is met:~~

~~● RTEP Market Efficiency Analysis~~

~~Constrained facilities will be identified utilizing the market efficiency analysis. Facility constraints that are not resolved by an existing approved RTEP upgrade are identified for further consideration. PJM may propose a new LDA when annual market efficiency analysis identifies persistent congestion on a 500 kV or above facility or interface for multiple years beyond the next BRA.~~

~~○ RTEP Long Term Planning~~

~~Future constrained facilities or clusters of facilities are identified utilizing the long term planning analysis. Potential facilities are screened using thresholds that are utilized in the RTEP long term planning studies. This analysis is updated annually based on approved RTEP upgrades. 500 kV and above facilities that advance more than three years between RTEP cycles are identified for further consideration. If the~~

~~driver for a 500 kV facility advancing more than three years is linked to a specific event (e.g. significant generation retirement), it may require further analysis.~~

~~Once a facility has been identified utilizing the above methods, distribution factor analysis is utilized to determine the specific busses included in the analyzed LDA. The model used to determine the load bus distribution factors would include all approved RTEP upgrades. A distribution factor cutoff is established based on one of the existing LDA's, and is dependent upon an analysis of the specific system topology and the identified constrained facility(s).~~

~~These procedures are consistent with the changing nature of load responsibility under wholesale and retail access and provide a wider range of information about the performance of the Transmission System as electrical areas of different sizes are evaluated. The sequence of evaluating areas of differing size involves nesting small sub-areas into larger areas and finally areas into larger geographical areas of PJM to help identify the interrelationships between local and large geographical area deliverability problems.~~

After an area LDA is defined, two generation patterns must be established. The first represents the capacity resource Capacity Resource deficiency within the area LDA. Based on the calculated CETO for the area LDA, sufficient resources must be removed from service to create a need to import energy into the area LDA. As the magnitude of the deficiency is adjusted, single contingency analysis is used to establish the CETL value. The second generation pattern required represents the dispatch of the remainder of PJM and surrounding non-PJM areas, and is comprised of a much larger number of generators that are not experiencing any emergency conditions. The larger area in PJM is modeled as experiencing only normal levels of unit outages simulated through a uniform reduction of all on-line generation. The reduction is based on an average Equivalent Forced Outage Rate (EFORd) as that term is defined by NERC standards (<http://www.nerc.com/pa/Stand/Pages/default.aspx>) for PJM capacity resource Capacity Resources.

~~Both Thermal and voltage studies under single contingency conditions are performed at the CETO to determine potential overload conditions and substations with voltage issues. For each LDA, two different dispatches at the CETO import level are examined. The first dispatch is based on a are evaluated using a probabilistic approach whereby up to 10,000 different generation outage scenarios within the study area are simulated to determine create a statistically-based Mean Dispatch Casean expected value for the various facility loading levels under test at the CETO. Voltage analysisThe second dispatch uses a combination of discrete generator outages and scaled generator outputs in the LDA to create a Discrete Outage Caseunder test at the CETO.~~

~~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/library/manuals.aspx>~~

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

~~C.5.1 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. Twenty Seven 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.~~

~~C.5.2 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 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.~~

~~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 is assumed to be operating normally and able to supply the study area with emergency power up to the limit of its available reserves. Load in all other PJM areas beyond the area under test will be modeled at 50/50 load level.~~

~~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.~~
- ~~• The adjustment of any Phase Angle Regulators (PARs) which PJM or PJM member companies control (within existing agreements for emergency operation). The PJM/NYISO PAR flows will be set according to Attachment B Section (B.3) (VII)(P)~~
- ~~• 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.5.3.3C.2.2 Current Study Area Definitions—Zonal and Global Locational Deliverability Area Definitions~~

~~A study area, also referred to as a Locational Deliverability Area (LDA), may consist of a single PJM transmission owner's transmission system (230-345 kV and below for the Mid-Atlantic system) with its connected load and generation. The study area may also consist of a portion of such an LDA. In this both of these cases, 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. Study areas comprised of combinations of Zonal study areas are referred to as Global study areas. Assessment of both Global and Zonal and Global Load Deliverability~~

analyses study areas will identify the most restrictive emergency import margins with respect to reliability criteria and deliverability of capacity resources Capacity Resources to load within the PJM footprint.

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 and UGI.

Mid-Atlantic Region – Comprises all load and generation connected 500 kV and lower in Penelec, Met-Ed, PP&L, UGI, 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, DEOK, Duquesne, AP, OVEC and EKPC. Note that CPP is within the ATSI transmission Zone. Also note that the inclusion of OVEC into the Western Region is subject to their integration into PJM.

PJM Zonal CETL Study Areas

Penelec – All load and generation connected at 230-345 kV and below.

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

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

Cleveland – All load and generation connected at at 345 kV and below as defined in Figure E-3

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

EKPC – All load and generation connected at 345 kV 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 230-345 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.

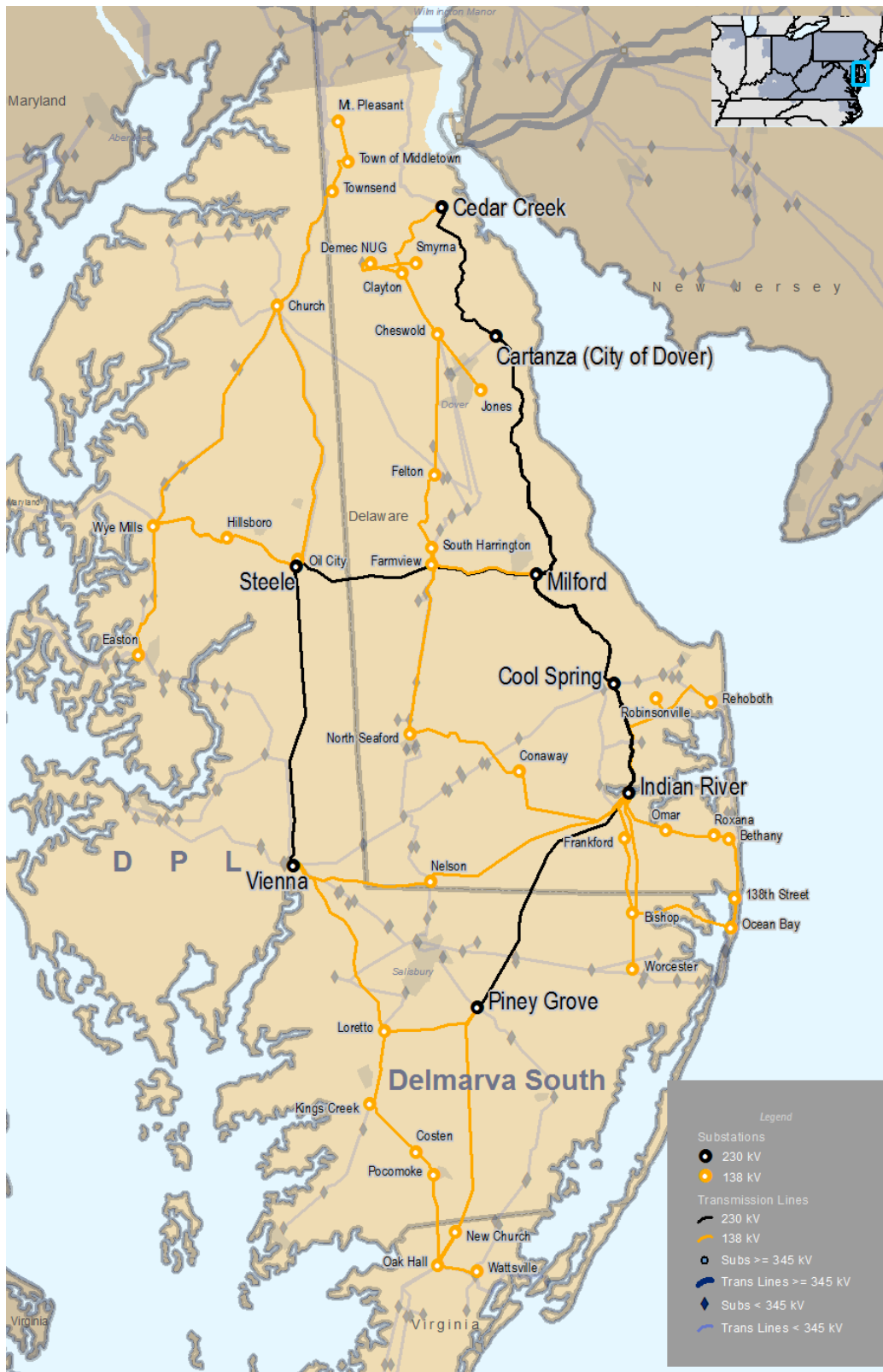
Dayton - All load and generation connected at 345 kV and below.

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 ~~230-345~~ kV and below as defined in Figure E-2.



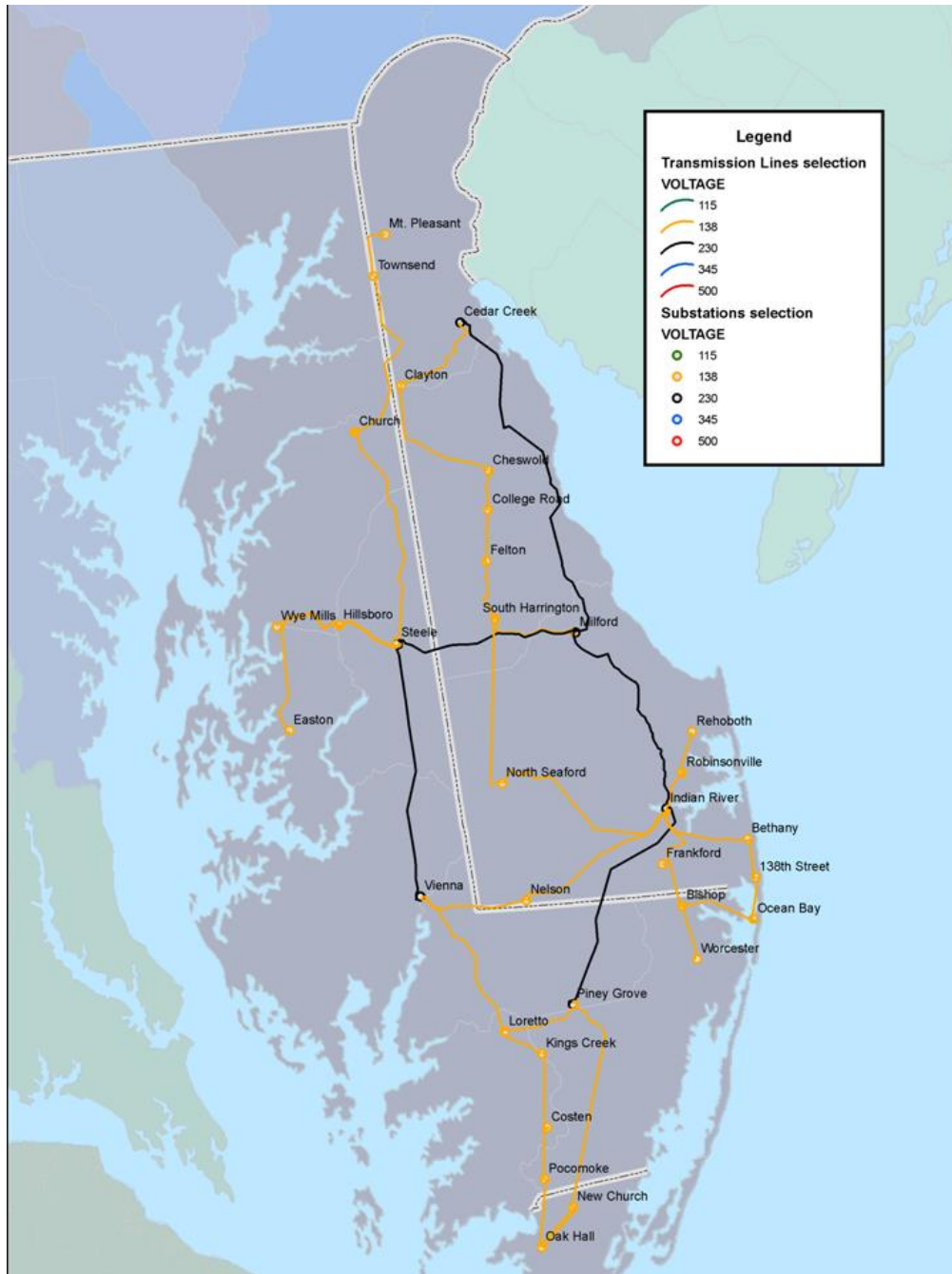


Figure E-1 (Delmarva South)



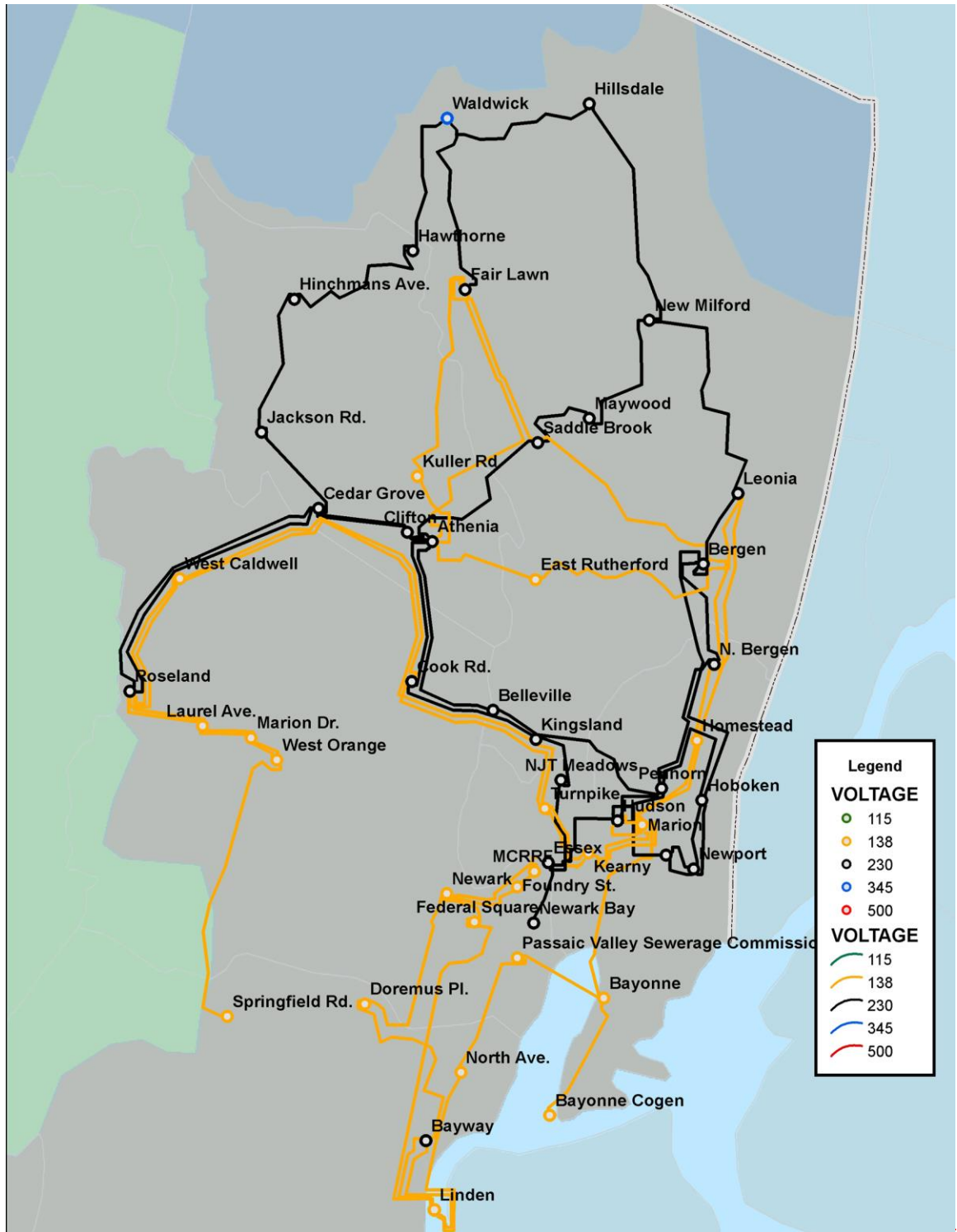


Figure E-2 (PSE&G North)

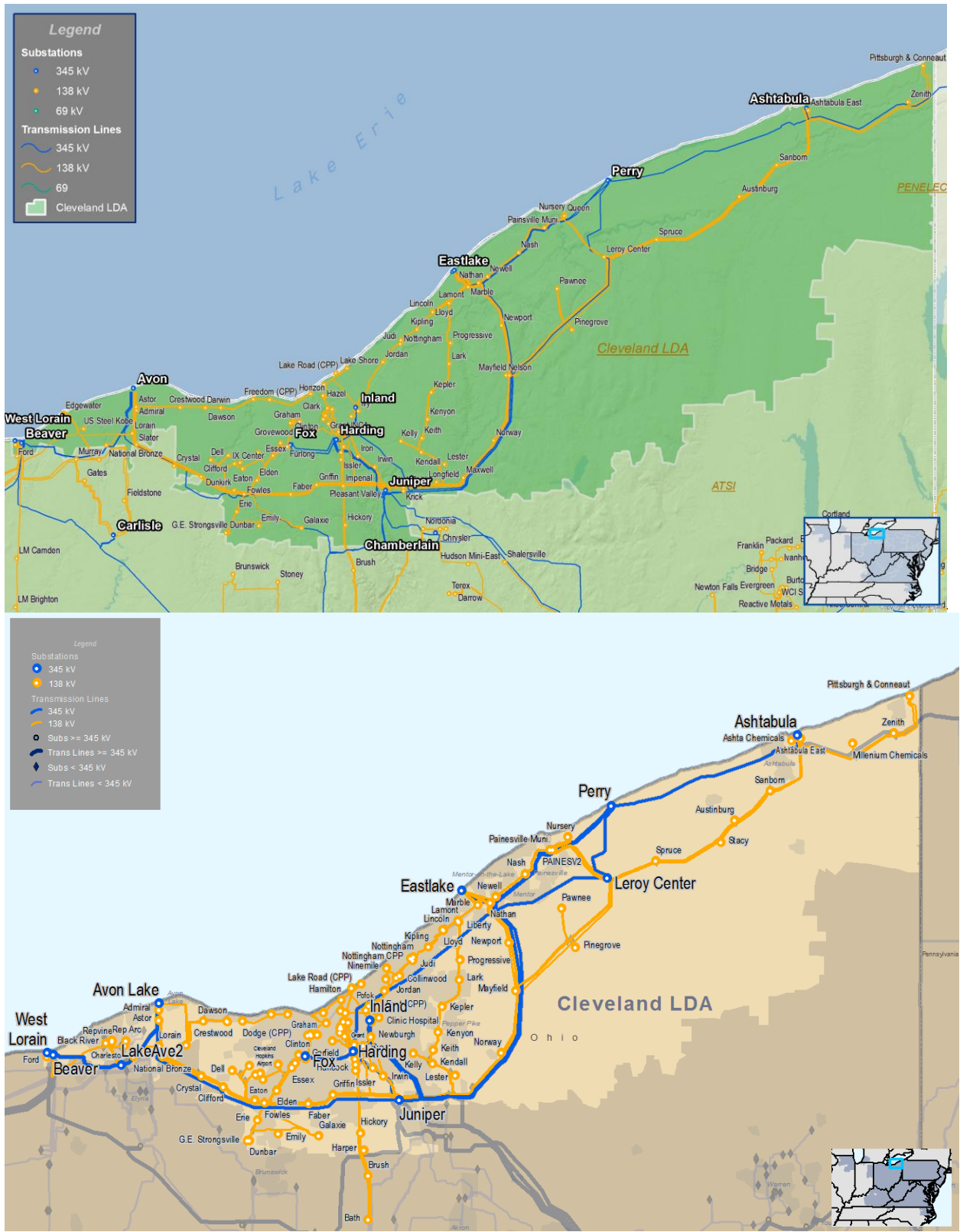


Figure E-3 (Cleveland LDA)



C.5.4C.2.3 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, interchange 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>.~~

~~C.5.4.1C.2.3.1 Study Load Deliverability Area Capacity Deficiency Assumptions~~

The study area being evaluated is assumed to be experiencing ~~the a~~ generation ~~deficiency emergency~~ 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 ~~PJM Load Forecast Report LAS report~~ along with generator outage scenario(s) that would lead to a ~~generation deficiency emergency inside the LDA which and thereby potentially~~ cause a transmission import limitation. All Capacity Resources in the LDA are initially modelled online and then generator outage scenarios are developed.

To calculate plausible generator outage scenarios, a file containing the installed MW capacity and the five-year planning equivalent forced outage rate demand (EFORd) for every PJM ~~capacity resource~~ Capacity Resource will be developed. The EFORDs are developed using the Generator Availability Data System (eGADs). Information related to eGADs can be found at <http://pjm.com/markets-and-operations/etools/eqads.aspx>.

Below is a list of additional assumptions that are made when setting up and analyzing the LDA.

~~C.5.4.2 Study Area CETL Base Case Modeling Summary~~

- ~~o~~ BBehind 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. If this historic information is not available, then these units will be turned off in the power flow model and not included in the load deliverability study.
- ~~o~~ No study areas will be defined with 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).
- PARs located within PJM may be operated as needed subject to the appropriate agreements (if any) and PJM Operating Company practices. The PJM/NYISO PAR flows will be set according to Attachment B Section (B.3) (VII)(P)
- ~~If The~~ forecast 90/10 MW load ~~minus for the area under test will be reduced by~~ the available DR (~~-in-MW~~) ~~is less than the 50/50 MW load, then. The greater of the 90/10 MW load in the area under test reduced by DR or the~~ the 50/50 MW load, will be used ~~as the MW load~~ in the area being tested. If this situation arises, then the 50/50 MVAR load will need to be adjusted upwards to account for the reduction of the 90/10 MW load to the 50/50 MW load at the same power factor as the 50/50 load instead of at the higher power factor of the 90/10 load, i.e., DR is assumed to have the same power factor as the 50/50 load.

C.2.3.2 Dispatch for Load Deliverability Study Area

Two separate power flow cases are created for each LDA. The Mean Dispatch case models the average value of each generator's output for the LDA under study from over 10,000 unique dispatches at the CETO. The Discrete Outage case models the most likely discrete generator outage pattern within the LDA at the CETO. As described in the CETL determination section, thermal and voltage analysis is performed on both of these power flow cases.

C.2.3.2.1 Dispatch Procedure for 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 assigning a random value between 1 and 0 to each generator in the study area. If the random value is greater than the generator forced outage rate, then that generator is turned on at its full capability. 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.

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 and reactive capability of each generator determined using the above steps.

C.2.3.2.2 Dispatch Procedure for Discrete Outage Case

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 at the CETO.
 - a. LDA target generator outage value = LDA UCAP – LDA target generation
 - b. LDA UCAP = Sum $(1-EFORD)*P_{MAX}$ for each LDA generator
 - c. LDA target generation = LDA load – LDA CETO
4. Multiple generators at the same substation may be ~~outaged~~ **taken off line** 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~~ **taken off line** since $100\text{ MW}/300\text{ MW} = 33\%$ but two units would not be ~~outaged~~ **taken off line** since $200\text{ MW}/300\text{ MW} = 66\%$)
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.

~~If the 50/50 load is used to model the load in the test area, the forecast 90/10 MW load reduced by the amount of DR needs to be adjusted by a MW adder to reach the level of 50/50 MW load. The MVAR load associated with the 50/50 load 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>.) 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 criteria⁴.

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 requirements.

- ~~— 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.~~
 - ~~— 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.~~

C.5.4.42.3.3 Dispatch for PJM Areas Not not in a 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~~enforced.

C.5.4.4.1C.2.3.4 Dispatch for non-PJM Areas ~~Not~~ not in a 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. The PJM firm interchange shall not be adjusted as part of the load deliverability test.

No dispatch or other adjustments will be made to the non-PJM areas to support the PJM area experiencing the capacity emergency.

C.2.4 Capacity Emergency Transfer Objective (CETO) Procedure

The Capacity Emergency Transfer Objective (CETO) analysis determines a target MW import value for an LDA that ensures sufficient transmission capability exists to access available PJM capacity reserves located outside the LDA. The import value determined is a measure of the transmission capability required by the LDA so that the study area does not experience a planned, transmission-induced loss of load event more frequently, on average, than 1 time in 25 years.

The CETO for each LDA in PJM is determined using PJM’s reliability software to perform a single area reliability study for each LDA. 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 to be 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 requires no more than one loss of load event per LDA in 25 years.

More detail about the CETO is available in PJM Manual 20 – Resource Adequacy Analysis at <http://www.pjm.com/library/manuals.aspx>

C.2.5 Capacity Emergency Transfer Limit (CETL) Procedure

The goal of a PJM Load Deliverability study is to establish the amount of emergency power, or CETL, that can be reliably transferred to the study area from the remainder of PJM in the event of a generation deficiency within the study area. This transfer limit, in combination with its corresponding CETO, is then used to determine if the import capability required in order to meet the reliability objective of a 1/25 LOLE is sufficient. An indicator of the amount of reserve transfer capacity available is provided by the difference between the CETL and CETO.

C.5.5 Dispatch for Load Deliverability Study Area

C.5.5.1 Procedure to Determine Dispatch for Voltage Analysis

- 1. ~~Derate all generators in the zone by their EFORD.~~**

- ~~2. Rank generators by $EFOR_d^{(1/P_{MAX})}$.~~
- ~~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 $100\text{ MW}/300\text{ MW} = 33\%$ but two units would not be outaged since $200\text{ MW}/300\text{ MW} = 66\%$)~~
- ~~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.~~

~~C.5.5.2 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 generation 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 1 and 2 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 C.5.3.2 can be implemented and the procedure in section C.5.5.2 is repeated.~~

~~11. Any overloads that still remain will require mitigation in order for the study area GETL to exceed the GETO.~~

C.2.5.1 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.

C.2.5.1.1 Internal PJM Load Deliverability Facility List

- PJM monitors all internal transmission facilities for its load deliverability test and screens criteria violations for upgrades that pass an outage transfer distribution factor (OTDF) 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>.) The resulting list of facilities constitutes the PJM Load Deliverability Facility List and may vary from study to study because changes in system topology may change the OTDF.
- PJM ensures load deliverability for its entire region by individually studying each LDA. A different subset of the Transmission Facilities is therefore the primary focus for each study area. PJM Transmission Facilities that are not included in the Load Deliverability Facility List are still considered in the load deliverability test. However, they will not be considered as limiting Transmission Facilities for imports into an LDA unless there is also one or more Load Deliverability Facilities simultaneously limiting imports into the LDA, or unless both PJM and the Transmission Owner agree that the facility should be included in the Load Deliverability Facility List regardless of the OTDF.
- The following list of rules defines the OTDF (TDF for pre-contingency violations) cutoff for PJM facilities that will be included in the separate Load Deliverability Facility List for each study area. A TDF is the MW flow over a facility that results from a MW transfer from a source point of all PJM generation external to the study area and a sink point of all load internal to the study area. An OTDF is the TDF after a transmission outage has occurred on the system. Note that if a 100 kV and up facility has a OTDF that is below the OTDF cutoff for each LDA, then

that facility will either be addressed in the generator deliverability test or become subject to reliability screening under the standard NERC TPL 001-4 criteria².

- All non-radial facilities with a low side voltage 345 kV or greater will be included if their OTDF is greater than or equal to 5%.
- All non-radial facilities with a low side voltage 345 kV or greater will be included if their OTDF is greater than 2% and less than 5% unless both PJM and the TO agree that the facility should not be included.
- All non-radial facilities with a low side voltage 345 kV or greater will be not included if their OTDF is less than 2% unless both PJM and the TO agree that the facility should be included.
- All non-radial facilities with a low side below 345 kV with an OTDF greater than 10% will be included.
- All non-radial facilities with a low side below 345 kV with an OTDF between 5% and 10% will be included unless both PJM and the TO agree that the facility should not be included.
- All non-radial facilities with a low side below 345 kV with an OTDF less than 5% will not be included unless both PJM and TO agree that the facility should be included.
- All PJM monitored facilities will be included when determining any generation redispatch or PAR movements required for the base case development. However, only the facilities on the Load Deliverability Facility List will require a system upgrade if overloaded for this load deliverability test.
- The substations to be included for voltage analysis will be developed based on the Load Deliverability Facility List. In other words, the OTDF for a substation will be determined based on the highest OTDF of the transmission facilities directly connected to the substation under the contingency conditions that result in voltage issues. Additional substations will be included for voltage analysis if agreed to by PJM and the TO.

C.2.5.1.2 External PJM Load Deliverability Facility List

For transmission facilities outside of but electrically close to PJM, PJM conducts joint coordinated interregional studies on a periodic basis that examine and address deliverability issues between PJM and adjacent external systems. Based on the results of these joint studies, PJM may choose to include specific non-PJM transmission facilities in the load deliverability test in order to account for significant loop flows that occur through non-PJM transmission systems when large transfers within PJM are present.

C.5.6 Study Results

² 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 requirements.

- ~~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.~~

C.2.5.2.2 CETL Determination

~~The CETL for the LDA under study will be the lower of the CETLs identified during the load deliverability studies for thermal and voltage problem constraints.~~

C.2.5.2.1 CETL for Thermal Problems

- ~~1. Perform an AC contingency thermal analysis on both the Mean Dispatch Case and the Discrete Outage Case to obtain the percent loading on each flowgate for each case at the CETO.~~
- ~~2. If any overloads exist, any of the system adjustments noted in section C.2.1.3.2 can be implemented.~~
- ~~3. Any overloads that still remain will require mitigation in order for the study area CETL to exceed the CETO.~~
- ~~4. If no overloads remain at the CETO import level, then additional transfers into the LDA will be simulated and system adjustments will be applied as necessary. This procedure will be repeated until a transfer level is found (CETL) where one or more transmission facilities on the PJM Load Deliverability Facility list for the LDA under study reaches its applicable thermal limit.~~
- ~~5. The thermal CETL will be the lower of the CETLs determined from the Mean Dispatch and the Discrete Outage Cases~~

~~C.2.5.2.2 After steps 5.5.1 and 5.5.2 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

- ~~1. Perform an AC contingency voltage analysis on both the Mean Dispatch Case and the Discrete Outage Case after system adjustments have been implemented to resolve any thermal overloads. In general, rRedispatch procedures will only be performed to alleviate thermal issues and not voltage issues.~~

2. Any voltage issue that appears at the CETO will require mitigation in order for the study area CETL to exceed the CETO.
3. If no voltage issues exist at the CETO import level, then additional transfers into the LDA will be simulated and system adjustments will be applied as necessary. This procedure will be repeated until a transfer level is found (CETL) where one or more substations on the PJM Load Deliverability Facility list for the LDA under study reaches its applicable voltage limit.
4. The voltage CETL will be the lower of the CETLs determined from the Mean Dispatch and the Discrete Outage Cases.

~~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 5.5.1. 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.~~

C.5.82.6 CETO/CETL as an Input to RPM

PJM follows a similar procedure for ~~the CETO/CETL analysis-analysis~~ used as an input to the RPM Base Residual Auction (BRA). This analysis is based on the CETO/CETL ~~analysis-analysis~~ used in the RTEP Load Deliverability procedure, but focuses on a 3 year out ~~eastcase~~.

In addition to the CETO/CETL analysis performed as an input to the RPM BRA, PJM also determines if there are any easily resolved constraints that could improve the ratio between the CETL and the CETO beyond the threshold of 115%. The process for determining the inclusion of an easily resolved constraint as a transmission upgrade in the RTEP is documented in the PJM OATT (Tariff) in Section 15 of Attachment DD. Criteria needed to be met to include an easily resolved constraint as a transmission upgrade in the RTEP include:

- o The transmission upgrade(s) will result in a Capacity Emergency Transfer Limit that exceeds 1.15 times the Capacity Emergency Transfer Objective for the LDA; and

- The transmission upgrade(s) is/are expected to be in-service prior to June 1 of the Delivery Year for which the Base Residual Auction is being conducted; and
- The transmission upgrade cost is expected to be less than \$5 million; and
- There are no Merchant Network Upgrades that have or are expected to have an executed Facilities Study Agreement by 45 days prior to the Base Residual Auction that are designed to resolve the same constraint for which the RTEP upgrade is designed to resolve.

The annual costs of such upgrade shall be allocated as specified in Schedule 12 of the tariff.

C.5.8.1 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.~~