Section 1: Resource Adequacy Planning

1.1 Overview

This manual focuses on the criteria, studies, and methodologies employed to ensure resource adequacy of the PJM system effective with the 2025/2026 Delivery Year. In particular,

- The Reserve Requirement Study (RRS). This is the study that calculates, for a future Delivery Year, the amount of installed and unforced capacity reserves required by the PJM system to meet the RTO-wide resource adequacy criteria.
- The Capacity Emergency Transfer Objective (CETO) studies. These studies are performed, for a future Delivery Year, at the Locational Deliverability Area (LDA) level, to determine the amount of imports an LDA requires to meet the LDA resource adequacy criteria.
- The Effective Load Carrying Capability (ELCC) study. This study is performed, for a future Delivery Year, to determine the accreditation that Capacity Resources can use to offer or otherwise provide capacity in the Capacity Market.
- The resource adequacy criteria employed at the RTO level and at the Locational Deliverability Area (LDA) level to perform the above studies.

1.2 Resource Adequacy Metrics

- Loss of Load Expectation (LOLE): Expressed in terms of days per year. It refers to the number of days in a year that are expected to have a single loss of load event (or multiple non-contiguous events) regardless of the duration or magnitude.
- Loss of Load Hours (LOLH): Expressed in terms of hours per year. It refers to the number of hours in a year that are expected to have a loss of load.
- Expected Unserved Energy (EUE): Expressed in terms of megawatt-hours per year. It refers to the number of megawatt-hours in a year that are expected to be unserved during loss of load events. A normalized version of this metric can be derived by dividing the EUE value by the total forecasted annual energy.

1.3 Resource Adequacy Criteria

- RTO-wide: The RTO-wide Resource Adequacy Criteria is a LOLE criterion of 1 day in 10 years, or 0.1 days per year.
- LDA: The LDA Resource Adequacy Criteria is a normalized EUE criterion of 40% times Portfolio EUE times Annual Energy Normalizing Factor for an area, where
  - Portfolio EUE. This is the Expected Unserved Energy of the RTO when the RTO meets the RTO-wide Resource Adequacy Criteria, and

- Annual Energy Normalizing Factor is defined as the LDAs' forecasted Annual Net Energy divided by the RTO's forecasted Annual Net Energy

1.4 Key Parameters

- Capacity Benefit Margin (CBM). This value represents the maximum external emergency capacity assistance that can impact the Installed Reserve Margin and Forecast Pool Requirement.
- Capacity Benefit of Ties (CBOT). This value represents the actual external emergency capacity assistance used in the calculation of the Installed Reserve Margin and Forecast Pool Requirement. It is expressed as percent of forecasted peak load.
- Installed Reserve Margin (IRM). This value is expressed as a percentage. It refers to the amount of Installed Capacity in the RTO in excess of the RTO's forecasted peak load for a future Delivery Year, which is required to meet the RTO-wide resource adequacy criteria after accounting for the CBOT. The IRM value is calculated as part of the RRS.
- Forecast Pool Requirement (FPR). This value is a scalar (greater than 1 or less than 1) representing the amount of Accredited UCAP in the RTO relative to the RTO's forecasted peak load for a future Delivery Year, which is required to meet the RTO-wide resource adequacy criteria after accounting for the CBOT. The FPR value is calculated as part of the RRS.
- Capacity Emergency Transfer Objective (CETO). This value is expressed in megawatts representing the amount of imports into an LDA that an LDA requires to meet the LDA's resource adequacy criteria.
- LDA Reliability Requirement (RR). This value is calculated for each LDA, in megawatts, representing the amount of total Accredited UCAP (internal plus external) that an LDA requires to meet the LDA's resource adequacy criteria. The LDA RR values are calculated as part of the CETO studies.
- ELCC Class Rating. This value is expressed as a percentage. It represents the rating factor, as a share of Effective Nameplate Capacity or Installed Capacity, as applicable, that ELCC Resources that are members of an ELCC Class receive as part of the calculation of the resource's Accredited UCAP. The ELCC Class Rating values are calculated as part of the ELCC study.
- Accredited UCAP: This value is expressed in megawatts of unforced capacity. It is calculated for each ELCC Resource so that a resource can offer or otherwise provide capacity in the Capacity Market. In general, it is a function of the ICAP, ELCC Class Rating and Performance Adjustment as detailed in Manual 21B: Rules and Procedures for Determination of Generating Capability.
- Pool-wide Average Accredited UCAP Factor: This value is the ratio of the total Accredited UCAP to total installed capacity of all resources in the ELCC/RRS case. It is stated in percent.

1.5 Approval Process

The ELCC/RRS model results are reviewed through the PJM Committee structure. The PJM Members Committee then forwards its recommendation for the IRM and FPR to the PJM Board. The PJM Board is ultimately responsible for approving the PJM IRM and FPR.

Section 2: Reserve Requirement Study (RRS) and Effective Load Carrying Capability (ELCC) Study

This section covers both, the RRS and the ELCC study, because the inputs and a large share of the methodology are identical for both studies. The differences between the studies concern the outputs, which for the ELCC study are described in subsections 2.6 and 2.7 and for the RRS in subsections 2.8, 2.9, and 2.10.

2.1 Overview

The objective of the RRS is to determine the amount of both, installed and accredited unforced capacity, that the system requires to meet the RTO-wide resource adequacy criteria. Specifically, the study is performed for at least each of the next five Delivery Years. The objective of the ELCC study is to determine the ELCC Class Ratings for the ELCC Classes when the system meets the RTO-wide resource adequacy criteria. Both studies, therefore, require simulating the PJM system meeting the RTO-wide resource adequacy criteria. To achieve this, multiple probabilistic scenarios of load and resource performance must be simulated. These scenarios, and their required inputs, as well as the methodology employed to get the PJM system to meet the RTO-wide resource adequacy criteria are common to the RRS and the ELCC Study.

2.2 Inputs for RRS and ELCC Study

2.2.1 Load Inputs

The load scenarios used in the RRS and ELCC Study are produced using the most recent PJM Load Forecast Model. The load scenarios are hourly and cover an entire Delivery Year. For each future Delivery Year, the load scenarios are developed using weather data beginning on June 1st, 1993 until May 31st of the most recent Delivery Year for which complete data exists, and data for other variables included in the model (e.g., economic, energy efficiency) forecasted for the Delivery Year under examination. The weather data corresponds to historical weather values recorded at the weather stations listed in PJM Manual 19: Load Forecasting and Analysis. The load scenarios include scenarios derived by assuming that the historical weather pattern occurs in the same day of the week as it historically occurred and, also, scenarios derived by assuming that the historical weather occurs ± X days relative to the day it actually occurred (this is also referred to as the “weather rotation”), as described in the annual Load Forecast Supplement. Each of the load scenarios is assumed to have the same probability of occurrence.

In addition, to account for the error between observed daily peak loads and the fitted daily peak loads produced by the PJM Load Forecast regression model, the hourly loads of each day in each load scenario in the ELCC/RRS model are adjusted randomly by a factor, determined for each day, derived by sampling from a normal distribution to be reviewed with stakeholders prior to running the ELCC/RRS model annually.

2.2.2 Resource Performance Inputs

The resource performance inputs can be divided into two input types. First, the RRS and ELCC Study require an expected portfolio of resources for a given future Delivery Year. Second, for resources included in the expected portfolio, input performance data beginning in June 1st, 2012 is required. The following paragraphs describe these two input types.

Resource Portfolio

For each future Delivery Year included in the analysis, an assumed resource portfolio is developed. The assumed resource portfolio is intended to identify resources that are expected to offer, clear, or otherwise be in-service in upcoming Delivery Years. The development of the assumed resource portfolio is therefore informed by existing Capacity Resources, submitted deactivation notices, the interconnection queue process, the Notices of Intent (NOI) submitted by planned generators, and other available information based on Sell Offers submitted in RPM Auctions or Fixed Resource Requirement plans for the applicable Delivery Year. Resources included in the assumed resource portfolio that are expected to only offer or otherwise provide a portion of their Accredited UCAP for a future Delivery Year are represented in the analysis in proportion to the expected quantity offered or delivered divided by the Accredited UCAP.

Actual or Putative Historical Resource Performance Data: the type of historical or putative historical resource performance data required by the model to derive the hourly simulated resource performance/output varies by resource type:

Unlimited Resources: for each unlimited resource, the following is required:

- Actual or putative hourly time series of full or partial forced outages since June 1st, 2012 until May 31st of the most recent Delivery Year for which complete data exists as submitted to PJM eGADS. In the case where actual historical outage data is available, the historical outage data utilized must be reflective of the current ELCC Class the resource belongs to. In the case where actual historical outage data reflective of the resource's current ELCC class is not available, putative outage data is derived for each historical hour based on the performance of existing resources in the same ELCC Class in the historical hour. For instance, if a resource with X MW of ICAP did not exist during historical hour H, but the aggregate forced outage of existing resources in the same ELCC Class during historical hour H was 30%, then the putative forced outage for the resource during historical hour H is X times 30%.
- Actual or putative hourly time series of ambient derates since June 1st, 2012 until May 31st of the most recent Delivery Year for which complete data exists as submitted to PJM eDART. The same process used to derive historical putative full or partial outage data is used to derive historical putative ambient derate data.

- Planned and Maintenance Outage Requirement. For each Delivery Year in the period June 1st, 2012 until May 31st of the most recent Delivery Year for which complete data exists, the total amount of weeks that the resource spent in a planned or maintenance outage is calculated as follows:

$$\frac{\sum_i S_i * L_i}{ICAP}$$

  where S_i is the share of the resource's ICAP (in megawatts) in a planned or maintenance outage during planned or maintenance outage i, L_i is the duration (in weeks) of planned or maintenance outage i, and ICAP is the ICAP of the resource. The source for the outage data employed in the above calculation is eGADs. For resources that do not have full history back to June 1st, 2012, the total requirement of planned and maintenance outages is calculated as the weighted average of: i) the requirement calculated with the history of the unit and ii) the requirement calculated with the entire set of units in the same class, i.e., the class average requirement, and the weights are: i) the proportion of the period between June 1st, 2012 and May 31st of the most recent Delivery Year for which complete data exists for which historical data for the unit is available and ii) one minus that proportion.
- The hourly simulated output of Unlimited Resource shall not exceed the greater of the resource's Capacity Interconnection Rights, or transitional system capability as limited by the transitional MW ceiling as defined in PJM Manual 14B: PJM Region Transmission Planning Process, awarded for the applicable Delivery Year.

Variable Resources: for each variable resource, the following is required:

- Actual or putative hourly time series of full or partial output since June 1st, 2012 until May 31st of the most recent Delivery Year for which complete data exists. In the case where actual historical output data is available, the data must be reflective of the current ELCC Class the resource belongs to. In the case where actual historical output data reflective of resource's current ELCC class is not available, putative output data is derived by the backcast process described in Manual 21B: Rules and Procedures for Determination of Generating Capability. The hourly actual output of a Variable Resource is adjusted to reflect a unit's actual historical curtailments and the simulated output of a Variable Resource is capped in any hour at: (i) the greater of the unit's CIR MW value, or the transitional system capability as limited by the transitional resource MW ceiling as defined in PJM Manual 14B: PJM Region Transmission Planning Process, awarded for the applicable Delivery Year during hours in the months of June through October and the following May of the Delivery Year, and ii) the unit's assessed deliverability as defined in PJM Manual 14B: PJM Region Transmission Planning Process for the applicable Delivery Year during hours in the months of November through April of the Delivery Year. Specifically, for winter hours beginning 0, 1, 2, 3, 4, 5, 6, 7, 8, 18, 19, 20, 21, 22, 23, the cap is the winter deliverability MW, while for winter hours beginning 9, 10, 11, 12, 13, 14, 15, 16, 17, the cap is the light load deliverability MW.

Limited Duration Resources: for each limited duration resource, the following is required:

- Equivalent Demand Forced Outage Rate (EFORd). This value is calculated using eGADS data from the most recent 5-year period[1]. The EFORd of a resource is used to derate the maximum output of a limited duration resource in each hour in the model. If historical data is not available for a resource, the EFORd is derived using historical data of resources with similar operational characteristics in a similar duration ELCC class. If no similar duration ELCC class is identified, external sources may be used to derive an EFORd for the resource.

Combination Resources (with a Variable Resource and a Limited Duration): for each combination duration resource with a variable resource component and a limited duration component, the data described above for Variable Resources and Limited Duration Resources is required. In addition, the output of Combination Resources shall be capped in any hour at: (i) the greater of the Combination Resource's Capacity Interconnection Rights, or the transitional system capability as limited by the transitional resource MW ceiling as defined in the PJM Manual 14B: PJM Region Transmission Planning Process, awarded for the applicable Delivery Year, during the months of June through October and the following May of the Delivery Year, and (ii) the Combination Resource's assessed deliverability, as defined in the PJM Manual 14B: PJM Region Transmission Planning Process, during the months of November through April of the Delivery Year.

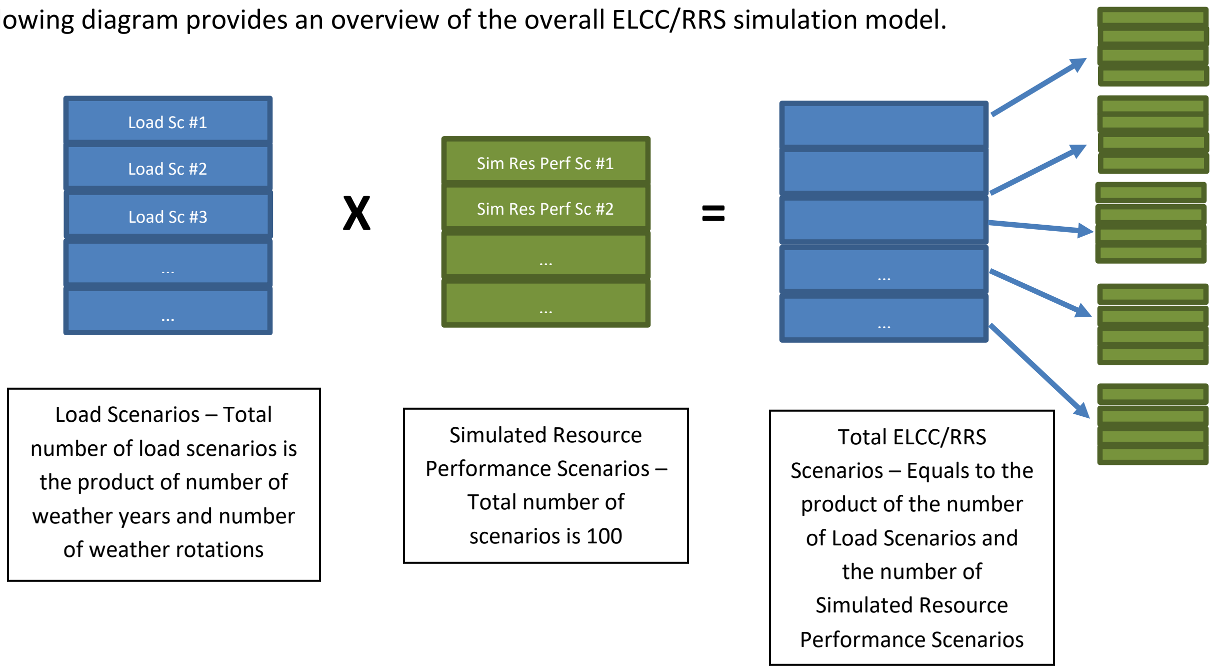
Combination Resources – Hydropower with Non-Pumped Storage: for each hydropower with non-pumped storage resource, the required data is listed and described in PJM Manual 21B: Rules and Procedures for Determination of Generating Capability. Also, an EFORd calculated using eGADS data from the most recent 5-year period is required[2].

[1] For a unit without a full most recent 5-year period history, the EFORd is calculated using the unit's forced outage data and forced outage data of all units in the relevant ELCC Class. In the case that the unit belongs to an ELCC Class that has no or very few existing units, PJM will use units with similar operational characteristics in a similar duration class to derive the EFORd. If no similar duration ELCC Class is identified, PJM may rely upon external sources to derive an EFORd for the unit.

[2] For a unit without a full most recent 5-year period history, the EFORd is calculated using the unit's forced outage data and forced outage data of all units in the Hydropower with Non-Pumped Storage ELCC Class.

2.3 Simulated Output of Resources

The simulated output of resources for each hour and scenario in the model is developed contingent on the resource type. However, prior to describing the simulated output for each resource type, the following diagram provides an overview of the overall ELCC/RRS simulation model.



This subsection describes the procedure to derive the Simulated Resource Performance Scenarios in the Figure above.

<u>Unlimited Resources</u>

Forced Outages and Ambient Derates.

The forced outages and ambient derates of unlimited resources are simulated as a function of weather. This is accomplished by setting a label for each historical day in the simulation since June 1st, 1993 based on the observed minimum hourly RTO-wide Temperature Humidity Index (THI), if the day is a winter[3] day, and the observed maximum hourly RTO-wide Temperature Humidity Index (THI), if the day is a summer day. The summer days are then grouped in Weather Bins using the maximum daily THI values. Similarly, the winter days are then grouped in Weather Bins using the minimum daily THI values. The derivation of the Weather Bins is performed using algorithms employed in the derivation of histograms (e.g. Freedman Diaconis Estimator Method) as well as adjustments necessary to avoid Weather Bins

[3] Winter comprises the months of November, December, January, February, March and Abril. Summer comprises the rest of the months.

with small sample sizes. PJM will review with stakeholders the Weather Bins prior to performing the annual ELCC/RRS.

Though the simulation uses historical days since June 1st, 1993, the historical forced outages and ambient derates of Unlimited Resources are modeled using data starting on June 1st, 2012. Therefore, the Resource Performance Bins are produced by only selecting dates starting on June 1st, 2012 in the bins described below.

Winter Weather Bins	Winter Resource Performance Bins
Bin 1: Jan XX 1994, Feb XX 1996.....Dec XX 2013, Jan XX 2018…	Bin 1: Dec XX 2013, Jan XX 2018…
Bin 2: Feb XX 1998, Jan XX 2000.....Jan XX 2015, Jan XX 2021…	Bin 2: Jan XX 2015, Jan XX 2021…
Bin 3: Dec XX 2000, Jan XX 2005.....Dec XX 2020, Feb XX 2022…	Bin 3: Dec XX 2020, Feb XX 2022…
Bin N: Jan XX 1999, Feb XX 2002.....Dec XX 2017, Jan XX 2019…	Bin N: Dec XX 2017, Jan XX 2019…

Summer Weather Bins	Summer Resource Performance Bins
Bin 1: Jun XX 1996, Aug XX 2000.....Jul XX 2017, Jul XX 2018…	Bin 1: Jul XX 2017, Jul XX 2018…
Bin 2: Aug XX 1999, Jul XX 2006.....Aug XX 2013, Jun XX 2016…	Bin 2: Aug XX 2013, Jun XX 2016…
Bin 3: Jul XX 2000, Jul XX 2005.....Jun XX 2018, Aug XX 2022…	Bin 3: Jun XX 2018, Aug XX 2022…
Bin N: Jul XX 1995, Aug XX 2002.....Aug XX 2020, Aug XX 2021…	Bin N: Aug XX 2020, Aug XX 2021…

The forced outages and ambient derates of unlimited resources are simulated for each Load Scenario by first identifying the Weather Bin that contains each day in the Load Scenario. For example, if the Load Scenario is based on weather year 2005, and the day being simulated is Jul XX, 2005, then (Summer) Bin 3 contains such day. To derive the Forced Outages and Ambient Derates for the 100 Simulated Resource Performance Scenarios for each day in each Load Scenario, 100 random draws from the days in the corresponding Resource Performance Bin are performed. Continuing with the above example, because (Summer) Bin 3 contains Jul XX, 2005, then 100 random draws are performed from the (Summer) Bin 3 Resource Performance Bin. If the corresponding Resource Performance Bin has n days, then roughly 100 / n of the random draws will be from each of the days in the Resource Performance Bin. Note that the entire 24-hour pattern of forced outages and ambient derates is used from each of the sampled days.

Planned Outages and Maintenance Outages

The planned and maintenance outages of unlimited resources are scheduled based on a heuristic that levelizes installed reserves in each Load Scenario.

The heuristic includes an initial step in which all resources are sorted based on their total requirement expressed in terms of MW * week/year. Subsequently, one by one, based on the sorted list, the resources' planned and maintenance outages are scheduled by levelizing installed reserves throughout the Delivery Year. For example, if the heuristic is scheduling the planned and maintenance outages for the first unit in the sorted list of units and the installed capacity is constant throughout the Delivery Year, the levelizing installed reserves step will schedule the outages of the unit during the weeks with contiguous lowest weekly peak loads.

In addition to the planned and maintenance outages scheduled by the above reserve-levelizing heuristic, which results in most planned and maintenance outages scheduled during periods of lower loads, the ELCC/RRS model includes planned and maintenance outages intentionally scheduled to take place during high risk periods. PJM will review with stakeholders the level of planned and maintenance outages intentionally scheduled during high risk periods prior to performing the annual ELCC/RRS.

<u>Variable Resources</u>

For variable resources, historical or putative generation performance/output data that is inclusive of all outage and derate types is used to derive the simulated performance in the model. Therefore, no differentiation between the outage/derate type being modeled is needed.

The procedure employed to derive the simulated performance of Variable Resources, except for Intermittent Hydropower, is identical to the procedure described above to simulate the forced outages and ambient derates of Unlimited Resources. In fact, the historical correlation between forced outages and ambient derates of Unlimited Resources with the performance/output of Variable Resources is maintained when performing the 100 random draws from each Resource Performance Bin.

For Intermittent Hydropower, the procedure employed to derive the simulated performance is based on using the historical hourly or putative performance/output of resources for each Delivery Year since

2012/2013 (for resources that existed at the time the historical observation was recorded). For load scenarios derived with weather starting on June 1st, 2012, the simulated hourly availability of Intermittent Hydropower resources will match the historical hourly availability (or the historical class average availability) hour by hour. For example, for a load scenario created with weather data from June 1st, 2012 through May 31st, 2013, the hourly availability of Intermittent Hydropower resources will match the historical hourly availability (or the historical class average availability) from June 1st, 2012 through May 31st, 2013. For load scenarios created with weather data from Delivery Years before June 1st, 2012, an approach that matches a Delivery Year before 2012/2013 to a Delivery Year after 2011/2012 is employed. The Delivery Year match is established based on the forecasted summer and winter peak loads of the forecasted load scenarios. For example, if the forecasted summer and winter peak loads using weather data from Delivery Year 1993/1994 are most similar in value to the forecasted summer and winter peak loads using weather data from Delivery Year 2013/2014 (compared to all the forecasted summer and winter peaks derived using weather data from Delivery Years after 2011/2012), then the simulated hourly availability of Intermittent Hydropower resources for a load scenario created with weather data from June 1st, 1993 through May 31st, 1994 will match the historical hourly availability of Intermittent Hydropower resources (or the historical class average availability) from June 1st, 2013 through May 31st, 2014. This approach was taken for Intermittent Hydropower resources, instead of the Resource Performance Bin approach, to preserve river streamflow patterns during consecutive days (under the Resource Performance Bin approach performance patterns for consecutive days in the ELCC/RRS model may come from days in different Delivery Years).

<u>Limited Duration Resources, Combination Resources and Demand Resources.</u>

For Limited Duration, Combination and Demand Resources, the simulated performance (and re-charging of resources) is mainly derived by using a simulated dispatch heuristic in each Load Scenario. For Limited Duration Resources and Combination Resource, an EFORd value is used to decrease the maximum amount of megawatts that a resource can output in each hour (and also the maximum amount of megawatts that each resource can re-charge in an hour). For example, if a 100 MW ICAP Limited Duration Resource has an EFORd equal to 5%, then the maximum hourly output of such resource in the simulation will be 100 MW x (1-5%) = 95 MW.

Demand Resources have a seasonal performance window in accordance with PJM Manual 18: PJM Capacity Market. If the simulated hour in the model requires Demand Resources to be dispatched in an hour that falls outside of the seasonal performance window, the amount of Demand Resources dispatched in the hour is assumed to be zero. If the simulated hour falls within the seasonal performance windows established for Demand Resources, then the amount of Demand Resources available to be dispatched in the hour is calculated as the Nominated Demand Resource Value (a constant value for an entire Delivery Year as forecasted in the most recent PJM Load Forecast) times F, where F is defined as the ratio of simulated hourly load (in MW) to 50/50 peak load (in MW). This approach to estimate the amount of available DR within the seasonal performance window is rooted on the assumption that Demand Resources have a Firm Service Level (FSL), which means that such resources must reduce their megawatt consumption to a specified firm level regardless of their megawatt consumption at the time of the dispatch.

The simulated dispatch heuristic has the following steps:

Chronologically, for each hour in each scenario that results from combining Load Scenarios with Simulated Resource Performance Scenarios:

- Add up total output of Unlimited Resources and Variable Resources
  - If the total output value is greater than the hourly load, the hourly preliminary margin M is positive and therefore, no output of Limited Duration Resources, Combination Resources and Demand Resources is needed. If recharging is required, it follows the following steps
    - Calculate the total hourly recharging need from the grid R from all Limited Duration Resources, and Combination Resources.
    - Compare the total recharging need R to the hourly preliminary margin M. If M is greater than or equal to R, the total hourly recharging can proceed. If M is less than R, continue to the next step.
    - Calculate the ratio M/R, which will be less than 1. Multiply the recharging need of each Limited Duration and Combination Resources' class by the M/R ratio. This partial hourly recharging for each class can proceed.
  - If the total output value is less than the hourly load, the hourly preliminary margin M is negative and therefore, Limited Duration Resources, Combination Resources and Demand Resources are dispatched. The classes are to be dispatched based on the following order, which seeks to rank classes from "more available" to "less available", until the hourly load is met or a loss of load event occurs in the simulation.
    - Demand Resources
    - 10-hour Storage
    - 8-hour Storage
    - 6-hour Storage
    - Hydropower with Non-Pumped Storage
    - Solar-Storage (4-hour) Hybrids Open-Loop
    - Solar-Storage (4-hour) Hybrids Closed-Loop
    - 4-hour Storage

    For ELCC Classes that require specific modeling of the individual units in the Simulated Dispatch (e.g., Hydropower with Non-Pumped Storage), the hourly simulated ouput of each individual unit in the class is determined based on the share of ICAP/ENC of each unit relative to the total ICAP/ENC in the class.

2.4 Calculation of LOLE and EUE

The total number of annual ELCC/RRS Scenarios can be calculated as the product of the number of Load Scenarios and the number of Simulated Resource Performance Scenarios, where the number of Load Scenarios is calculated as the product of the number of weather years and the number of weather rotations. Each of these annual ELCC/RRS Scenarios is assumed to be equally likely. Therefore, the probability of each annual ELCC/RRS Scenario is equal to one divided by the total number of annual

ELCC/RRS Scenarios. For example, if there are 30 weather Delivery Years, 13 weather rotations, and 100 Simulated Resource Performance Scenarios, the total number of annual ELCC/RRS Scenarios is 13 x 30 x 100 = 39,000 and the probability of each such scenarios is 1/39,000.

The RTO-wide Resource Adequacy Criteria is specified in terms of the Loss of Load Expectation (LOLE) metric. LOLE is calculated using the following procedure

- For each annual ELCC/RRS Scenario, count the number of days in a year that include at least one hour of loss of load;
- Multiply the quantities from the previous step by the probability of each ELCC/RRS Scenario; and
- Sum all the quantities calculated in the previous step. The result is the LOLE of the simulated system.

The LDA Resource Adequacy Criteria is specified as a function of the RTO-wide Expected Unserved Energy (EUE). Also, ELCC Class Ratings are calculated as a function of the RTO-wide EUE. EUE is calculated using the following procedure:

- For each annual ELCC/RRS Scenario, count the number of megawatt-hours of unserved energy in a year;
- Multiply the quantities from the previous step by the probability of each ELCC/RRS Scenario; and
- Sum all the quantities calculated in the previous step. The result is the EUE of the simulated system.

2.5 Meeting the RTO-wide Resource Adequacy Criteria

As noted in subsection 2.2.2, PJM uses an assumed resource portfolio as input to the ELCC/RRS model. This assumed resource portfolio may fall long or short in meeting the RTO-wide Resource Adequacy Criteria given the Load Scenarios for a future Delivery Year. Therefore, first, the Load Scenarios are per-unitized on the median value of the annual peak distribution generated by the Load Scenarios. Then, the per-unitized Load Scenarios are iteratively scaled up or down based on “candidate simulated annual peak load” values until the RTO-wide Resource Adequacy Criteria is achieved. The candidate simulated annual peak load value that allows the ELCC/RRS model to meet the RTO-wide Resource Adequacy Criteria is the “solved simulated annual peak load”. Once the solved simulated annual peak load has been found, the EUE of the system is calculated. This EUE is called the “solved EUE”. The Portfolio EUE for the Delivery Year under study is calculated as the solved EUE divided by the ratio of the solved simulated annual peak load to the forecasted annual peak load.

2.6 Calculation of ELCC Class Ratings

Once the Portfolio EUE and the solved simulated annual peak load have been found, the ELCC Class Ratings for ELCC Classes without unit-specific ELCC values are calculated as follows:

- Add an incremental quantity (e.g., 100 MW ICAP) of an Unlimited Resource with no outages to the forecasted resource portfolio. This resource serves as a proxy for a “perfect” resource. Calculate the resulting EUE of the system and the EUE improvement relative to the Portfolio EUE (i.e., Portfolio EUE minus new EUE value). The magnitude of the improvement is designated the EUE Perfect Resource Improvement.
- For each ELCC Class, setting separate runs of the ELCC/RRS model, add an incremental quantity (e.g., 100 MW ICAP/Nameplate) to the forecasted resource portfolio. Calculate the resulting EUE of the system and the EUE improvement relative to the Portfolio EUE (i.e., Portfolio EUE minus new EUE value). The magnitude of the improvement is designated the EUE Class Improvement.
- Calculate the ratio of the EUE Class Improvement to the EUE Perfect Resource Improvement. The result corresponds to the ELCC Class Rating.

No ELCC Class Rating is determined for Combination Resources and ELCC Resources in the Hydropower with Non-Pumped Storage Class, in the Complex Hybrid Class, in the Other Unlimited Resource Class, and in any ELCC Class whose members are so distinct from one another that a single ELCC Class Rating would fail to capture their physical characteristics. For such resources, Unit Specific ELCC Ratings are calculated.

2.7 Calculation of Unit-Specific ELCC Ratings

Once the Portfolio EUE and the solved simulated annual peak load have been found, the Unit-Specific ELCC Class Ratings are calculated as follows:

- Add an incremental quantity (e.g., 100 MW ICAP) of an Unlimited Resource with no outages to the forecasted resource portfolio. This resource serves as a proxy for a “perfect” resource. Calculate the resulting EUE of the system and the EUE improvement relative to the Portfolio EUE (i.e., Portfolio EUE minus new EUE value). The magnitude of the improvement is designated the EUE Perfect Resource Improvement.
- For each unit that requires a Unit-Specific ELCC Class Rating, setting separate runs of the ELCC/RRS model, add an incremental quantity of the specific unit (e.g., 100 MW ICAP/Nameplate) to the forecasted resource portfolio. Calculate the resulting EUE of the system and the EUE improvement relative to the Portfolio EUE (i.e., Portfolio EUE minus new EUE value). The magnitude of the improvement is designated the EUE Unit-Specific Improvement.
- Calculate the ratio of the EUE Unit-Specific Improvement to the EUE Perfect Resource Improvement. The result corresponds to the Unit-Specific ELCC Class Rating.

2.8 Calculation of the Installed Reserve Margin

The Installed Reserve Margin, expressed as a percentage, refers to the amount of installed capacity in the RTO in excess of the RTO's forecasted peak load for a future Delivery Year, which is required to meet the RTO-wide resource adequacy criteria after accounting for the Capacity Benefit of Ties (CBOT). PJM will review with stakeholders the CBOT prior to performing the annual ELCC/RRS. Using the total installed capacity included in the assumed resource portfolio as well as the solved simulated annual peak load, which is the annual peak load that the assumed resource portfolio can serve while meeting the RTO-wide Resource Adequacy Criteria, the IRM can be calculated as follows:

IRM = [(Total installed capacity in assumed resource portfolio / Solved Simulated Annual Peak Load) – 1] – Capacity Benefit of Ties.

2.9 Calculation of the pool-wide average Accredited UCAP Factor

The pool-wide average Accredited UCAP Factor is the ratio of total Accredited UCAP to installed capacity in the assumed resource portfolio. Mathematically,

Pool-wide average Accredited UCAP Factor = Total Accredited UCAP in assumed resource portfolio / Total installed capacity in assumed resource portfoliowhere the Total Accredited UCAP in the assumed resource portfolio is calculated using the ELCC Class Ratings and the Unit-Specific ELCC Ratings.

2.10 Calculation of the Forecast Pool Requirement

The Forecast Pool Requirement is a scalar (greater than 1 or less than 1) representing the amount of Accredited UCAP in the RTO relative to the RTO's forecasted peak load for a future Delivery Year, which is required to meet the RTO-wide resource adequacy criteria after accounting for the CBOT. The FPR is calculated as follows:

FPR = (1 + IRM) x pool-wide average Accredited UCAP Factor

<u>Section 3: Capacity Emergency Transfer Objective (CETO) Study</u>

This section the Capacity Emergency Transfer Objective (CETO) Study, which is performed for each Locational Deliverability Area (LDA) for future Delivery Years.

3.1 Overview

The objective of the CETO study is to determine the amount of imports (i.e. capacity emergency) required by an LDA to meet the LDA Resource Adequacy Criteria. The CETO value is therefore driven by the performance of the LDA's internal resources as well as the load levels inside the LDA. The CETO is calculated with the CETO model, which shares many similarities with the ELCC/RRS model.

The CETO value for an LDA is compared to the Capacity Emergency Transfer Limit (CETL). Details about the CETL and the comparison between CETO and CETL are provided in PJM Manual 14B: PJM Region Transmission Planning Process.

Note that CETO values are calculated for both, RPM and RTEP purposes. The detail below applies to both CETO types unless otherwise noted.

3.2 Inputs for CETO Study

The inputs for the CETO Study are largely the same as those for the ELCC/RRS model but the data is compiled for the LDA under study as opposed to the RTO. The following exceptions apply:

- The resource portfolio used in the CETO Study for a future Delivery Year for RPM or RTEP purposes is derived in accordance with PJM Manual 14B: PJM Region Transmission Planning Process.

3.3 Simulated Output of Resources

The heuristic to simulate the output of resources in the CETO Study is identical to the one used in the ELCC/RRS model. The only minor difference is that in a CETO Study an "import level guess" is iteratively assumed for each LDA until the LDA Resource Adequacy Criteria is achieved. The "import level guess" takes the form of perfect capacity megawatts, which are simulated as available in each hour of each scenario before the megawatt output of all other resource types (i.e., Unlimited, Variable, etc) in the LDA are counted in the simulation model.

3.4 Calculation of LOLE and EUE

The procedure to calculate LOLE and EUE in a CETO Study is identical to the procedure used in the ELCC/RRS model.

3.5 Meeting the LDA Resource Adequacy Criteria

As mentioned earlier, the CETO Study requires an "import level guess' that is iteratively updated until the LDA Resource Adequacy Criteria is achieved. The imports are megawatts of "perfect capacity" that are added to the output of the LDA's resource portfolio in each hour of each scenario to meet hourly load levels. Compared to the ELCC/RRS model, load values in the LDA are not per-unitized nor are they iteratively scaled up or down. Instead, the iterative step in the CETO study applies to the import level.

3.6 Calculation of the CETO

The import level that allows an LDA to meet the LDA Resource Adequacy Criteria in a Delivery Year is the Capacity Emergency Transfer Objective (CETO). For example, if the initial import level guess results in the LDA falling short of the LDA Resource Adequacy Criteria, the import level needs to be iteratively increased until the LDA Resource Adequacy Criteria is achieved.

3.7 Calculation on an LDA's Reliability Requirement

An LDA’s Reliability Requirement can be described as the total amount of Accredited UCAP required by the LDA to meet the LDA Resource Adequacy Criteria. Consequently, an LDA’s Reliability Requirement is calculated as the LDA’s internal Accredited UCAP (derived with the LDA’s resource portfolio in the CETO study) plus the LDA’s CETO. Note that LDA’s Reliability Requirement are only calculated for RPM purposes (and not RTEP purposes). Further adjustments to the LDA’s Reliability Requirement are performed in accordance with PJM Manual 18: PJM Capacity Market.