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Disclaimer:

Please note that PJM Manuals are living documents and these references may not be up to date. Please go to: <http://www.pjm.com/library/manuals.aspx> to ensure that the rules are correct.

Manual 10: Pre-Scheduling Operations

Section 3: Reserve Requirements

Non-Synchronized Reserve

Non-Synchronized Reserve is reserve capability of a resource that can be fully converted into energy within 10 minutes of the request from the PJM dispatcher and is provided by equipment not electrically synchronized to the system. Included as Non-Synchronized Reserve is the maximum output energy level of a resource which can be attained within 10 minutes from the PJM dispatcher’s request to initiate the starting sequence. The resources that generally qualify in this category are currently shutdown run-of-river hydro, pumped storage hydro, industrial combustion turbines, jet engine/expander turbines, and diesel generators.

Manual 11: Energy & Ancillary Services Market Operations

Section 2: Overview of the PJM Energy Markets

Intermittent Generation Resources, that are Capacity Resources, and Capacity Storage Resources shall meet the must offer requirement by either self-scheduling (Availability = Must Run) or may allow the Day-ahead Market to schedule by offering the unit as a dispatchable resource (Availability = Economic). The hourly Day-ahead self-scheduled values for intermittent resources and Capacity Storage Resources may vary hour to hour from the capacity obligation value

Section 4: Overview of the PJM Synchronized Reserve Market

Tier 1 estimates for other resource types that cannot reliably provide Synchronized Reserve service shall be set to zero MW during the market clearing process. Such resource types include, but are not limited to: Nuclear, Wind, Solar, Energy Storage Resources, and Hydro units. Owners of any specific resource(s) or these resource types may request an exception from the default zero MW estimated value of their resource(s) if they notify PJM that the resource(s) are able to reliably provide Tier 1 Synchronized Reserve. PJM will only grant such requested exceptions on a prospective basis. A resource will only be credited for Tier 1 Synchronized Reserve if the resource was considered during the market clearing process, unless such resource actually provides Tier 1 Synchronized Reserve during a Synchronized Reserve Event. For further information on the exception process, please visit "Communication Process for Consideration of Some Resources for Tier 1" at this link: <http://www.pjm.com/markets-and-operations/ancillary-services.aspx>.

A non-emergency generation capacity resource that cannot reliably provide Synchronized Reserve service may submit an offer quantity of zero MW. The participant responsible for a given resource must be able to justify a zero MW offer quantity. Certain unit types including, but not limited to, Nuclear, Wind, Solar, and Energy Storage Resources, are expected to have zero MW Tier 2 Synchronized Reserve offer quantities.

Section 5: Overview of the Non-Synchronized Reserve Market

5.2.5 Hydro Calculator

For PJM RTO-Scheduled Resources, PJM is responsible for developing the schedules for the run-of-river and pumped storage plants located within the PJM RTO and turned over to PJM for coordination. To assure hydraulic coordination of the hydro plants, PJM uses a computer program called the Hydro Calculator. The Hydro Calculator computes hourly reservoir elevations and plant generation from input river flows and plant discharges. PJM scheduling staff uses the Hydro Calculator to concentrate on economic placement of available hydro energy.

Section 11: Overview of the Day-Ahead Scheduling Reserve Market

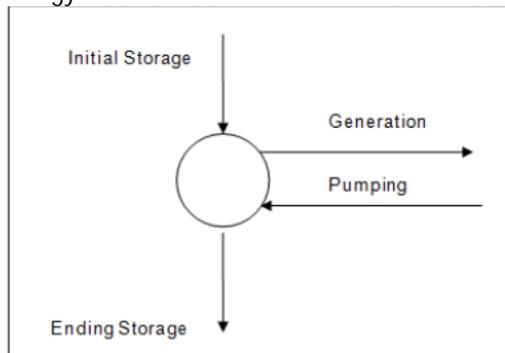
Day-Ahead Scheduling Reserve Market offers may be submitted only for those resources located electrically within the PJM RTO. Resources that cannot reliably provide Day-Ahead Scheduling Reserve obligations in real time shall be excluded from the Day-Ahead Scheduling Reserve process. Such resources types includes, but are not limited to: Nuclear units, run-of-river and self-scheduled pumped hydro units, Wind units, Solar units, and non-energy resources such as batteries which do not have capability to provide the obligations of Day-Ahead Scheduling Reserve for entire hour. Owners of any specific resource(s) or these resource types may request an exception from the default non-eligibility to provide Day-Ahead Scheduling Reserve if they notify PJM that the resource(s) are able to reliably provide Day- Ahead Scheduling Reserve Obligation in real time.

Attachment B: Pumped Storage Modeling

This Attachment describes the pumped storage model developed by PJM that can be used by participants to schedule their pumped storage plants optimally.

Description of Model

The model treats the pumped storage plant as a MWh reservoir. When the plant generates MW are removed from the reservoir, when the plant pumps MW are added. A pumping efficiency factor is used to translate the pump load to energy transferred into the reservoir. The following figure illustrates the model for a single time period.



This model enforces the classical “Conservation of Flow” constraint for each hour. Hourly Plant Storage may also be constrained by MaxStorage and MinStorage values. The Beginning and Ending storage for the day can then be constrained by setting MaxStorage and MinStorage values.

Since the objective of the unit commitment software is to minimize total cost over the study period, the resulting generation and pumping schedule will be maximized so as to produce the lowest possible system cost (maximum benefit). The conservation of flow constraint assures us that pumping will only occur if the cost of pumping can be offset by an associated benefit of generating.

The inputs to the model include:

Plant Data

- Initial Storage Level
- Final Storage Level
- Maximum Storage Level
- Minimum Storage Level
- Pumping efficiency factor.

Unit Data

- Minimum and Maximum generating and pumping limits

Note that pumping increases the storage by $- \text{Pumping Efficiency} * \text{Pumping MWh}$ and generation decreases the storage by MWh the plant is generating

Manual 12: Balancing Operations
 Section 5: Transmission Facility Control

PJM RTO Problems					
Typical Means of Control	Overloads & Excess Transfers	Low Transmission Voltage	High Transmission Voltage	Low Frequency Conditions	High Frequency Conditions
External Interchange Schedule Adjustment	Adjust External Interchange Schedules				
Generator Reactive Power Adjustment		Increase Excitation	Decrease Excitation		
Transformer Tap Adjustment		Raise/Lower Tap Position	Raise/Lower Tap Position		
Shunt Capacitor Switching		Connect to Grid	Disconnect from Grid		
Shunt Reactor Switching		Disconnect from Grid	Connect to Grid		
Synchronous Condenser Adjustment		Increase Excitation	Decrease Excitation		
Transmission Line Switching	Selected Line Switching		Outage Pre-studied Lines		
Circuit Breaker Switching	Change Network Topology			Change Network Topology	Change Network Topology
Pumped Storage Pump Operation	Change Pump Status	Shut Down Pumps	Start Up Pumps	Shut Down Pumps	Start Up Pumps
Pumped Storage Generator Operation	Change Generator Status	Start Up Generators	Shut Down Generators	Start Up Generators	Shut Down Generators
Customer Load Voltage Reduction	Apply As Necessary	Apply As Necessary		Apply As Necessary	
Customer Load Shedding	Apply As Necessary	Apply As Necessary		Apply As Necessary	

Exhibit 15: Corrective Control Strategies

Manual 13: Emergency Operations
 Section 2: Capacity Emergencies

Exhibit 3: Light Load Related Procedures

2.4.1 Actions Prior to Minimum Generation Alert

The purpose of the Minimum Generation Advisory/Alert is to provide an early alert that system conditions may require the use of the PJM Emergency Procedures. They are implemented when the expected generation level is within 2,500 MW of normal minimum energy limits. They differ in their time of issuance ahead of the event in that an Advisory is issued when PJM is aware two or more days in advance of the event, and an Alert is issued one day in advance of the event.

MINIMUM GENERATION ADVISORY

PJM Actions:

- PJM reviews the valley load forecasts for the next several days. If the RTO load is projected to be at or below 70,000 MW (Summer/Winter) or 65,000 MW (Spring/Fall), PJM Issues a **Minimum Generation Advisory** message to the Emergency Procedures site 1 or more days ahead of time to provide an informational only notice that a Min Gen Alert/Action is likely.
- PJM prepares Minimum Generation Worksheet (see [Minimum Generation Calculation](#) exhibit or [eDART Minimum Generation Calculation Worksheet](#) exhibit, each in [Attachment H](#)) to determine if Minimum Generation Alert criteria are met and if Light Load Procedures are required for upcoming scheduling period.

- PJM personnel formulate a scheduling strategy for the light load period. Hydro plant schedules are reviewed to ensure, where possible, pumping at pumped storage plants is maximized and generation at run-of-river plants is minimized during the light load period(s).
- PJM Dispatch cancels the Advisory, when appropriate.

[Attachment C: Supplementary Status Report](#)

[Part A: Instantaneous Capacity Check](#)

When PJM Dispatch requests a Supplementary Status Report, a time will be specified for providing the information on the report. In Part A, the **synchronized capacity** for all units should be broken down by the specified categories of “on cost” and maximum emergency.

- Hydro and CT/Diesel Units that can be started and synchronized within ten minutes of the time specified are to be considered instantaneous capacity.

The intent of Part A is to provide PJM with an accurate “real-time” picture of the **actual available capacity**. Part A should only include the actual available capacity at the specified time. If any part of the capacity is unavailable for any reason, (i.e. start failure, partial derating, etc.) that capacity **should not** be included in Part A but reported in Part E: Capacity Changes.

The categories of capacity are defined as follows:

Nuclear Capacity: Any nuclear unit synchronized at the time of the Supplementary Status Report. The net capacity of all nuclear units should be broken down by:

Line A - **On cost:** All capacity that will be loaded following economic dispatch.

Line B - **Max Emergency:** The total amount of capacity classified as Maximum Emergency generation. This is the amount above economic (on cost) generation that will load if PJM declares a Maximum Generation Emergency.

Fossil Capacity: Any unit synchronized that is classified as a fossil unit (including combined cycles) at the time of the Supplementary Status Report.

The net capacity of all fossil units should be broken down by:

Line C - **On-cost:** All capacity that will be loaded following economic dispatch.

Line D - **Max Emergency:** The total amount of capacity classified as Maximum Emergency generation. The total amount of capacity classified as Maximum Emergency generation. This is the amount above economic (on cost) generation that will load if PJM declares a Maximum Generation Emergency.

Hydro Capacity: Any unit that is classified as a Hydro unit (including pumped storage and run of river) at the time of the Supplementary Status Report. The net capacity of all hydro units should be broken down by:

Line E - **On-cost:** All capacity that will be loaded following economic dispatch.

CT/Diesels Capacity: Any unit synchronized that is classified as a CT or diesel unit at the time of the Supplementary Status Report.

The net capacity of all CT/Diesel units should be broken down by:

NOTE: HYDRO AND CT/DIESEL UNITS THAT CAN BE STARTED AND SYNCHRONIZED WITHIN TEN MINUTES OF THE TIME SPECIFIED ARE TO BE CONSIDERED “ON COST”.

Line F - **On-cost:** All capacity that will be loaded following economic dispatch.

Line G - **Max Emergency:** The total amount of capacity classified as Maximum Emergency generation. This is the amount above economic (on cost) generation that will load if PJM declares a Maximum Generation Emergency.

[Manual 14B: PJM Region Transmission Planning Process](#)

[Attachment D-2: PJM Reliability Planning Criteria Methods](#)

[D-2.1 Light Load Reliability Analysis](#)

The light load reliability analysis tests the ability of an electrical area to export generation resources to the remainder of PJM during light load conditions. The export generation is selected by using the historical mix of generation that operates at the light load level. This test is applied to ensure that generation capability, including renewable

generation capability that typically operates at light load such as wind, pumped hydro, or other emerging storage technologies are not "bottled" from a reliability perspective.

[Attachment G: PJM Stability, Short Circuit and Special RTEP Practices and Procedures](#) [G.2.2 Dynamics Analysis](#)

The two dynamics cases Originate from the RTEP Power Flow Case that is created for the annual RTEP Plan analyses. The annual RTEP cycle is depicted in Manual 14B, Exhibit 1. The earliest availability for this annual RTEP reference power flow case is for the impact studies associated with the interconnection request queue that closes on January 31. For subsequent project queues that close later in the year, this reference RTEP case is updated to the most current data. The reference power flow case is reviewed and modified as necessary to correspond to the dynamics database (which includes external world dynamics data from the NERC System Dynamics Data Working Group as well as PJM data.) In addition, the case is modified to include generator step-up transformers and explicit modeling of generator station service power use along with gross generator rating. Also, because of the demands of dynamics analyses, power flow static load representations are replaced with their dynamic load model representations. PJM currently represents loads as 100% constant current real power and 100% constant impedance reactive power. In light load representations, pumped storage resources are in pumping mode.

[Attachment H: Power System Modeling Data](#)

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

[Manual 14D: Generator Operational Requirements](#) [Section 12: Solar Park Requirements](#) [12.2.2 Real Time Output](#)

All solar parks greater than or equal to 3 MW (Maximum Facility Output), regardless of voltage level of connected bus, are required to provide the real-time solar park MW/MVAR output along with other data points. This output should be telemetered at low-side gross. High-side net may also be required as dictated by PJM's model. If a solar park is collocated with an energy storage facility such as a battery, then separate metering is required for each component in order to preserve solar forecast accuracy. (p95)

[Attachment E: PJM Generator and Synchronous Condenser Reactive Capability Testing](#) [E.2 General Requirements](#)

Note that the term "facilities" throughout this Attachment E includes individual generating units, aggregated generating plants including wind farms and solar projects, and synchronous condensers. The requirements in this attachment apply to all applicable facilities within the PJM RTO footprint. The requirements do not apply to PJM capacity or energy resources that are physically located outside the PJM RTO footprint or Reliability Coordinator area, or to energy storage installations such as batteries or flywheels.

- The following facilities are required to perform reactive capability testing:
- Individual generating units with a gross nameplate rating greater than 20 MVA and directly connected to the Bulk Electric System
- Generating plants/facilities with a gross aggregate nameplate rating greater than 75 MVA including variable resources such as wind, solar, run of river hydro, etc.

- Synchronous condensers with a gross nameplate rating greater than 20 MVA and directly connected to the Bulk Electric System
- All generating units providing PJM Black Start Service
- All other individual units/facilities will verify the reactive capability reported in the PJM eDART system on a periodic basis consistent with PJM Manual 14D.
- Generation Owners and Transmission Owners of synchronous condensers are required to test approximately 20% of their applicable facilities annually, totaling 100% of their applicable facilities over a 66 month period. More frequent testing may be done if the owner so chooses.
- The MOC for the operating company of a joint owned generating facility is responsible for scheduling the tests and updating the applicable eDART D-curves as required.

For the maximum lagging test at maximum real power output for generators and the maximum lagging test for synchronous condensers, the PJM reactive capability testing period will begin on May 1 and continue through September 30. The preferred testing times during these months is between 1200 – 1800 hours on weekdays.

For the maximum leading test at minimum real power output the preferred time for testing fossil steam units, nuclear units, combined cycle plants, and hydro units that operate as synchronous condensers is during the off peak hours (2300 – 0700 hours EPT) anytime during the year.

For all other required reactive testing, the owner will determine the best time to conduct the tests. Testing may be conducted in conjunction with other testing (including real power testing), provided all other requirements of the reactive capability tests are met. Facilities should be tested with all auxiliary equipment needed for normal operation in service.

As an alternative, data collected during routine operation of the facility is acceptable, provided all test requirements are met. The tests required are functional and do not require special instrumentation. They are designed to demonstrate that the ratings can be obtained for the time periods required under normal operating conditions for the equipment being tested.

Projected system conditions must permit the unit/facility to operate at the required real power and reactive power output without adversely impacting system operations. PJM will consider other test periods on a case by case basis, so long as proposed testing periods do not adversely impact system operations.

- Note: Procedures for real-power testing are contained in **PJM Manual, 21 – Rules and Procedures for Determination of Generating Capability** and the **PJM eGADS User Manual**. Also, refer to PJM Compliance Bulletin CB023, which references the submittal of real and reactive power verification data....

Applicable hydroelectric generating facilities (e.g. run of river, pumped storage) shall perform maximum leading and maximum lagging tests at maximum real power output and at minimum real power output. The maximum lagging reactive capability test at maximum real power output should be conducted for a minimum of one hour. Data for maximum leading at maximum real power output and for tests at minimum real power output may be recorded as soon as a limit is encountered.

Manual 15: Cost Development Guidelines

Section 2: Policies for All Unit Types

2.8 Regulation Service

Regulation is the capability of a specific resource with appropriate telecommunications, control and response capability to increase or decrease its output in response to a regulating control signal to control for frequency deviations.

The cost-based regulation offer is split into two portions:

Current Rules Related Energy Storage in PJM Markets
 V1: May 10, 2018

- The Regulation Capability portion consists of the fuel cost increase and unit specific heat rate degradation due to operating at lower loads and the margin risk adder;
- The Regulation Performance portion consists of the cost increase in VOM, cost increase due to heat rate increase during non-steady state operation and, where applicable, energy losses for energy storage devices.

The \$/MW value determined in the performance offer will be converted to cost per mileage \$/ΔMW by dividing the value by the mileage ΔMW/MW for the applicable signal for that offer as described in Manual 11. Regulation Capability costs to provide Regulation Service from a unit shall include the following components up to but not exceeding:

$$\text{Regulation Capability Regulation Costs} \left(\frac{\$}{\text{MWh}} \right) \leq$$

(Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at Lower Loads)

+ Margin Risk Adder

Regulation Performance costs to provide Regulation Service from a unit shall include the following components up to but not exceeding:

$$\text{Regulation Performance Costs} (\$ / \Delta\text{MW}) \leq$$

{Cost Increase in VOM
 + Cost Increase due to Heat Rate Increase during nonsteady state operation

(above heat rate factor not to exceed 0.35%) + (Energy Storage Unit Losses)}/ΔMW/MW

Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at lower loads:

The costs (in \$/MWh of Regulation) to provide Regulation Service from units shall not exceed the fuel cost increase due to operating the unit at lower loads than at the optimal economic dispatch level load and the unit specific heat rate degradation from operating at lower loads, resulting from operating the unit at lower MW output incurred from the provision of Regulation over the entire generator MW range of providing Regulation Service....

Energy Storage Unit Losses:

Energy storage unit losses can only be greater than zero for energy storage type devices and calculated in accordance with the guidance provided in section 11.8.

Cost increase in VOM:

The cost increase (in \$/MWh of Regulation) of variable operations and maintenance (VOM) cost resulting from operating the unit at lower MW output incurred from the provision of Regulation. VOM costs shall be calculated by the following methods and shall not exceed those levels below:

For non-hydro units that have been providing Regulation Service for less than 10 years, or all hydro units regardless of the historical years of Regulation Service, the following variable operation and maintenance (VOM) costs can be applied by unit type up to the following:

Unit Type	VOM
Super-critical Steam:	\$10.00 per MWh of Regulation
Sub-critical Steam:	\$3.50 per MWh of Regulation
Combined Cycle:	\$2.50 per MWh of Regulation
Combustion Turbine:	\$2.00 per MWh of Regulation
Hydro:	\$1.00 per MWh of Regulation
Energy Storage:	Based on OEM estimates initially and actual as history is available

Exhibit 4: VOM for All Hydro Units or Non-Hydro Units providing service for less than 10 years

For non-hydro units that have been providing Regulation Service for more than 10 years, the VOM rates above can be utilized only if the annual VOM dollar amounts resulting from those rates and included in Regulation cost based

offers, are subtracted from the escalated 10 or 20 year historical total VOM accounts and the Regulation MWh based on the average of the last three years.

Energy storage units that participate only in regulation Service shall include all their VOM Cost increase in VOM adder in Regulation cost offers.

Section 7: Hydro

This section contains information for the development of Hydro or Pumped Storage Hydro cost offers.

Hydro Units – Generating unit in which the energy of flowing water drives the turbine generator to produce electricity. This classification includes pumped and run-of-river hydro.

Pumped Storage Hydro Unit – Hydroelectric power generation that stores energy in the form of water by pumping from a lower elevation source to a higher elevation reservoir, then allowing the upper reservoir to drain turning the turbines to produce power.

7.1 Pumping Efficiency (Pumped Storage Hydro Only)

Pumping Efficiency is the Pumped Storage Hydro Unit's version of a heat rate. It measures the ratio of generation produced to the amount of generation used as fuel. Pumping Efficiency (PE) is calculated by dividing the MWh of generation produced while operating in generation mode by the MWh required to pump the water needed to produce the generation MWh.

$$\text{Pumping Efficiency} = \frac{\text{MWh Generation Produced}}{\text{MWh Generation Pumped as Fuel}}$$

For example, it requires 1,000 ft³ to produce one MWh of generation as water flows from the pond to the sink and it requires 1.4 MWh of pumping load to pump 1,000 ft³ of water from the sink to the pond. The resultant efficiency is:

$$\text{Pumping Efficiency} = \frac{\text{MWh Generation Produced}}{\text{MWh Generation Pumped as Fuel}} = \frac{3.5 \text{ MWh (Generated)}}{5 \text{ MWh (Pumped)}} = 0.70$$

In order to account for environmental and physical factors associated with the characteristics of the pond and pumping operations that limit the accuracy of calculating short term pumping efficiency, a seven day rolling total of pumping and generation MWh are utilized for pumping efficiency calculations.

PE can be calculated by one of three methods. A Market Seller must make the choice of method by December 31 prior to the year of operation and cannot change to another method for a period of one calendar year.

- Option 1: Twelve month calendar actual Pumping Efficiency.

The previous 12-month calendar year average Pumping Efficiency based on actual pumping operations.

- Option 2: Three month rolling Pumping Efficiency.

The previous three months rolling actual efficiency where the average monthly availability is 50% or greater. The calculation must be updated after each month.

- Option 3: The previous month actual Pumping Efficiency. The previous month actual efficiency where the availability is 50% or greater. The calculation must be updated monthly.

7.2 Performance Factors

Note: The information in Section 2.2 contains basic Performance Factor information relevant for all unit types. The following additional information only pertains to hydro units.

7.3 Fuel Cost

The fuel costs for a run-of-river hydro Unit are equal to zero. For a Pumped Storage Hydro Unit to be consistent with other PJM units within this manual the term fuel cost is used to account for the energy necessary to pump from the lower reservoir to the upper reservoir.

Note: The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to Pumped Storage Hydro Units.

If a Market Seller wishes to change its method of calculation of pumped storage TFRC, the Market Seller shall notify PJM and the MMU in writing by December 31 prior to the year of operation, to be evaluated pursuant to the Cost

Methodology and Approval Process before the beginning of the cycle in which the new method is to become effective. The new cycle starts on February 1st and continues for a period of one year

Basic Pumped Storage Fuel Cost – Pumped storage fuel cost shall be calculated on a seven (7) day rolling basis by multiplying the real time bus LMP at the plant node by the actual power consumed when pumping divided by the pumping efficiency. The pumping efficiency is determined annually based on actual pumping operations or by OEM curves if annual data is not available due to the immaturity of the unit. The following equations govern pumping storage fuel cost:

$$\text{Pumping Power Cost (\$/MWh)} = \text{Real Time LMP (\$/MWh)} * \text{Pumping Power (MWh)}$$

$$\text{Pumped Storage Fuel Cost (\$/MWh)} = \frac{\text{Pumping Power Cost (\$/MWh)}}{\text{Pumping Efficiency}}$$

Generation

Total energy input-related costs for all pumped storage hydro units shall be defined as follows:

Pumped Storage Hydro Total Energy Input Related Cost = Basic Pumped Storage Energy Input Cost + Maintenance Cost

7.4 Start-up Cost

See section 7.7 Condensing Start Costs.

7.5 No-Load Cost

Hydro Units do not have No-Load Costs.

7.6 Maintenance

Note: The information in Section 2.6 contains basic Maintenance Cost information relevant for all unit types. The following additional information only pertains to hydro units. This account shall include the cost of labor, materials used and expenses incurred in the maintenance of plant, includible in Account 332, Reservoirs, Dams, and Waterways. (See operating expense instruction 2.) However, the cost of labor materials used and expenses incurred in the maintenance of fish and wildlife, and recreation facilities, the book cost of which is includible in Account 332, Reservoirs, Dams, and Waterways, shall be charged to Account 545, Maintenance of Miscellaneous Hydraulic Plant. Further, Pumped Storage Hydro Units scheduled by the Office of the Interconnection pursuant to the hydro optimization tool in the Day-ahead Energy Market may not include maintenance costs in their offers because such offers may not exceed an energy offer price of \$0.00/MWh.

7.7 Synchronized Reserve: Hydro Unit Costs to Condense

Note: The information in Section 2.7 contains basic Synchronized Reserve Cost information relevant for all unit types.

The following additional information only pertains to hydro units if applicable.

Some Hydro Units have the ability to purge the turbines of water and run backwards effectively creating a capacitor. This method of operation of the machine is referred to as operating the Hydro unit in synchronous condensing mode. Total synchronous condensing costs for Hydro units shall include the following components:

$$\text{Hydro Costs to Condense (\$/MWh)} = \text{Condensing Start Costs} + \left(\frac{\text{VOM}}{\text{Synchronized Reserve MW}} \right) + \text{Margin}$$

Condensing Start costs if applicable, start costs shall be applied when a unit moves from cold to condensing operations and when a unit moves from condensing operations to energy generation, but shall not be applied when a unit moves from energy generation to condensing operations.

In addition (+) identified **variable Operating and Maintenance** cost in \$/Hr. divided by the Synchronized MW provided. These costs shall be totaled over the Maintenance Period and divided by total MWh generated over the maintenance period. These variable Operating and Maintenance costs shall include:

- Maintenance of Electric Plant as derived from FERC Account 544
- Maintenance of Reservoirs as derived from FERC Account 543

In addition (+) margin up to \$7.50 per MW of Synchronized Reserve service provided. Total hydro condensing offers must be expressed in dollars per hour per MW of Synchronized Reserve (\$/MWh) and must specify the total MW of Synchronized Reserve offered.

7.8 Regulation Cost

Note: The information in Section 2.8 contains basic Regulation Cost information relevant for all unit types.

Section 11: Energy Storage

This section contains information for the development of Energy Storage Resource cost offers. .

11.1 Heat Rates

Energy Storage Resources do not burn fuel so heat rates are not applicable.

11.2 Performance Factors

Note: The information in Section 2.2 contains basic Performance Factor information relevant for all unit types. The following additional information only pertains to Energy Storage Resources. Energy Storage Resources do not burn fuel so Performance Factors are equal to 1.0.

11.3 Fuel Cost

Note: The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to Energy Storage Resources

Energy Storage Resource's fuel costs are equal to zero.

11.4 Start-up Cost

Energy Storage Resource's Start Fuel and Total Fuel Related Costs are equal to zero.

11.5 No-Load Cost

Energy Storage Resources do not have No-load costs.

11.6 Maintenance

Note: The information in Section 2.6 contains basic Maintenance Cost information relevant for all unit types. The following additional information only pertains to Energy Storage Resources.

11.7 Synchronized Reserve Cost

Note: The information in Section 2.7 contains basic Synchronized Reserve Cost information relevant for all unit types. The following additional information only pertains to Energy Storage Resources if applicable.

11.8 Regulation Cost

Note: The information in Section 2.8 contains basic Regulation Cost information relevant for all unit types. The following additional information only pertains to Energy Storage Resources.

Energy Storage Resources shall calculate Energy Storage Unit Losses in accordance with the equation below. The "Cost Increase due to Heat Rate Increase during non-steady state operation" and the "Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at lower loads" shall be equal to zero. If a Market Seller wishes to change its method of calculating these losses, the Market Seller shall submit a request to change its Fuel Cost Policy to PJM and the MMU pursuant to Section 2.3.1. The approved method of calculation may be implemented upon approval and may be updated no more frequently than once every 12 months. If any action by a government or regulatory agency that results in a need for the Market Seller to change its method of cost calculation, the affected Market Seller may submit a request, or notification as appropriate, to PJM and the MMU for evaluation, pursuant to Section 2.3.1.

Energy Storage Unit Losses (\$/MW) – shall be the calculated average of seven (7) days of rolling hourly periods where the real time bus LMP (\$/MWh) at the plant node is multiplied by the net energy consumed (MWh) when regulating divided by the regulation offer (MW). The seven (7) days of rolling hourly periods shall consist of the unit's last 168 hour periods with accepted regulation offers. The following equation governs energy storage unit's fuel cost increase:

$$\text{Energy Storage Unit Losses}(\$/\text{MW}) = \text{Average of 7 Days} \left\{ \frac{(\text{Hourly LMP} \left(\frac{\$}{\text{MWh}} \right) * \text{Hourly Net Energy Consumed}(\text{MWh}))}{\text{Hourly Accepted Regulation Offers}(\text{MW})} \right\}$$

Manual 18: PJM Capacity Market

Section 1: Overview of PJM Capacity Market

Internal and external Generation Capacity Resources that can qualify as Capacity Performance Resource product type, Demand Resources that meet Capacity Performance DR product type requirements, Energy Efficiency resources that provide permanent, continuous load reduction during both summer and winter peak seasons in accordance with the Capacity Performance EE product type requirements, Capacity Storage Resources, and Qualifying Transmission Upgrades are eligible to offer as the Capacity Performance product type. Resources that clear and have a Capacity Performance Resource Commitment are subject to Non-Performance Assessment during the relevant Delivery Year in accordance with Section 8.4A of this manual.

Internal and external Generation Capacity Resources, Capacity Storage Resources, Demand Resources that meet Base Capacity DR product type requirements, Energy Efficiency Resources which only provide permanent, continuous load reduction during the defined EE Performance Hours are eligible to offer as the Base Capacity Resource product type for the 2018/2019 and 2019/2020 Delivery Years. Resources that clear and have a Base Capacity Resource Commitment are subject to Non-Performance Assessment in the months of June through September of the relevant Delivery Year in accordance with Section 8.4A of this manual.

Section 4: Supply Resources in the Reliability Pricing Model

For an RPM Auction, a party's Daily Unoffered ICAP for a generation resource is equal to the party's Minimum Available ICAP Position minus the Offered ICAP in the party's sell offer. Effective with the 2020/2021 Delivery Year, the Daily Unoffered ICAP for Capacity Storage, Intermittent, and Environmentally-Limited Resources is not applicable since these resources are not subject to a Capacity Performance must offer requirement.

$$\text{DailyUnofferICAP}_{GEN} = \text{MinAvailableICAPPosition}_{GEN} - \text{OfferedICAP}$$

...

4.9 Aggregate Resources (Effective with 2018/2019 Delivery Year)

Effective with the 2018/2019 Delivery Year, capacity resources which may not, alone, meet the operational requirements of a Capacity Performance product, may combine their capabilities and offer as a single, pseudo aggregate resource. Capacity Market Sellers that own one or more Intermittent Resources, Capacity Storage Resources, Demand Resources, Energy Efficiency Resources, or environmentally limited resources may create and offer an Aggregate Resource located in the smallest modeled LDA common to the underlying aggregated resources for a PJM approved unforced capacity value that satisfies the requirements of a Capacity Performance product. The following business rules apply to Aggregate Resources:

Intermittent Resources, Capacity Storage Resources, Demand Resources, Energy Efficiency Resources, and environmentally limited resources that are combined to form an Aggregate Resource will be considered to be located in the smallest modeled LDA common to the underlying aggregated resources and must reside in a single Capacity Market Seller account in eRPM.

4.10 Seasonal Capacity Performance Resources

Effective with the 2020/2021 Delivery Year, Capacity Market Sellers may offer Seasonal Capacity Performance Resources into RPM Auctions. A Seasonal Capacity Performance Resource is a Summer-Period Capacity Performance or Winter-Period Capacity Performance Resource, as described below.

A Summer-Period Capacity Performance Resource may include the following types of Capacity Resources that are eligible to submit a sell offer as a Summer-Period Capacity Resource: Summer-Period Demand Resource, Summer-Period Energy Efficiency Resource, Capacity Storage Resource, Intermittent Resources, or Environmentally-Limited Resource that has an average expected energy output during the summer peak-hour periods consistently and measurable greater than its average expected energy output during winter peak hour periods.

A Winter-Period Capacity Performance Resource may include the following types of Capacity Resources that are eligible to submit a sell offer as a Winter-Period Capacity Performance Resource: Capacity Storage Resource, Intermittent Resource, and Environmentally-Limited Resource that has an average expected energy output during winter peak-hour periods consistently and measurably greater than its average expected energy output during summer peak hour periods.

Section 5: RPM Auctions

With the exception of Intermittent Resources and Capacity Storage Resources, each Generation Capacity Resource with available capacity that is capable or can reasonably become capable of qualifying as a Capacity Performance Resource must submit a Capacity Performance sell offer segment.

Capacity Storage Resources shall mean any hydroelectric power plant, flywheel, battery storage, or other such facility solely used for short term storage and injection of energy at a later time. An acceptable method for determining the quantity of unforced capacity MW that may offer as Capacity Performance for a Capacity Storage Resource is based on calculating the average of the hourly output (MWh) of the intermittent resource during the expected performance hours in the summer and winter. The expected performance hours in the summer are hours ending 15:00 through 20:00 EPT in the months of June, July, and August. The expected performance hours in the winter are hours ending 6:00 through 9:00 EPT and 18:00 through 21:00 EPT in the months of January and February.

Intermittent Resources, Capacity Storage Resources, Demand Resources, Energy Efficiency Resources are not required to submit a Capacity Performance sell offer segment. (p112)

Following a Base Residual Auction, a party's Daily Unoffered ICAP for a generation resource is calculated and is equal to the Available ICAP Position minus the Offered ICAP in the party's sell offer. Effective with the 2020/2021 Delivery Year, the Daily Unoffered ICAP for Capacity Storage, Intermittent, and Environmentally-Limited Resources is not applicable since these resources are not subject to a Capacity Performance must offer requirement.

$$DailyUnofferICAP_{GEN} = AvailICAPPosition_{GEN} - OfferedICAP$$

A party's Minimum Available ICAP Position represents the minimum amount that must be offered into an RPM Auction. A party's Minimum Available ICAP Position on a unit for an RPM Auction is equal to the *minimum* Daily Minimum Available ICAP for such unit during the Delivery Year. Effective 2020/2021 Delivery Year, a party's Minimum Available ICAP for the summer/winter season will also be calculated in the eRPM system; however, Capacity Storage, Intermittent, and Environmentally Limited Resources are exempt from the Capacity Performance must offer requirement.

$$MinAvailableICAPPosition_{GEN} = Min (DailyMinAvailableICAP_{GEN})$$

A party's Daily Unoffered ICAP for a specific unit is calculated by adding the sum of any Daily Unoffered ICAP for such unit in prior RPM Auctions to Daily Unoffered ICAP amounts transacted through a party's approved unit-specific bilateral sales/purchases. Effective with the 2020/2021 Delivery Year, the Daily Unoffered ICAP for Capacity Storage, Intermittent, and Environmentally-Limited Resources is not applicable since these resources are not subject to a Capacity Performance must offer requirement.

$$DailyUnofferICAP_{GEN} = \sum (DailyUnofferICAP_{Prior\ RPM\ Auctions} + UnofferICAP_{Bilateral\ Sales/Purchases})$$

Section 8: Resource Performance Assessments

In accordance with M-21, a Net Capability Test must be performed during both the Summer and the Winter testing periods. The Summer test period begins the first day of June and ends the last day of August. The Winter test period begins the first day of December and ends on the last day of February. Alternatively, data collected during the

summer verification window may be used to satisfy winter test requirements after adjustment to appropriate ambient winter conditions. Hydro generation and pumped storage units must perform rating tests during the Summer test period. If the entire unit is on a forced or planned outage during the entire summer or winter testing period, the unit is expected to submit an out-of period capability test when the outage ends.

Manual 21: Rules and Procedures for Determination of Generating Capability

Introduction

The rules and procedures recognize the difference in types of generating units involved as resources within the PJM Capacity Markets processes and the relative ability of units to maintain output at stated capability over a specified period of time. Factors affecting such ability include fuel availability, stream flow for hydro units, reservoir storage

Section 2: Net Capability/ 2.1 General

6. The determination of Net Capability for a hydro (with storage and/or pooling capability) or pumped storage unit shall recognize the head available giving proper consideration to operating restrictions and the reservoir storage program during a normal cycle at the expected time of the PJM peak.

7. The determination of Net Capability for a storage (non-hydro) unit shall recognize the MWH energy available, giving proper consideration to other market activities for which the storage (non-hydro) unit may be committed during the expected time of the PJM peak.

10. The Net Capability of a planned steam or combined-cycle unit shall be based on the manufacturer's guarantee or estimate of performance. The Net Capability of a planned combustion turbine or combined-cycle unit shall give recognition to the elevation of the unit location, the type of fuel available for use, and the owner's policy with respect to the maximum output. The Net Capability of a planned hydro unit shall be based on the expected head and/or streamflow in accordance with items 6 or 8 above. The Net Capability of a planned storage (non-hydro) unit shall be based on the MWH energy available, given proper consideration to other market activities in which the unit may be participating at the expected time of the PJM peak.

13. All or any part of a unit's capability that can be sustained for a number of hours of continuous operation commensurate with PJM load requirements, specified as 10 hours, shall be considered as unlimited energy capability. All or any part of a unit's capability shall be considered as limited energy capability only for those periods in which it does not meet the foregoing criteria for sustained operation. Such limited energy capability will be used to meet the energy requirements of PJM and depending on the extent to which it meets these requirements such capability may be reduced as provided in Schedule 9 of the Reliability Assurance Agreement (RAA).

Section 2: Net Capability/ 2.2 Summer Net Capability

5. The determination of the Summer Net Capability of hydro (with storage and/or pooling capability) and pumped storage units shall be based on operational data or test results taken once each PJM delivery year during the summer test period under summer conditions.

6. The determination of the Summer Net Capability of storage (non-hydro) units shall be based on the expected inventory of energy given other market activities for which the storage (non-hydro) unit may be committed under summer conditions.

Section 2: Net Capability/ 2.3 Winter Net Capability

5. The determination of the Winter Net Capability shall be waived for all hydro and pumped storage units.

6. The determination of the Winter Net Capability of storage (non-hydro) units shall be based on the expected inventory of energy given other market activities for which the storage (non-hydro) unit may be committed under winter conditions.

Appendix A: Net Capability Verification Guidelines

3. If adequate data is available from normal operation to confirm Net Capability values and to satisfy the reporting requirements during the respective test period, data from normal operation can be used for that period's verification test. Units for which the foregoing data is not available shall be required to specifically test to confirm Summer and Winter Net Capability values. A test shall include any unit brought on-line or a unit that is on-line and its mode of operation altered for the specific purpose of capability verification. All verification tests, including those based on

actual operating data, shall be corrected for the respective summer or winter conditions. Cooling water and ambient conditions typically do not affect the performance of hydroelectric, pumped storage, non-hydro storage, fuel cell and diesel (including other reciprocating engine type) units; hence these types of units are exempt from the aforementioned correction criteria. However, if streamflow or fuel availability is affected, appropriate corrections for summer and/or winter conditions must be applied. The updated peaks, called the PJM Peak Hour History, are published by the Resource Adequacy Planning department after each respective test period and are posted on this PJM webpage: <http://www.pjm.com/planning/resource-adequacyplanning/resource-reports-info.aspx>

4. The duration of acceptance and verification tests shall be two (2) contiguous hours for nuclear, fossil steam and combined-cycle units, one (1) contiguous hour for hydro, pumped storage, nonhydro storage, simple cycle combustion turbine, fuel cell, and diesel (including other reciprocating engine type) units. If actual operating data is used for any acceptance verification test, the data must be contiguous for the aforementioned unit types and durations.

Manual 28: Operating Agreement Accounting

Section 5: Operating Reserve Accounting

Each unit that is not dispatchable in both the Day-ahead and Real-time market will be assessed deviations as Real-time MWh – Day-ahead scheduled MWh. Units that choose to participate in the Day-ahead pumped storage optimization program are considered not dispatchable in the Day-ahead market.

Section 13: Station Power Accounting

13.1 Station Power Accounting Procedure

In accordance with the June 28, 2001 FERC order regarding PJM's treatment of generator station power (Docket No. ER01-1936, effective July 1, 2001), PJM performs monthly netting of hourly generator output and station power consumption to determine if the following billing adjustments are required:

- Adjustment to Spot Market Energy billing (for third-party supply of station power)
- Adjustment to Non-firm Point-to-point Transmission Service billing (for remote self supply of station power)

The hourly net generation MWh quantities that are used in PJM energy market settlements (excluding energy consumed for pumping at pumped storage hydro facilities, for compressors at compressed air energy storage resources, for synchronous condensing, and solely for the charging of Energy Storage Resources (i.e., batteries and flywheels) for the later injection of energy) are netted over the calendar month for each generator and for each generation owner. The charging of an electric vehicle (EV) battery used for operating the vehicle would be treated as a retail transaction, even if the EV battery is also used to provide wholesale regulation or other ancillary services. Any billing adjustments required for generators or generation owners with net negative totals are calculated and included in the subsequent month's billing cycle. (92)

Manual 36: System Restoration

Section 8: System Restoration Plan Guidelines

Base case conditions exist which include both a system configuration following a disturbance and the operational status of equipment on the system. It is recognized that some equipment failures can and will occur during a system shutdown and subsequent restoration. These failures are addressed on an individual basis as they are found and adjustments are made to system restoration procedures, where necessary. For these guidelines, the assumptions are as follows:

- Black start unit is a unit that is capable from going to a shutdown condition to an operating condition and start delivering power without assistance from the system.
- All steam generators on-line at the time of the disturbance trip offline, without damage. Emergency diesels/batteries, where available, can be used to rotate turbines on turning gear. Emergency start-up power is accomplished without incident.
- Steam units are available to synchronize or energize the bus and subsequently load at times as found in the PJM Markets database.
- All voice and data communication systems required for system operations are functional.
- Emergency energy supply systems are operational.

- Fuel inventories at all peaking units and emergency generators are adequate.
- Transmission Owner restoration plans are coordinated with the adequacy of the substation battery capability. (p57)

Manual 40: Training and Certification Requirements

Section 3: Member Training and Certification Requirements

3.2.6 Energy Storage Device Operators

For the purpose of the training and certification requirements, Energy Storage Devices are equipment that is not a PJM capacity resource but may participate in PJM's Regulation or Synchronized Reserve markets. These devices may include, but are not limited to: batteries, plug-in hybrid electric vehicles (PHEV), flywheels and compressed air. Energy Storage Device Operators are those individuals who will interact with PJM Dispatch on Regulation and Synchronized Reserve assignments.

Initial Training:

Energy Storage Device Operators must complete an initial training module on the requirements and business rules of the Regulation and Synchronized Reserve markets and the PJM All-Call responses. This training module is available online, through the PJM Learning Management System (LMS) and must be completed, along with all open and required Just-in-Time training modules, within 3 months of the individual beginning participation in the PJM markets. Anytime during this 3 month period that an Energy Storage Device operator is interacting with the PJM control room without having completed the requirement outlined above, he/she must work under the direct supervision of another operator who has met the requirement, either in person or via an on-call arrangement. For new entities, at least one individual must complete the initial training prior to that entity beginning participation in the PJM markets.

Certification:

At this time, PJM certification is not required for Energy Storage Device Operators who are only participating in the Ancillary Service markets.

Continuing Training:

Energy Storage Device Operators must annually complete a brief refresher training module on the requirements and business rules of the Regulation and Synchronized Reserve markets and the PJM All-Call responses. This training is available online, through the PJM LMS.

3.3 Compliance Monitoring Process for Training and Certification

Requirements

Section 1 of this manual describes the various elements and activities involved in implementing the PJM/Member SAT. These represent best practices that help ensure relevant training is implemented in a coordinated manner. However each SAT element does not represent a compliance monitoring point. The specific individual requirements that are monitored for compliance are outlined in Section 3.2 of this manual. For additional clarity, below is a summary of the personnel requirements against which PJM performs compliance checks on a monthly and annual basis

TO Operator

- Task verifications and reverifications completed
- Initial Training Program (ITP) completed
 - Continuing Training Program requirements met
 - 32 Hours, per calendar year, Emergency Preparedness Training
 - Required Just-In-Time Training (by assigned due date)
 - Fulfillment of Annual Training Tasks (by the end of each calendar year)
- Active NERC and PJM Transmission Certifications

MOC Generation Dispatcher

- Initial Training Program (ITP) completed
- Continuing Training Program requirements met
- Active PJM Generation Certification
 - 54 hours of continuing/refresher training, per rolling three-year calendar
 - Required Just-In-Time Training (by assigned due date)

Small Generation Plant Dispatchers

- Initial Training Program (ITP) completed
- Operator Readiness Exam passed
- Continuing Training Program requirements met
 - 24 hours of continuing/refresher training, per rolling three-year calendar
 - Required Just-In-Time Training (by assigned due date)

Demand Response Resource and Energy Storage Device Operators

- Initial Training completed
- Continuing Training Program requirements met
 - Annual refresher training module assigning via the PJM LMS
 - Required Just-In-Time Training (by assigned due date)

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6 Fuel Performance Report Form (Card 99)

This monthly report contains fuel information. THIS SECTION DOES NOT APPLY TO HYDRO AND PUMPED STORAGE, WIND OR SOLAR UNITS.

PJM Markets Gateway User Guide

11.4 Submit Daily Regulation Offer

Heat Rate @ Eco Max [BTU/kWh] – The heat rate at the default economic maximum for a resource. The economic maximum that will correspond to this rate value will be the default economic maximum that is shown on both the Daily Regulation Offers and Unit Details pages. This is an optional parameter that may be submitted in the Markets Gateway System to support the cost-based regulation offer price. If not submitted it defaults to zero. Not a valid field for a Demand Response resource or energy storage resource.

Heat Rate @ Reg Min [BTU/kWh] – The heat rate at the default regulation minimum for a resource. The regulation minimum that will correspond to this rate value will be the default regulation minimum that is shown on both the Daily Regulation Offers and Unit Details pages. This is an optional parameter that may be submitted in the Markets Gateway System to support the cost-based regulation offer price. If not submitted it defaults to zero. Not a valid field for a Demand Response resource or energy storage resource.

VOM Rate [\$/MWh of Regulation] – The increase in VOM (variable operating & maintenance expense) resulting from operating the regulating resource at a higher heat rate than is otherwise economic for the purpose of providing regulation.

Fuel Cost [\$/MBTU] – The fixed fuel costs of the resource. This value will be used to determine the heat rate adjustments during steady-state and non-steady-state operation for the purpose of providing regulation. This is an optional parameter that may be submitted in the Markets Gateway System to support the cost-based regulation offer price. If not submitted it defaults to zero. Not a valid field for a Demand Response or energy storage resource.

Energy Storage Loss [\$/MWh of Regulation] – The value is used to account for the energy losses experienced by an energy storage device while providing regulation service. This field is valid only for energy storage resources.

OATT Definitions

Capacity Storage Resource:

“Capacity Storage Resource” shall mean any hydroelectric power plant, flywheel, battery storage, or other such facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets and which participates in the Reliability Pricing Model.

Energy Storage Resource:

"Energy Storage Resource" shall mean flywheel or battery storage facility solely used for short term storage and injection of energy at a later time to participate in the PJM energy and/or Ancillary Services markets as a Market Seller.

Small Generation Resource:

"Small Generation Resource" shall mean an Interconnection Customer's device of 20 MW or less for the production and/or storage for later injection of electricity identified in an Interconnection Request, but shall not include the Interconnection Customer's Interconnection Facilities. This term shall include Energy Storage Resources and/or other devices for storage for later injection of energy.

Station Power:

"Station Power" shall mean energy used for operating the electric equipment on the site of a generation facility located in the PJM Region or for the heating, lighting, air-conditioning and office equipment needs of buildings on the site of such a generation facility that are used in the operation, maintenance, or repair of the facility. Station Power does not include any energy (i) used to power synchronous condensers; (ii) used for pumping at a pumped storage facility; (iii) used for compressors at a compressed air energy storage facility; (iv) used for charging an Energy Storage Resource or a Capacity Storage Resource; or (v) used in association with restoration or black start service.

OATT Attachment K

Appendix Section 1.10

(d) Market Sellers in the Day-ahead Energy Market shall submit offers for the supply of energy, demand reductions, or other services for the following Operating Day for each clock hour for which the Market Seller desires or is required to make its resource available to the Office of the Interconnection. Offers for the supply of energy may be cost-based, market-based, or both, and may vary hourly. Offers shall be submitted to the Office of the Interconnection in the form specified by the Office of the Interconnection and shall contain the information specified in the Office of the Interconnection's Offer Data specification, this Section 1.10.1A(d), Section 1.10.9B, Schedule 2 of the Operating Agreement, and the PJM Manuals, as applicable. Market Sellers owning or controlling the output of a Generation Capacity Resource that was committed in an FRR Capacity Plan, self-supplied, offered and cleared in a Base Residual Auction or Incremental Auction, or designated as replacement capacity, as specified in Attachment DD of the PJM Tariff, and that has not been rendered unavailable by a Generator Planned Outage, a Generator Maintenance Outage, or a Generator Forced Outage shall submit offers for the available capacity of such Generation Capacity Resource, including any portion that is self-scheduled by the Generating Market Buyer. Such offers shall be based on the ICAP equivalent of the Market Seller's cleared UCAP capacity commitment, provided, however, where the underlying resource is a Capacity Storage Resource or an Intermittent Resource, the Market Seller shall satisfy the must offer requirement by either self-scheduling or offering the unit as a dispatchable resource, in accordance with the PJM Manuals, where the hourly day-ahead self-scheduled values for such Capacity Storage Resources and Intermittent Resources may vary hour to hour from the capacity commitment. Any offer not designated as a Maximum Emergency offer shall be considered available for scheduling and dispatch under both Emergency and non-Emergency conditions...

x) Shall not exceed an energy offer price of \$0.00/MWh for pumped storage hydropower units scheduled by the Office of the Interconnection pursuant to the hydro optimization tool in the Day-ahead Energy Market....

(a) Pool-scheduled resources shall be selected by the Office of the Interconnection on the basis of the prices offered for energy and demand reductions and related services, whether the resource is expected to be needed to maintain system reliability during the Operating Day, Start-up Costs, No-load Costs and cancellation fees, and the specified operating characteristics, offered by Market Sellers to the Office of the Interconnection by the offer deadline specified in Section 1.10.1A. Hydropower units can only be pool-scheduled if they are pumped storage units and scheduled by the Office of the Interconnection pursuant to the hydro optimization tool in the Day-ahead Energy Market...

(e) Hydropower units, excluding pumped storage units, may only be self-scheduled.

Appendix Section 6.6

f) For the 2016/2017 Delivery Year and subsequent Delivery Years, the following additional parameter limits shall apply for Capacity Performance Resources, other than Capacity Storage Resources, submitted in the Day-ahead Energy Market or rebidding period that occurs after the clearing of the Day-ahead Energy Market for the following Operating Day, and for the Real-time Energy Market for the same Operating Day, unless the Capacity Market Seller has requested for its Capacity Performance Resource, and the Office of the Interconnection has granted, an adjusted unit-specific start-up and/or notification time due to actual operating constraints pursuant to the process described in subsection (b) above:

- (i) The combined start-up and notification times shall not exceed 24 hours, except when a Hot Weather Alert or Cold Weather Alert has been issued;
- (ii) When a Hot Weather Alert or Cold Weather Alert has been issued, combined start-up and notification times shall not exceed 14 hours;
- (iii) When a Hot Weather Alert or Cold Weather Alert has been issued, notification time shall not exceed one hour; and,
- (iv) When a Hot Weather Alert or Cold Weather Alert has been issued, parameters shall be based on the actual operational limitations of the Capacity Performance Resource for both its market-based schedules and cost-based schedules.

Capacity Storage Resources that clear in a Reliability Pricing Model Auction shall, unless the Capacity Market Seller has requested for its Capacity Storage Resource, and the Office of the Interconnection has granted, an adjusted unit-specific start-up and notification time, and/or minimum down time, due to actual operating constraints pursuant to the process described in subsection (b) above:

- (i) Have combined start-up and notification times that shall not exceed one hour; and,
- (ii) Have a minimum down time that shall not exceed one hour.

OATT Attachment DD

Section 5.5A

(a) Capacity Performance Resources

Capacity Performance Resources are Capacity Resources which, to the extent such resources cleared in a Reliability Pricing Model Auction or are otherwise committed as a Capacity Resource, are obligated to deliver energy during the relevant Delivery Year as scheduled and/or dispatched by the Office of Interconnection during the Performance Assessment Intervals. As further detailed in Section 10A of this Attachment, Capacity Performance Resources that fail to meet this obligation will be subject to a Non-Performance Charge, unless excused pursuant to Section 10A(d) of this Attachment. Subject to 5.5A(a)(i), the following types of Capacity Resources are eligible to submit a Sell Offer as a Capacity Performance Resource: internal or external Generation Capacity Resources; Annual Demand Resources; Capacity Storage Resources; Annual Energy Efficiency Resources; and Qualifying Transmission Upgrades. To the extent the underlying Capacity Resource is an external Generation Capacity Resource, such resource must meet, to the extent subsection (b) or (c) of this section is applicable to offers from such resource, meet the applicable requirements of such subsection, and if neither subsection (b) or (c) is applicable, then offers from such resource must the criteria for obtaining an exception to the Capacity Import Limit as contained in article 1 of the Reliability Assurance Agreement....

(a) Capacity Performance Resources

Capacity Performance Resources are Capacity Resources which, to the extent such resources cleared in a Reliability Pricing Model Auction or are otherwise committed as a Capacity Resource, are obligated to deliver energy during the relevant Delivery Year as scheduled and/or dispatched by the Office of Interconnection during the Performance Assessment Intervals. As further detailed in Section 10A of this Attachment, Capacity Performance Resources that fail to meet this obligation will be subject to a Non-Performance Charge, unless excused pursuant to Section 10A(d) of this Attachment. Subject to 5.5A(a)(i), the following types of Capacity Resources are eligible to submit a Sell Offer as a Capacity Performance Resource: internal or external Generation Capacity Resources; Annual Demand Resources; Capacity Storage Resources; Annual Energy Efficiency Resources; and Qualifying Transmission Upgrades. To the extent the underlying Capacity Resource is an external Generation Capacity Resource, such resource must meet, to the extent subsection (b) or (c) of this section is applicable to offers from such resource, meet the applicable requirements of such subsection, and if neither subsection (b) or (c) is applicable, then offers from such resource must the criteria for obtaining an exception to the Capacity Import Limit as contained in article 1 of the Reliability Assurance Agreement.

(e) Seasonal Capacity Performance Resource

For the 2020/2021 Delivery Year and subsequent Delivery Years, a Seasonal Capacity Performance Resource shall mean a Summer-Period Capacity Performance Resource or Winter-Period Capacity Performance Resource, as defined below.

i) Summer-Period Capacity Performance Resource

For the 2020/2021 Delivery Year and subsequent Delivery Years, the following types of Capacity Resources are eligible to submit a Sell Offer as a Summer-Period Capacity Performance Resource: Summer Period Demand Resource, Summer-Period Energy Efficiency Resource, and Capacity Storage Resource, Intermittent Resource, or Environmentally-Limited Resource that has an average expected energy output during summer peak-hour periods consistently and measurably greater than its average expected energy output during winter peakhour periods. To the extent such resource clears an RPM Auction or is otherwise committed as a Summer-Period Capacity Performance Resource, it is obligated to deliver energy as scheduled and/or dispatched by the Office of Interconnection during Performance Assessment Intervals occurring in the calendar months of June through October and the following May of the Delivery Year, and must satisfy the requirements of a Capacity Performance Resource for such period of time. As further detailed in section 10A of this Attachment, Summer-Period Capacity Performance Resources that fail to

meet this obligation will be subject to a Non-Performance Charge, unless excused pursuant to section 10A(d) of this Attachment...

ii) Winter-Period Capacity Performance Resource

For the 2020/2021 Delivery Year and subsequent Delivery Years, the following types of Capacity Resources are eligible to submit a Sell Offer as a Winter-Period Capacity Performance Resource: Capacity Storage Resource, Intermittent Resource, and Environmentally-Limited Resource that has an average expected energy output during winter peak-hour periods consistently and measurably greater than its average expected energy output during summer peak-hour periods. To the extent such resource clears an RPM Auction or is otherwise committed as a Winter-Period Capacity Performance Resource, it is obligated to deliver energy as scheduled and/or dispatched by the Office of Interconnection during Performance Assessment Intervals occurring in the calendar months of November through April of the Delivery Year, and must satisfy the requirements of a Capacity Performance Resource for such period of time. As further detailed in section 10A of this Attachment, Winter-Period Capacity Performance Resources that fail to meet this obligation will be subject to a Non-Performance Charge, unless excused pursuant to section 10A(d) of this Attachment.

Section 5.6

5.6.1 Specifications

A Sell Offer shall state quantities in increments of 0.1 megawatts and shall specify, as appropriate:

- a) Identification of the Generation Capacity Resource, Demand Resource, Capacity Storage Resource or Energy Efficiency Resource on which such Sell Offer is based;...
- b) (h) For the 2018/2019 Delivery Year and subsequent Delivery Years, a Capacity Market Seller that owns or controls one or more Capacity Storage Resources, Intermittent Resources, Demand Resources, or Energy Efficiency Resources may submit a Sell Offer as a Capacity Performance Resource in a MW quantity consistent with their average expected output during peak-hour periods. Alternatively, for the 2018/2019 Delivery Year and subsequent Delivery Years, a Capacity Market Seller that owns or controls one or more Capacity Storage Resources, Intermittent Resources, Demand Resources, Energy Efficiency Resources, or Environmentally-Limited Resources may submit a Sell Offer which represents the aggregated Unforced Capacity value of such resources, where such Sell Offer shall be considered to be located in the smallest modeled LDA common to the aggregated resources. Such aggregated resources shall be owned by or under contract to the Capacity Market Seller, including all such resources obtained through bilateral contract and reported to the Office of the Interconnection in accordance with the Office of the Interconnection's rules related to its eRPM tools. For the 2018/2019 and 2019/2020 Delivery Years, any such offer may be submitted as Capacity Performance Resource, Base Capacity Resource, or as a coupled offer for Capacity Performance Resource and Base Capacity Resource, provided that, for any such coupled Sell Offers, the offer price of a Capacity Performance Resource offer must be at least \$.01 per MW-day greater than the offer price of a coupled Base Capacity Resource offer. For the 2020/2021 Delivery Year and subsequent Delivery Years, any such offer must be submitted as a Capacity Performance Resource.

Section 6

(c) Exceptions to the requirement in subsection (a) shall be permitted only for a resource which the Capacity Market Seller demonstrates is reasonably expected to be physically incapable of satisfying the requirements of a Capacity Performance Resource. Intermittent Resources, Capacity Storage Resources, Demand Resources, and

Energy Efficiency Resources shall not be required to offer as a Capacity Performance Resource, but shall not be precluded from being offered as a Capacity Performance Resource at a level that demonstrably satisfies such requirements. Exceptions shall be determined using the same timeline and procedures as specified in section 6.6.

Section 10A

Where the result of such formula is a positive number and where:
Expected Performance =

for Generation Capacity Resources (including external Generation Capacity Resources for any Performance Assessment Interval for which performance by such external resource would have helped resolve a declared Emergency Action; provided, however, that for any Delivery Year up to and including the 2019/2020 Delivery Year, performance of external Generation Capacity Resources shall be assessed only during Performance Assessment Hours for Emergency Actions declared for the entire PJM Region) and Capacity Storage Resources: [(Resource Committed Capacity * the Balancing Ratio)];

where

Resource Committed Capacity = the total megawatts of Unforced Capacity of the Capacity Resource committed by such Capacity Market Seller or Locational UCAP Seller; and

The Balancing Ratio = (All Actual Generation Performance, Storage Resource Performance, Net Energy Imports and Demand Response Bonus Performance) / (All Committed Generation and Storage Capacity); provided, however, that Net Energy Imports shall be included in the calculation of the Balancing Ratio only for any Performance Assessment Interval for which performance by any external Generation Capacity Resource would have helped resolve the Emergency Action that was the subject to the Performance Assessment Hour; and provided further that for any Delivery Year up to and including the 2019/2020 Delivery Year, Net Energy Imports shall be included in the calculation of the Balancing Ratio only for any Performance Assessment Hour for which the Emergency Action was declared for the entire PJM Region; and provided further that the Balancing Ratio shall not exceed a value of 1.0.

for purposes of which

All Committed Generation and Storage Capacity = the total megawatts of Unforced Capacity of all Generation Capacity Resources (including external Generation Capacity Resources for any Performance Assessment Interval for which performance by such external resource would have helped resolve the declared Emergency Action that was the subject to the Performance Assessment Hour; provided, however, that for any Delivery Year up to and including the 2019/2020 Delivery Year, performance of external Generation Capacity Resources shall be assessed only during Performance Assessment Hours for Emergency Actions declared for the entire PJM Region) and all Capacity Storage Resources committed by all Capacity Market Sellers, FRR Entities, Locational UCAP Sellers;

All Actual Generation Performance and Storage Resource Performance = the total amount of Actual Performance for all generation resources (including external Generation Capacity Resources for any Performance Assessment Interval for which performance by such external resource would have helped resolve the declared Emergency Action that was the subject to the Performance Assessment Hour; provided, however, that for any Delivery Year up to and including the 2019/2020 Delivery Year, performance of external Generation Capacity Resources shall be assessed only during Performance Assessment Hours for Emergency Actions declared for the

entire PJM Region) and storage resources during the interval;

Net Energy Imports = the sum of interchange transactions importing energy into PJM (not including those associated with external Generation Capacity Resources and therefore included in All Actual Generation Performance) minus the sum of interchange transactions exporting energy out of PJM, but not less than zero;

Demand Response Bonus Performance = the sum of Bonus performance provided by Demand Response resources as calculated in (g) below;

and for Demand Resources, Energy Efficiency Resources, and Qualifying Transmission Upgrades: Resource Committed Capacity;

where

Resource Committed Capacity = the total megawatts of capacity committed from such Capacity Resource committed capacity without making any adjustment for the Forecast Pool Requirement

and

Actual Performance =

for each generation resource, the metered output of energy delivered to PJM by such resource plus the resource's real-time reserve or regulation assignment, if any, during the Performance Assessment Interval;

for each storage resource, the metered output of energy delivered to PJM by such resource plus the resource's real-time reserve or regulation assignment, if any, during the Performance Assessment Interval;

RAA

Schedule 9

PROCEDURES FOR ESTABLISHING THE CAPABILITY OF GENERATION CAPACITY RESOURCES

- A. Such rules and procedures as may be required to determine and demonstrate the capability of Generation Capacity Resources for the purposes of meeting a Load Serving Entity's obligations under the Agreement shall be developed by the Office of Interconnection and maintained in the PJM Manuals.
- B. The rules and procedures for determining and demonstrating the capability of generating units to serve load in the PJM Region shall be consistent with achieving uniformity for planning, operating, accounting and reporting purposes.
- C. The rules and procedures shall recognize the difference in types of generating units and the relative ability of units to maintain output at stated capability over a specified period of time. Factors affecting such ability include, but are not limited to, fuel availability, stream flow for hydro units, reservoir storage for hydro and pumped storage units, mechanical limitations, and system operating policies.