Operating Agreement: Proposed Language for 5 Minute Dispatch and Pricing Short-Term Package

OA, Schedule 1, Section 2, 2.5 Calculation of Real-time Prices.

(e)During the Operating Day, the calculation set forth in (a) shall be performed every five minutes, using the Office of the Interconnection's Locational Marginal Price program, producing the Real-time Prices based on forecasted system conditions and the latest approved PJM security-constrained economic dispatch solution for the same target time~~during the preceding interval~~.

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2.1 Overview of PJM Energy Markets

The PJM Energy Markets consists of two markets, a Day-ahead market and a Real-time balancing market. The Day-ahead Market is a forward market in which hourly clearing prices are calculated for each hour of the next operating day based on generation offers, demand bids, Increment offers, Decrement bids and bilateral transaction schedules submitted into the Day-ahead Market. The balancing market is the real-time energy market in which the clearing prices are calculated every five minutes based on the actual system operations security-constrained economic dispatch.

Separate accounting settlements are performed for each market. The Day-ahead Market settlement is calculated for each Day-ahead Settlement Interval (hourly interval) based on scheduled hourly quantities and on day-ahead hourly prices. The balancing settlement is calculated for each Real Time Settlement Interval (five minute interval) based on actual five minute Revenue Data for Settlement MW quantity deviations from day-ahead scheduled quantities and on the applicable real-time prices. The day-ahead price calculations and the balancing (real-time) price calculations are based on the concept of Locational Marginal Pricing.

The Day-ahead Market enables participants to purchase and sell energy at binding Day-ahead Locational Marginal Prices (LMPs). The components of Day-ahead hourly LMPs are the Day-ahead System Energy Price, Day-ahead Congestion Price, and the Day-ahead Loss Price.

- It also allows transmission customers to schedule bilateral transactions at binding Day-ahead congestion charges based on the differences in the Congestion Prices between the transaction source and sink.

- Load Serving Entities (LSEs) may submit hourly demand schedules, including any price sensitive demand, for the amount of demand that they wish to lock-in at Day-ahead prices.
- Any generator that is a PJM generation capacity resource that has an RPM or FRR Resource Commitment must submit a bid schedule into the Day-ahead Market even if it is self-scheduled or unavailable due to outage. Other generators have the option to bid into the Day-ahead Market.
- Transmission customers may submit fixed, dispatchable or 'up to' congestion bid bilateral transaction schedules into the Day-ahead Market and may specify whether they are willing to pay congestion charges or wish to be curtailed if congestion occurs in the Real-time Market.
- Curtailment Service Providers (CSPs) may submit demand reduction bids.

All spot purchases and sales in the Day-ahead Market are settled at the Day-ahead prices. Congestion that results from the Day-ahead sales and purchases of energy is settled at the Day-ahead Congestion Price component of LMP. Transmission losses that result from the Day-ahead sales and purchases of energy are settled at the Day-ahead Loss Price component of LMP. After the daily quote period closes, PJM calculates the Day-ahead schedule based on the bids, offers and schedules submitted, using the scheduling programs described in Section 2 of this Manual, based on least-cost, security constrained resource commitment and dispatch for each hour of the next operating day. The Day-ahead scheduling process incorporates PJM reliability requirements and reserve obligations into the analysis. The resulting Day-ahead hourly schedules and Day-ahead LMPs represent binding financial commitments to the market participants. Financial Transmission Rights (FTRs) are accounted for at the Day-ahead Congestion Price component of LMP values (see PJM Manual 06: Financial Transmission Rights).

The Real-time Energy Market ~~is based on actual real-time operations~~ uses the~~.~~ real-time security constrained economic dispatch program to determine the least cost solution to balance supply and demand. The program considers resource offers, forecasted system conditions, and other inputs in its calculations. For more information regarding the real-time security constrained economic dispatch program, please refer to Section 2.5 of this Manual. Generators and Demand Resources that may alter their bids for use in the Real-time Energy Market as defined in Section 9.1 of this Manual during the following periods:

- during the Generation Rebidding Period which is defined from the line the office interconnection posts the results of the Day-ahead Energy Market until 1415.
- Starting at 1830 (typically after the Reliability Assessment and Commitment (RAC) Run is completed) and up to 65 minutes prior to the start of the operating hour.

Real-time LMPs and Regulation and Reserve Clearing Prices are calculated every five minutes by the Locational Price Calculator (LPC) program ~~for every Real-time Settlement Interval (five minute interval)~~ and are based on ~~actual system operating conditions~~ forecasted system conditions and the latest

approved real-time security constrained economic dispatch program solution. For more information regarding LPC, Real-time LMPs and Regulation and Reserve Clearing Prices, refer to Section 2.7 of this Manual. ~~as described by the PJM state estimator~~. LSEs pay the applicable Real-time LMPs for any demand that exceeds their Day-ahead scheduled quantities (and receive revenue for demand deviations below their scheduled quantities). In the balancing energy market, generators are paid the applicable Real-time LMPs for any generation that exceeds their day-ahead scheduled quantities (and pay for generation deviations below their scheduled quantities). Transmission customers pay congestion charges based on the applicable Real-time Congestion Price component of LMPs for bilateral transaction quantity deviations from Day-ahead schedules. CSPs may self-schedule demand reductions for Demand Resources not dispatched in real-time by PJM. All spot purchases and sales in the balancing market are settled at the applicable Real-time LMPs. Congestion that results from the Real-time sales and purchases of energy is settled at the Real-time Congestion Price component of LMP. Transmission losses that result from the real-time sales and purchased of energy are settled at the applicable Real-time Loss Price component of LMP.

2.2 Definition of Locational Marginal Price

Locational Marginal Price (LMP) is defined as the marginal price for energy at the location where the energy is delivered or received and ~~.~~ is based on forecasted system conditions and the latest approved real-time security constrained economic dispatch program solution. LMP is expressed in dollars per megawatt-hour ($/ MWh). LMP is a pricing approach that addresses Transmission System congestion and loss costs, as well as energy costs. Therefore, each spot market energy customer pays an energy price that includes the full marginal cost of delivering an increment of energy to the purchaser's location.

- When there is transmission congestion in PJM, the PJM dispatcher dispatches one or more of the generating units out of economic merit order to keep transmission flows within limits. There may be many resources that are dispatched to relieve the congestion. The LMP reflects the cost of re-dispatch for out-of-merit resources and cost of delivering energy to that location.
- LMPs are calculated at all injections, withdrawals, EHVs (nominal voltage of 500 KV and above), Interfaces, and various aggregations of these points.
- LMPS are calculated in both the Real-time Energy Market and Day-ahead Energy Market.
- The LMP calculation calculates the full marginal cost of serving an increment of load at each bus from each resource associated with an eligible energy offer as the sum of three separate components of LMP. In performing this LMP calculation, the cost of serving an increment of load at each bus from each resource associated with an eligible energy offer is calculated as the sum of the following three components of Locational Marginal Price:
    - System Energy Price - is the price at which the Market Seller has offered to supply an additional increment of energy from a generation resource or decrease an increment of energy being consumed by a Demand Resource. The

System Energy Price may include a portion of the defined reserve penalty factors should a reserve shortage exist.

- Congestion Price - is the effect on transmission congestion costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by a Demand Resource, based on the effect of increased generation from or consumption by the resource on transmission line loadings. The Congestion Prices may include a portion of the defined reserve penalty factors should a reserve shortage exist. As further described in Section 2.17 of this Manual, the congestion price is set to the specified transmission constraint penalty factor in the event a transmission constraint cannot be controlled below the penalty factor value. In addition, the Congestion Prices may include a portion of the defined reserve penalty factors should a reserve shortage exist.
- Loss Price - is the effect on transmission loss costs (whether positive or negative) associated with increasing the output of a generation resource or decreasing the consumption by a Demand Resource, based on the effect of increased generation from or consumption by the resource on transmission losses.

- The energy offer or offers that can serve an additional increment of load at a bus at the lowest cost, calculated in this manner, shall determine the Locational Marginal Price at that bus.

2.4 Real-Time Locational Marginal Price (LMP) Calculations

The PJM Real-time Locational Marginal Price (LMP) calculation process consists of several programming modules that are executed ~~as part of the real-time sequence~~ in order to calculate Locational Marginal Prices every five minutes. ~~The real-time sequence executes every five minutes.~~ In the Market Clearing Engine (MCE), the following systems are used in the calculation of the real-time LMP and ancillary service market clearing prices:

- The Real Time Market Applications (ASO, IT SCED and RT SCED)
- PJM State Estimator
- Locational Pricing Calculator (LPC)

Each of the PJM LMP Modules is described below in detail.

2.5 Real-Time Market Applications

To conduct the real-time markets, a multi-module software platform is used by PJM to dispatch energy, and ensure adequate reserves in real-time and regulation in near time (see the image below). The real time market applications and various other applications communicate jointly and the most recent

information from each application is stored, and upon request, provided the relevant data to each application. To run the Real-time Market, data is processed from the markets database and other PJM systems.

The applications jointly optimize the products on a 5-minute basis to ensure that all system requirements are met using the least cost resource set. The real-time market applications consist of the following:

- Ancillary Service Optimizer (ASO): The Ancillary Services Optimizer (ASO) performs the joint optimization function of energy, reserves and regulation. The ASO creates an interval-based solution over a one hour look-ahead period, as well as performs the regulation three pivotal supplier test. ASO does not calculate market clearing prices. The main functions of ASO are the commitment of all regulation resources and inflexible reserve resources for the next operating hour.
- Intermediate Term Security Constrained Economic Dispatch (IT SCED): The Intermediate Term Security Constrained Economic Dispatch (IT SCED) application is used by PJM to perform various functions over a 1-2 hour look-ahead period. Historical and current system information is used to anticipate generator performance to various requests, and to provide accurate information regarding generator operating parameters under multiple scenarios. The IT SCED solves a multi-interval, time-coupled solution to perform the following functions:
    - Calculate energy dispatch trajectory for use in real-time dispatch
    - Resource commitment recommendations for energy and reserves
    - Resource commitment decisions for economic demand resources
    - Execution of the Three Pivotal Supplier Test for energy
    - Coordinated Transaction Scheduling
- Real-Time Security Constrained Economic Dispatch (RT SCED): The Real-Time Security Constrained Economic Dispatch (RT SCED) application is responsible for dispatching resources for a future target dispatch time to maintain the system balance of energy and reserves over a near-termten-minute look-ahead period based on forecasted system conditions. The future target dispatch time is ten minutes from the program's execution time rounded up to the nearest 5 minute interval. Historical and current system information is used to anticipate generator performance to various requests, and to provide accurate information regarding generator operating parameters under multiple scenarios. RT SCED will jointly optimizes energy, regulation and reserves on online, dispatchable resources to ensure system needs are maintained. The results from the RT SCED are energy basepoints and Tier 2 and Non-Synchronized reserve commitments that are sent to resource owners in real-time. All quantities may change with each solution based on system economics and reserve needs. RT SCED determines reserves shortages.

  An RT SCED dispatch solution is executed automatically approximately every three to five minutes or when manually executed by the operator. To calculate the solution, data from multiple sources is used, including but not limited to, data regarding online and available

resources, resource offers, forecasted load, scheduled ~~and current~~ interchange, as well as various other input parameters effective for the period ending at the future dispatch target time. For Example, resource offers, Regulation and Inflexible Synchronized Reserve assignments from the 11:00 to 12:00 hour will be effective until the 12:00 future dispatch target time. Resource offers, resource offers, Regulation and Inflexible Synchronized Reserve assignments for the 12:00 to 13:00 hour will be used as input to RTSCED for the future dispatch target time of 12:05 and onwards until 13:00. The RT SCED cases uses ~~load~~ forecasted load and other system information that are effective for the ~~look-ahead interval~~future dispatch target time, rather than the time at which the case is executing, to achieve a dispatch solution that will adequately control for those forecasted conditions. Real-time data sources include:

- Load forecast data ~~from EMS~~
- Constraint data - resource sensitivities ~~from EMS~~
- State Estimator output ~~from EMS~~
- Loss Penalty Factors
- ~~Outage data from eDART~~
- Transaction data from ExSchedule
- Regulation and Inflexible Reserve commitments
- Generator operating parameters and offer data

Multiple RT SCED cases are then produced, with each solution solving the security constrained economic dispatch problem. Each of these solution cases contains:

- A ~~recommended~~ set of zonal dispatch rates
- A list of exceptions to the dispatch rates for constraint control
- Individual resource dispatch rates
- Individual Resource Desired MW level
- Individual Resource Reserve Commitments
  - Maintains Inflexible Reserve Assignments from ASO
  - Assigns flexible reserves
- Individual Resource Regulation Assignments

2.6 PJM State Estimator

The ~~Real-time LMP calculation~~ RT SCED solution depends upon having a complete and consistent power flow solution as an input. ~~This input requirement can be achieved by using a state estimator. The state estimator is a standard power system operations tool whose purpose is to provide a base case power flow solution for input into other computer programs.~~

~~The state estimator uses actual operating conditions that exist on the power grid (as described by metered inputs) along with the fundamental power system equations to calculate the remaining flows and conditions that are not metered. Since the state estimator solution provides a complete and consistent model of actual operating conditions based upon observable (metered) input and an underlying mathematical model, it can be used to provide the basis for the Locational Marginal Price calculations. The inputs to the state estimator are the available~~

~~(metered) real-time measurements, the current status of equipment (lines, generators, transformers, etc.), and the bus load distribution factors~~.

The state estimator is a standard power system operations tool whose purpose is to provide a base case power flow solution for input into other computer programs. It depends upon data redundancy and the underlying physical and mathematical relationships of the power system to provide a solution with less error than the original measurements. Therefore the state estimator can correct "bad data" and calculate missing data in the model to provide a consistent representation of existing network conditions.

The inputs to the state estimator are the available (metered) real-time measurements, the current status of equipment (lines, generators, transformers, etc.), and the bus model (impedance, parameters, etc.). The state estimator uses actual operating conditions that exist on the power grid (as described by metered inputs) along with the fundamental power system equations to calculate bus voltage and angle and flows based on metered data. Since the state estimator solution provides a complete and consistent model of actual operating conditions based upon metered input and an underlying mathematical model, it can be used to provide the basis for the Locational Marginal Price calculations.

~~This standard industry tool depends upon data redundancy and the underlying physical and mathematical relationships of the power system to provide a solution with less error than the original measurements. Therefore the state estimator can correct "bad data" and calculate missing data in the model to provide a consistent representation of existing network conditions.~~

~~The PJM state estimator is run on a thirty-second cycle and can provide the following inputs to the PJM LMP Model, on a five-minute basis~~ A new state estimator solution is typically available every minute to RTSCED and can provide the following inputs:

- AC power flow solution
- Actual generator MW output
- Bus loads
- Tie line flows
- MW losses by transmission zone
- Actual MW flow on any constrained transmission facility

2.7 Locational Pricing Calculator (LPC)

The function of the Locational Pricing Calculator (LPC) is to determine the Real-Time LMP values and Regulation and Reserve Clearing Prices ~~Ancillary Service clearing prices~~ on a five minute basis. ~~To accomplish this, the LPC utilizes input data from the approved Real-Time Security Constrained Economic Dispatch (RT SCED) solution that was used to dispatch the system at the time the LPC case was executed.~~ Real-Time LMPs and Regulation and Reserve Clearing Prices are based on the latest approved real-time security constrained economic dispatch (RT SCED) program case, referred to as the reference case, for the same target time. If there is not an approved RT SCED case for the same target time, LPC will use the most recently approved RT SCED case prior to the target time as the reference case. The Real-time LMPs and Regulation and Reserve Clearing Prices calculated by LPC are applied to each five-minute Real-time Settlement Interval ending at the LPC target time.

The LPC calculates LMPs for each of the PJM nodes in the state estimator model and for interface busses used as a proxy for transfers to and from PJM and external control areas. The Real-Time LMPs are defined as the cost to serve the next increment of load at each node bus location for the current system, taking into account eligible resource real-time offer prices and the buses' location with respect to transmission limitations and incremental system losses.

The LPC is an incremental linear optimization program that is formulated to jointly optimize and price both energy and reserves. The objective is to minimize the cost function including the cost of energy and reserves subject to the power balance constraint, the Synchronized and Primary Reserve requirements, specific generator and demand resource operating limitations, transaction MW limits, and any transmission constraints that currently exist on the system and a normalized distribution of system losses to a network location. Every 5 minutes the LPC calculates:

- Locational Marginal Prices (LMPs)
- Synchronized Reserve Market Clearing Prices (SRMCPs)
- Non-Synchronized Reserve Market Clearing Prices (NSRMCPs)
- Regulation Market Clearing Prices (RMCPs) and Regulation Market Performance Clearing Price (RMPCP), which are then used to derive the Regulation Market Capability Clearing Price (RMCCP)

Each energy and reserve clearing price is calculated as the cost to serve the next MW of demand for each individual product considering its impact on the others. For example, LMPs are calculated such that they reflect the cost to serve the next MW of energy demand in each location while considering the impact of that additional MW of energy on the ability to meet the Primary Reserve and Synchronized Reserve Requirements. This method of calculation of LMPs is consistent with the joint optimization of energy and reserves performed and ensures consistency between LMPs and dispatch directives. Regulation clearing prices are calculated as the cost of the last resource committed to meet the Regulation requirement, as further described in section 3.

2.9.1 Determination of a Reserve Shortage

If the approved Real-Time Security Constrained Economic Dispatch (RT SCED) solution used by the Locational Pricing Calculator forecasts a Primary Reserve shortage and/or a Synchronized Reserve shortage as further described in the Section(s) 2.8 and 4.2 of this Manual, PJM shall deem this to be a Primary Reserve shortage and/or a Synchronized Reserve shortage. PJM shall implement shortage pricing through the inclusion of the applicable Primary Reserve and/or Synchronized Reserve Penalty Factors in the Real-Time LMP and reserve pricing calculations.

Shortage pricing shall exist until the approved RT SCED solution used in a pricing interval is able to meet the specified reserve requirements and no Voltage Reduction Action or Manual Load Dump Action is still in effect.

If a Primary Reserve shortage and/or Synchronized Reserve shortage exists and cannot be accurately forecasted by the Office of the Interconnection due to a technical problem with or malfunction of the Real-Time Security Constrained Economic Dispatch (RT SCED) software program, including but not limited to program failures or data input failures, PJM utilizes the best available alternate data sources to determine if a Reserve Zone or Reserve Sub-zone is experiencing a Primary Reserve shortage and/or a Synchronized Reserve shortage.

2.13.2 Balancing Settlement

Balancing settlement is based on the Real-time five minute LMP values. The components of Real-time LMPs are the Real-time System Energy Price, Real-time Congestion Price, and the Real-time Loss Price. Please refer to PJM Manual 28: Operating Agreement Accounting for additional settlements details. FTRs do not apply to balancing settlement. FTRs apply to the day-ahead settlement only, because of the market revenue adequacy issue. PJM cannot provide financial hedging in both the day-ahead and the balancing markets, which in effect is selling the service twice.

3.1 Overview of the PJM Regulation Market

The PJM Regulation Market provides PJM participants with a market-based system for the purchase and sale of the Regulation ancillary service. Resource owners submit specific offers for Regulation Capability and Regulation Performance, and PJM utilizes these offers together with energy offers and resource schedules from the Markets Gateway System as input data to the Ancillary Service Optimizer (ASO) which is an hour-ahead Market Clearing Engine. ASO optimizes the RTO dispatch profile and forecasts LMPs to determine hourly commitments of Regulation to meet the requirement. The real-time security constrained economic dispatch (RT SCED) program ~~In real-time PJM jointly optimizes the Regulation committed~~ jointly optimizes the committed Regulation ~~simultaneously~~ with energy and reserves. ~~-~~For more information on how RT SCED uses Regulation commitments in the joint optimization, please refer to Section 2.5 of this Manual. ~~and calculates t~~The five minute Regulation Market Clearing Price (RMCP) and Regulation Market Performance Clearing Price (RMPCP), are calculated by the Locational Price Calculator as described in Section 2.7 of this Manual and ~~which~~ are used to derive the five-minute Regulation Market Capability Clearing Price (RMCCP)) ~~every 5 minutes based on the current system conditions~~. These clearing prices are then used in market settlements to determine the credits awarded to providers and charges allocated to purchasers of the Regulation service.

PJM uses resource schedules, regulation, and energy offers from the Markets Gateway System as input data to the ASO to provide the lowest cost alternative for the procurement of Regulation for each hour of the operating day. The lowest cost alternative for this service is achieved through a simultaneous co-optimization with Synchronized Reserve, Non-Synchronized Reserve and energy. Within the co-optimization, an RTO dispatch profile is forecasted along with LMPs for the market hour. Using the dispatch profile and forecasted LMPs, an opportunity cost, adjusted by the applicable performance score and benefits factor, is estimated for each resource that is eligible to provide regulation. The

estimated opportunity cost for Demand Resources is zero. The adjusted lost opportunity cost is added to the adjusted regulation capability cost and the adjusted regulation performance cost to make the adjusted total regulation offer cost. The adjusted total regulation offer cost is then used to create the merit order price. Resource owners may self-schedule Regulation on any qualified resource. The merit order price for any self-scheduled Regulation resource is zero. All available regulating resources are then ranked in ascending order of their merit order prices, and the lowest cost set of resources necessary to simultaneously meet the PJM Regulation Requirement, PJM Synchronized Reserve Requirement, PJM Primary Reserve Requirement and provide energy in that hour is determined. If there is an excess of self-scheduled and zero-cost offers over and beyond the Regulation requirement, PJM uses resource-specific historic performance scores, selecting those resources with the highest performance scores, as a tie-breaker to determine which set of resources to commit to meet the Regulation requirement. The least cost set of regulation resources identified through this process are then committed. Prices for Regulation are calculated simultaneously with energy and reserve every 5 minutes by the Locational Pricing Calculator (LPC). The highest merit order price associated with this lowest cost set of resources awarded regulation becomes the RMCP. The RMPCP is calculated as the highest adjusted performance offer from the set of cleared resources. The RMCCP is the difference between RMCP and RMPCP. In the after-the-fact settlement, any resources self-scheduled to provide Regulation are compensated based on the processes described in PJM Manual 28: Operating Agreement Accounting.

4.1 Overview of the PJM Synchronized Reserve Market

The PJM Synchronized Reserve Market provides PJM participants with a market-based system for the purchase and sale of the Synchronized Reserve ancillary service. Resource owners submit resource-specific offers to provide Synchronized Reserve, and PJM utilizes these offers together with energy offers and resource schedules from the Markets Gateway System, as input data to the Ancillary Service Optimizer (ASO). ASO then optimizes the RTO dispatch profile and forecasts LMPs to determine hourly commitments of the inflexible Synchronized Reserves. Although the ASO considers all available resources during its commitment process, the hourly commitments for Synchronized Reserve from the ASO are limited to inflexible resources only and may only represent a portion of PJM's Synchronized Reserve needs for the hour. The real-time security constrained economic dispatch (RT SCED) program ~~In real-time PJM~~ jointly optimizes the remaining RTO reserve needs simultaneously with energy and regulation. For more information on how RT SCED uses Synchronized Reserve commitments and Tier 2 Synchronized Reserve offers in the joint optimization, please refer to Section 2.5 of this Manual. ~~and~~ The Locational Pricing Calculator (LPC) calculates a clearing price for Synchronized Reserve every 5 minutes as described in Section 2.7 of this Manual~~based on the current system conditions~~. Five minute, real-time, Synchronized Reserve Market Clearing Prices (SRMCP) are used for market settlement.

Inflexible resources are defined as those resources that physically require an hourly commitment due to minimum run time constraints or staffing constraints. Inflexible resources include but are not limited to synchronous condensers that are operating in condensing mode solely for the purpose of providing Synchronized Reserves and Demand Resources that are prepared to curtail in response to a PJM reserve event.

PJM initially uses forecasted LMPs and resource schedules to estimate the amount of incidental Synchronized Reserve present on the PJM system due to economic dispatch and this capability is designated as Tier 1. Tier 1 is provided by any resource that is on line, following economic dispatch, and capable of increasing its output within ten (10) minutes following a call for a Synchronized Reserve Event. If the forecasted amount of Tier 1 estimated for a given duration is insufficient to meet the PJM Synchronized Reserve Requirement, PJM must commit resources to operate at a point that deviates from economic dispatch in order to provide the remainder of the requirement. The extra capacity that must be committed is designated Tier 2. ASO commits any inflexible resources that are forecasted to be economic to provide Synchronized Reserves during the operating hour. If the solution does not foresee the need to commit Tier 2 reserves or does not commit enough inflexible resources to meet the Synchronized Reserve requirement due to economics, PJM jointly optimizes the balance of the Tier 2 required in real-time with energy.

During each execution of RT SCED, additional Synchronized Reserves are committed to meet the Synchronized Reserve requirement based on ~~current~~ forecasted system conditions. IT SCED has the ability to project conditions further out into the future and make a recommendation to commit additional inflexible resources for reserves where they are economic. RT SCED has the ability to re-dispatch online generating resources to meet the Synchronized Reserve requirement in addition to committing additional flexible resources to provide Synchronized Reserves should they be economic. Prices for Synchronized Reserves are calculated simultaneously with energy, regulation and non-synchronized reserve every 5 minutes by LPC as described in Section 2.7 of this Manual. In the after-the fact settlement, any resources cleared as self-scheduled to provide Synchronized Reserve are compensated at the applicable five minute SRMCP. Any pool-scheduled resources selected to provide Synchronized Reserve are compensated at the higher of the applicable five minute SRMCP or their real-time opportunity cost plus their Synchronized Reserve offer price. LSEs required to purchase Synchronized Reserve are charged their obligation ratio share of the hourly SRMCP Credits plus their percentage share of opportunity cost credits and Tier 1 credits

4b.1 Overview of the Non-Synchronized Reserve Market

PJM has an obligation to maintain a certain quantity of total 10 minute reserves on the system. Total 10 minute reserve, or Primary Reserve, includes both Synchronized and Non-Synchronized Reserves. As defined in Section 4 of this Manual, a subset of the Primary Reserve capability must be maintained in resources that are synchronized to the system. That quantity is defined by the Synchronized Reserve requirement. The balance between the Primary and Synchronized Reserve requirements can be met by the most economic combination of additional Synchronized Reserve or Non-Synchronized reserve or some combination of the two products. This means that there is no defined, hourly requirement for Non-Synchronized reserves but it will be procured when economic to meet the Primary Reserve requirements. The PJM Non-Synchronized Reserve Market provides PJM participants with a market-based system for the purchase and sale of the Non-Synchronized Reserve ancillary service. PJM determines the MW capability of each resource based on its operational characteristics and uses this information together with energy offers and resource schedules as input data to realtime market applications. The real-time security constrained economic dispatch (RT SCED) jointly optimizes the

remaining RTO reserve needs simultaneously with energy and regulation as described in Section 2.5 of this Manual.~~The real-time market applications optimize the RTO dispatch profile while simultaneously determining the most economic set of resources to provide Synchronized and Non-Synchronized Reserves~~. Non-Synchronized Reserve commitments are telemetered to each resource. As a result of the real-time joint optimization of energy and reserves, PJM ~~will~~ calculates a clearing price for Non-Synchronized Reserve every 5 minutes~~-~~ by the Locational Pricing Calculator (LPC) as described in Section 2.7 of this Manual~~based on the current system conditions~~. The five minute Non-Synchronized Reserve Market Clearing Prices (NSRMCP) are used for market settlement.