Two Settlement
Agenda

• Two-Settlement:
  – Overview
  – Market Timelines
  – Virtual Bids
    • INC Offers
    • DEC Bids
  – Up-to Congestion Transactions
What is Two-Settlement?

• Provides PJM Market Participants with the option to participate in a forward market for electric energy in PJM
  – Consists of two markets:
    • Day-Ahead
    • Real-Time (Balancing)
  – Separate settlements performed for each market
Two-Settlement Markets

• Day-Ahead Market
  – Develop Day-Ahead schedule using least-cost security constrained unit commitment and security constrained economic dispatch programs that simultaneously optimize energy and reserves
  – Calculate hourly LMPs for next Operating Day using generation offers, demand bids, and bilateral transaction schedules

• Real-Time Energy Market
  – Calculate 5 minute LMPs based on actual operating conditions as described by the PJM State Estimator
  – Actual financial settlement performed on hourly integrated LMP
Two-Settlement Markets

• Day-Ahead Market Settlement
  – Based on scheduled hourly quantities and Day-Ahead hourly prices

• Real-Time Market Settlement
  – Based on actual hourly deviations from Day-Ahead schedule, priced at Real-Time LMPs
Day Ahead Energy Market

- Day-Ahead hourly forward market

- Objective is to develop set of financial schedules that are physically feasible
  - Full transmission system model
  - Unit commitment constraints
  - Reserve requirements model

- Day-Ahead market results based on participant demand bids and supply offers
Features of Two-Settlement

• Provide additional price certainty to Market Participants by allowing them to ...

  – Commit and obtain commitments to energy prices and transmission congestion charges in advance of Real-Time dispatch (forward energy prices)
  – Submit price sensitive demand bids
  – Submit increment offers, decrement bids, and up-to-congestion transactions
Participant Responsibilities

• Distribution Providers (DP) – Market Buyers
  – Submit Day-Ahead demand bids
    • (hourly demand schedules)
  – Submit Day-Ahead price sensitive demand bids
  – For any demand they wish to lock in at Day-Ahead prices
  – Participation is optional for an DP in the Day-Ahead market

• Generators – Market Sellers
  – Any generator that is a capacity resource that has an RPM commitment must submit a schedule into the Day-Ahead market **even** if self-scheduling or unavailable due to an outage
  – Non-capacity generators have the option to participate in the Day-Ahead energy market
Balancing Market

• DPs will pay the Real-Time LMP for any demand that exceeds their Day-Ahead scheduled quantity

• DPs will receive Real-Time LMP for any demand that is below their Day-Ahead scheduled quantities

• Generators are paid Real-Time LMP for any generation that exceeds their Day-Ahead scheduled quantities

• Generators will pay for any generation that is below their scheduled quantities
Settlements

- Day-Ahead schedules are financially binding

- Demand scheduled Day-Ahead
  - Pays Day-Ahead LMP for Day-Ahead MW scheduled
  - Pays Real-Time LMP for actual MW above scheduled
  - Paid Real-Time LMP for actual MW below scheduled

- Generation scheduled Day-Ahead
  - Paid Day-Ahead LMP for Day-Ahead MW scheduled
  - Paid Real-Time LMP for actual MW above scheduled
  - Pays Real-Time LMP for actual MW below scheduled
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Unit Commitment Analysis

10:30 a.m.
Day-Ahead Market Closes

First Commitment
• Determines commitment profile that satisfies fixed demand, price sensitive demand bids, virtual bids and offers, and PJM Operating Reserve Objectives
• Minimizes total production cost

13:30
Day-Ahead Results Posted and Balancing Market Bid Period Opens

14:15
Balancing Market Bid Period Closes

Reserve Adequacy Assessment
• Focus is reliability
• Updated unit offers and availability
• Based on PJM load forecast
• Minimizes startup and cost to run units at minimum

Transmission Security Assessment
• Focus is reliability
• Performed as necessary starting two days prior to the operating day
• Based on PJM Load Forecast
PJM Markets Timeline

0800-1030
Data Hand-off Ops. → Mkts

- Ops. Technical Analysis
  0800 - 1030

Market Participant Bid/Offer Period
Before 1030
Market participants enter bids and offers.

1030-1330
Data Hand-off Ops. → Mkts

Day-Ahead Results Posted & Balancing
1030 - 1330
- Process all the markets requests from day-ahead bids
- Post Day-Ahead Market results by 1330

1330-1415
Data Hand-off Ops. → Mkts

Re-bid Period
After day-ahead results are available 1415 - Midnight
Make adjustments based on the clearing results.

1415-2400
Real-Time Operations and Monitoring

Balancing Market Bid Period Closes
1415 - Midnight

Commitments
Second
Reliability analysis includes:
- Updated offers
- Unit availabilities
- PJM load forecast info

Supplemental
- Reliability performed as needed
- Minimize start-up and cost to run
Day-Ahead Market Information Flow

Generation Offer
System Condition
Demand
Demand Side Response

PJM Systems

Operational Results
Day-Ahead binding constraints
Day-Ahead net tie schedules
Day-Ahead reactive interface limits

Participant Results
Schedules for next day (generation, demand, DSR & Virtuals)
Transaction schedules

Settlements

08/24/2016
Day-Ahead Data Flow

Market User Interface
- Hourly LMPs
- Hourly Demand, DSR & Generation Schedules
- Transmission Limitations
- Inc/Dec, Up-to schedules

Day-Ahead Software
- Network Model
- Transmission Outages
- Equipment Ratings
- Breaker positions

PJM EMS
- Generation Offer Data
- Demand Bids
- DSR
- Incr Offers/Dec Bids/Up-tos
- Agg. Bus Distributions

Other PJM Systems
- PJM Load Forecast
- Hydro Schedules
- Reserve Requirements

PJM OASIS
- Energy Transactions
- External Energy Offers
- Net Tie Schedules

ExSchedule
- Energy Transaction Schedules
- External Energy Schedules
- Net Tie Schedules

Settlements
Determining Schedules & LMPs

**Inputs**

- **RSC** = Resource Scheduling and Commitment (Unit Commitment)
- **SPD** = Scheduling, Pricing and Dispatch (Economic Dispatch)
- **SFT** = Simultaneous Feasibility Test

**Results**
Resource Scheduling & Commitment (RSC)

• Performs **security-constrained unit commitment (SCUC)** based on generation offers, demand bids, and transaction schedules submitted by participants

• Enforces constraints – physical unit specific and generic transmission
Scheduling, Pricing & Dispatch (SPD)

• Performs **security-constrained economic dispatch** (SCED), using unit commitment produced by RSC, to determine generator MW dispatch while honoring ramp limits

• Determines LMPs for all load and generation buses

• Considers additional generic constraints that affect dispatch, such as reactive interface limits

• Day-Ahead Scheduling Reserve Clearing Prices
Simultaneous Feasibility Test (SFT)

• Creates a model for each hour of scheduling day based on:
  – Network topology
  – Generation MW profile produced by SPD
  – Equipment's limits

• Performs contingency analysis using contingency list

• Develops violations as constraints and passes them back to SPD for resolution

• Help ensure the Day-Ahead Market results are physically feasible
Day-Ahead Posting Results

• Public
  – Transaction Schedules
  – Day-Ahead LMPs
  – Day-Ahead Binding Constraints
  – Day-Ahead Net Tie Schedules
  – Day-Ahead Reactive Interface Limits
  – Day-Ahead Summary

• Private
  – Schedules for Next Day (generation, demand, DSR & virtuals)
Posted Generation Schedules

• For steam units, use Day-ahead schedule for the time to be online and ready to follow dispatch rate
  – Once online, unit should follow real-time dispatch and NOT Day-Ahead schedule
    • Unless unit is self-scheduled
  – Changes to posted schedules will be communicated verbally to generation owner
    • Earlier start time, cost-capping, additional commitments

• Combustion Turbines that have a startup and notification time greater than two hours should follow their Day-Ahead schedule
  – CT’S with less than 2 hour startup and notification time will be dispatched in real-time as needed by the PJM Operators
Self-Scheduling Generation

• Generation Owners may self-schedule (must-run) generation at any time

• Implications:
  – Can not set LMP (but will receive LMP at their bus)
  – Still must bid in Day-Ahead
  – 20 minute notice required to self-schedule in real-time
  – May be subject to Balancing Market Operating Reserve charges (if deviation from Day-Ahead schedule)
  – NOT eligible for Operating Reserve credits
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Increment Offers and Decrement Bids

- Market participants can submit increment offers and decrement bids at any hub, transmission zone, aggregate or single bus or eligible external interface for which an LMP is calculated.

- Increment Offer (INC) looks like a “virtual generator”

- Decrement Bid (DEC) looks like a “virtual load”

- It is not required that physical generation or physical load exists at the location that is specified in the increment offer or decrement bid

- Increment Offers and Decrement Bids are financial instruments in the Day-Ahead market ONLY!
How Do Virtual Bids Work?

**Increment Offer (INC) Offer**

- **Sells** MW into Day-Ahead Market at Day-Ahead LMP
- **Buys** replacement MW from Real-Time Market at Real-Time LMP
- **Profits** when Day-Ahead Prices are Higher than Real-Time Prices

**Decrement Bid (DECP) Bid**

- **Buys** MW from Day-Ahead Market at Day-Ahead LMP
- **Sells** those MW in Real-Time Market at Real-Time LMP
- **Profits** when Day-Ahead Prices are Lower than Real-Time Prices
Why Use an INC or DEC?

• Cover one side of a bilateral transaction

• Cover In-Schedule transaction
  – Allows opposite party access to Real-Time LMP while you participate in Day-Ahead

• Protect a Day-Ahead generation offer
  – Use a decrement bid
**Example - Decrement Bid**

**Self-Scheduled Generator (200 MW) Wants to See Real-Time Pricing**

**Day-Ahead**

Generator self-schedules unit at 200MW
Decrement bid at same bus for 200 MW at $100

Assume Day-Ahead LMP = $30

Day Ahead Settlement (Gen) = 200 MW * $30 = $6000 credit

Day Ahead Settlement (Dec) = 200 MW * $30 = $6000 charge

Net Day Ahead Position = 0

**Real-Time**

Assume Generator produces 200 MW
Assume Real-time LMP = $35

Deviation from DA schedule (Gen) = 0 MW
Decrement bid at same bus for 200 MW at $100

Balancing Settlement (Gen) = 0 MW * $35 = 0

Balancing Settlement (Dec) = 200 MW * $35 = $7000 credit

Balancing Position = $7000 credit

**Net Position = 0 + $7000 = $7000 Credit**
Example - Decrement Bid with Generator

Generator in Danger of a Forced Reduction in Real-Time (i.e. Mechanical Failure)

**Day-Ahead Generator**
- 200 MW Scheduled Generation
- Dec bid 100 MW @ $20
- Assume Day-Ahead LMP = $15
- Day Ahead Settlement (Gen) = 200 MW * $15 = $3000 credit
- Day Ahead Settlement (Dec) = 100 MW * $15 = $1500 charge

Net Day Ahead Position = 1500 credit

**Real-Time Generator**
- Generator produces 100 MW
- Assume Real-time LMP = $20
- Deviation from DA schedule (Gen) = -100 MW
- Deviation from DA schedule (DEC) = 100 MW
- Balancing Settlement (Gen) = -100 MW * $20 = $2000 charge
- Balancing Settlement (Dec) = 100 MW * $20 = $2000 credit

Balancing Position = $0

Net position = $1500 + $0 = $1500 credit

Without DEC Net credit = $1000
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An up-to congestion transaction is a conditional transaction that permits a market participant to specify a maximum of a (+/-) $50/MWh price spread between the transaction source and sink in the Day-Ahead Market.

Up-to congestion transactions are cleared based on the price difference between source and sink (Congestion and Loss component of LMP):
- Day-Ahead Charge = Transaction MWh * (Sink DA LMP – Source DA LMP)
- Balancing Credit = Transaction MWh * (Sink RT LMP – Source RT LMP)
Day-Ahead Charge = 100 MWh * ($30/MWh-$5/MWh) = $2,500
Balancing Charge = -100 MWh * ($40/MWh-$10/MWh) = -$3,000
Up-to Congestion Transactions

- PJM will maintain an up-to date list of source/sink combinations that will be available for ‘Up to’ congestion bidding on the PJM OASIS

- Up-to congestion transactions are supported in the Day-Ahead Market *only*
PJM Day-Ahead Market
Capacity Resource Requirements

• Any generator that is a PJM generation capacity resource that has an RPM Resource Commitment:
  – Must submit an offer schedule into the Day-ahead Market even if it is self-scheduled or unavailable due to outage

• Generation capacity resources shall submit:
  – A schedule of availability for the next seven days
  – May submit non-binding offer prices for the days beyond the next Operating Day

• The set of offer data last submitted for each generation capacity resource
  – Shall remain in effect for each day until specifically superseded by subsequent offers
Unit Parameters
Unit Parameters

• Each generator has different characteristics that it submits to PJM along with their energy offer

• These variables can be cost-based, price-based, time-based, or physical parameters
Generators can be cost-based or price-based:

- Determined for each new unit or new unit ownership

  - Cost (per cost development guidelines)
  - Price (per participants offer strategy)
  - A generation capacity resource offer may not exceed $2000/MWh
Energy Market Offer Cap: Cost-Based Offers

- For the purposes of setting LMP, all offers are capped at $2,000/MWh
  - Cost-based offers above $2,000/MWh will not be eligible to set LMP

- Generation resources with demonstrated costs above $2,000/MWh can recover those costs through make-whole payments
  - The 10% adder will not apply to costs above $2,000/MWh

- Participants wishing to enter cost-based offers above $2,000/MWh will need to contact the Markets Hotline to get assistance to enter such offers
  - Cost-based offers above $2,000/MWh will be considered in merit order for dispatch purposes
Energy Market Offer Cap: Price-Based Offers

- Price-based offers will be capped at the lower of $2,000/MWh or the corresponding cost-based offer when costs are above $1,000/MWh
  - Remain capped at $1,000/MWh when the corresponding cost-based offers are at or below $1,000/MWh

Example:

If a unit’s cost offer is $1500, the price offer can be no higher than $1500
If a unit’s cost offer is $800, the price offer can be no higher than $1000
If a unit’s cost offer is $2200, the price offer can be no higher than $2000
Shortage Pricing

• Max energy price = energy offer cap + 2 * Reserve penalty factor
  – Yields $3,700/MWh max energy price under shortage conditions going forward

• Current offer cap rules apply year round
Notification and Startup Times

The following information can be changed on the Schedule Detail page:

**Notification Times:**
The time interval in hours, between PJM notification and the start sequence of a generating unit that is currently in one of three temperature states

- Hot Notification Time
- Inter Notification Time
- Cold Notification Time

**Startup Times:**
The time interval, measured in hours, from the actual unit start sequence to the breaker close for a generating unit in one of the three temperature states

- Hot Startup Time
- Inter Startup Time
- Cold Startup Time
Start Costs for Price-Based Units

1. Price-based units choosing price-based start-up and no-load costs can only change them twice per year effective for two six month periods
   - Entered on Unit Detail page

2. Price-based units have the option to submit cost-based start-up and no-load costs on a daily basis
   - Entered on Schedule Detail page
   - Must stay as cost-based start-up and no-load costs for the entire 6-month period
   - Choice between using cost-based or price-based start up and no-load fees can be made twice a year
Bi-annual Periods for *Price Based* Start Costs

<table>
<thead>
<tr>
<th>Period</th>
<th>Period Covers:</th>
<th>Submit By:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>April 1(^{st}) to September 30th</td>
<td>10:30 Hours March 31st</td>
</tr>
<tr>
<td>2</td>
<td>October 1(^{st}) to March 31st</td>
<td>10:30 Hours September 30th</td>
</tr>
</tbody>
</table>

If a priced based unit chooses the price-based start-up and no-load fees option, the decision cannot be changed until the next open enrollment period takes place.
Use Start Costs

• The generation owner determines whether PJM should use the startup and no load information for their unit (price-based or cost-based) on a daily basis

• This is accomplished by marking the Use Startup No Load switch available and unavailable on the Schedule Detail web page
Markets Gateway

Unit Parameters
Uses of Markets Gateway

• PJM Markets Gateway is the system that PJM Market Participants use to participate in the Day-Ahead Energy Market, Synchronized Reserve Market, and Regulation Market. Market Participants can use PJM Markets Gateway to prepare and submit:
  – Generation offers
  – Regulation offers
  – Synchronized reserve offers
  – Demand bids
  – Increment offers and decrement bids
  – Load response bids
  – Enter bilateral regulation and reserve transactions
  – Review public and private Day-Ahead Energy and Ancillary Services market results
Uses of Markets Gateway

- Enter bilateral regulation and reserve transactions
- Review public and private Day-Ahead Energy and Ancillary Services market results
Unit Parameters in Markets Gateway

Unit
- Unit Status
- Resource Type
- MW Operating Limits
- Ramp Rates
- Weather and Wind Forecasts
- Startup and & No-Load Costs for price-based units

Schedule
- Schedule Types and Selection
- Offer Curves
- MW Operating Limits
- Startup & No-Load Cost for cost-based schedules
- Startup/No-Load switch
- Startup and Notification times
- Min and Max Data
- Condenser Data

Hourly Updates
- Commit Status
- MW Operating Limits
- Notification Time
Unit Detail

Unit default values are entered on the page

• **Emergency Max (MW)** - The MW energy level at which the operating company operates the generating unit once PJM requests Maximum Emergency Generation
  - This represents the highest short-term MW level a generating unit can produce and may require extraordinary procedures to produce the desired output

• **Economic Max (MW)** - The highest unrestricted level of energy, in MW, that the operating company operates the unit
  - This represents the highest output available from the unit for economic dispatch
• **Economic Min (MW)** - The minimum energy available from the unit for economic dispatch

• **Emergency Min (MW)** - The lowest level of energy in MW the unit can produce and maintain a stable level of operation. The Operating Company operates the unit at this level during a Minimum Generation Emergency

• **CIR** - Indicates the MW value of the **Capacity Interconnection Rights** of the wind resource
  - For a wind resource, the Economic Min and Emergency Min must be less than or equal to the resource’s CIR value
• **Default Ramp Rate (MW/Min)** – The default energy ramp rate, in MW/minute, for increasing or decreasing a unit’s output
  – This average rate is used by PJM in the Day-Ahead commitment process

• Use the **Unit Detail** web page to change the startup and no-load costs during the open enrollment periods
  – Period 1 Cost Based Startup Cost and Period 2 Cost Based Startup Cost
    • Indicates whether or not a unit’s startup and no-load are cost based for Period 1 and Period 2 respectively
Energy Ramp Rates

The MW segment ramp rates are used during real-time operations

- A maximum of 10 Ramp Rate segments can be defined

- The first MW/ramp rate segment represents the ramp rate from 0 MW/0 Min to the first MW/Min point

- The second MW/ramp rate point represents the ramp rate from the first MW point to the second MW point (and so on)
Synchronized Reserve Ramp Rates

• Synchronized reserve ramp rates may be specified for Tier 1 resources (MW/min)

• A maximum of 10 ramp rate segments can be defined

• These rates must be greater than or equal to the real time economic ramp rate(s) submitted for the unit
  – Synchronized ramp rates that exceed economic ramp rates must be justified via submission of actual data from past synchronized events to the PJM Performance Compliance Department
Schedule Parameters
Price-Based Unit Schedule Requirements

Units must have at least one cost-based schedule and may have two price-based schedules available:

1. Cost-based schedule must be parameter limited
2. Two price-based schedules
   a) Non-parameter limited
   b) Parameter limited
Schedule Manager

Schedules define the offer and offer type

• Multiple schedules can be created
  – Schedule Name (8 characters) – Name used to reference schedule offer
  – Schedule Description (40 characters) – Text description of the schedule
  – Schedule Type
    • 1 - 69 and 80 - 90 — cost-based parameter limited schedules (PLS)
    • 70 - 79 — Price PLS schedules
    • 91 - 99 — price-based schedules

* Editing, Adding or Deleting is not permitted when market is closed
Schedule Detail

Market Type

• **DayAhead** - Indicates whether the schedule is available for the Day-Ahead market

• **Balancing** - Indicates whether or not the schedule is available for the balancing market (used for re-bidding period)

• **Both** - Indicates whether or not the schedule is available for both the Day-Ahead market and balancing market (used for re-bidding period)

• **Use Startup No Load** - The generation owner determines whether PJM should use the startup and no load information for their unit (price-based or cost-based) on a daily basis
Schedule Detail

• **Minimum Downtime** (hour) — The minimum number of hours between when the unit shuts-down and the next time the unit is put online

• **Minimum Runtime** (hour) — The minimum number of hours a unit must run

• **Maximum Weekly Starts** — The maximum number of times a unit can be started in one week

• **Maximum Runtime** (hour) — The max number of hours a unit can run before it needs to be shut down

• **Maximum Daily Starts** — The maximum number of times that a unit can be started in a day

• **Maximum Weekly Energy** (MWh) — The maximum amount of energy, reported in MWh, that the unit can produce in one week used for study purposes
Schedule Offers

• Up to 10 pairs of MW and pricing points can be created or modified for each price schedule

• The Offer Slope selection can be used to calculate the schedule’s offer when dispatched between MW segments

*Cannot be changed for today or the next day when the market is closed
The Schedule Selection web page is used to mark schedules as Available or Not Available and allows the user to modify the no load cost, cold start cost, intermediate start cost and hot start cost

- At least one cost-based schedule must be made available in both the Day-Ahead Market and in the Balancing Market

- Two price-based schedules may be available:
  a) Non-parameter limited
  b) Parameter limited (required)
Questions?

**PJM Client Management & Services**

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**Toll Free Telephone:** (866) 400-8980  
**Website:** [www.pjm.com](http://www.pjm.com)

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