PJM Markets 201

PJM State & Member Training Dept.

Objectives

What can you expect to learn?

- Better understanding of PJM Markets
  - Business rules
- Enhance job performance
- Understand financial impacts to company portfolios
- Hands-on simulations to reinforce course topics

Certificate & NERC CEH

- To earn Certificate and/or NERC CEHs to support PJM Markets Certification or Generator Dispatcher Certification, you MUST:
  - Scan your badge/sign in at the start of each session
  - Attend all presentations and complete all activities
- Rules for quizzes
  - 75% or higher is required
  - Re-testing is available
- Rules for Simulations:
  - You must participate in the full Simulation activity

Function and Production Cost

Objectives

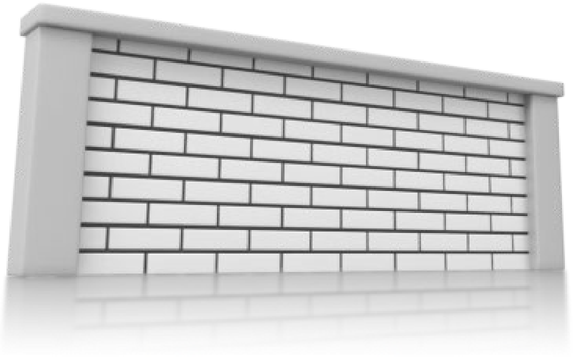
Students will be able to:

- Explain how optimization is used in the energy markets
- Evaluate operating parameter impacts on production cost

What is Optimization?

- Optimization seeks to minimize or maximize the value of a desired outcome:
  - In PJM's case: the " Function"

- Achievement of this outcome must consider the availability of resources or other limiting factors
  - Subject to "Boundary Conditions"



Optimization in Energy Markets

- The “objective function” in the Day Ahead Market is to minimize total production costs
- The “boundary conditions” are extremely complex and include:
  - Thermal / Reactive limits
  - Generator operating constraints
  - External transaction schedules
  - Regional reliability requirements
  - Synchronized Reserves Requirement
  - Regulation Requirement
  - Etc.

Optimization

- The objective in the Real Time Market is to maintain reliability and minimize Start-Up and No-Load costs
- PJM Real-Time Market clearing is a joint optimization between energy, regulation, synchronized reserves and non-synchronized reserves products
- The goal of the optimization is to minimize the total cost of producing energy, regulation, and reserves

Production Cost

- Defined by the bids from suppliers (offers)
  - Minimized to meet energy balance
  - Not violating other constraints in system operation
  - Determines the price in the Day-Ahead and Real-Time Energy Markets
  - Paid to generation or demand resources

Production Cost

- Generation must be placed in and out of service and operated to achieve the lowest possible overall cost for the system

- Unit Production Cost is the cost to operate a unit for a particular <u>period of time</u>

- Two types of Production Cost are used at PJM:
  - Hourly Production Cost
  - Total Production Cost

Hourly Production Cost

- Cost per hour to operate a unit, assuming a startup has already occurred
- Calculated by summing all costs which are incurred during one hour of operation
  - No-Load Cost
  - Total Energy Cost per Segment

Hourly Production Cost

=

No-Load Cost

+

Sum of Total Energy Cost per Segment

No-Load Cost

- No-load cost (or price) is the hourly fixed cost (or price), expressed in $/hr, to run the generating unit at zero net output
  - Needed to create the starting point of a monotonically increasing incremental cost curve

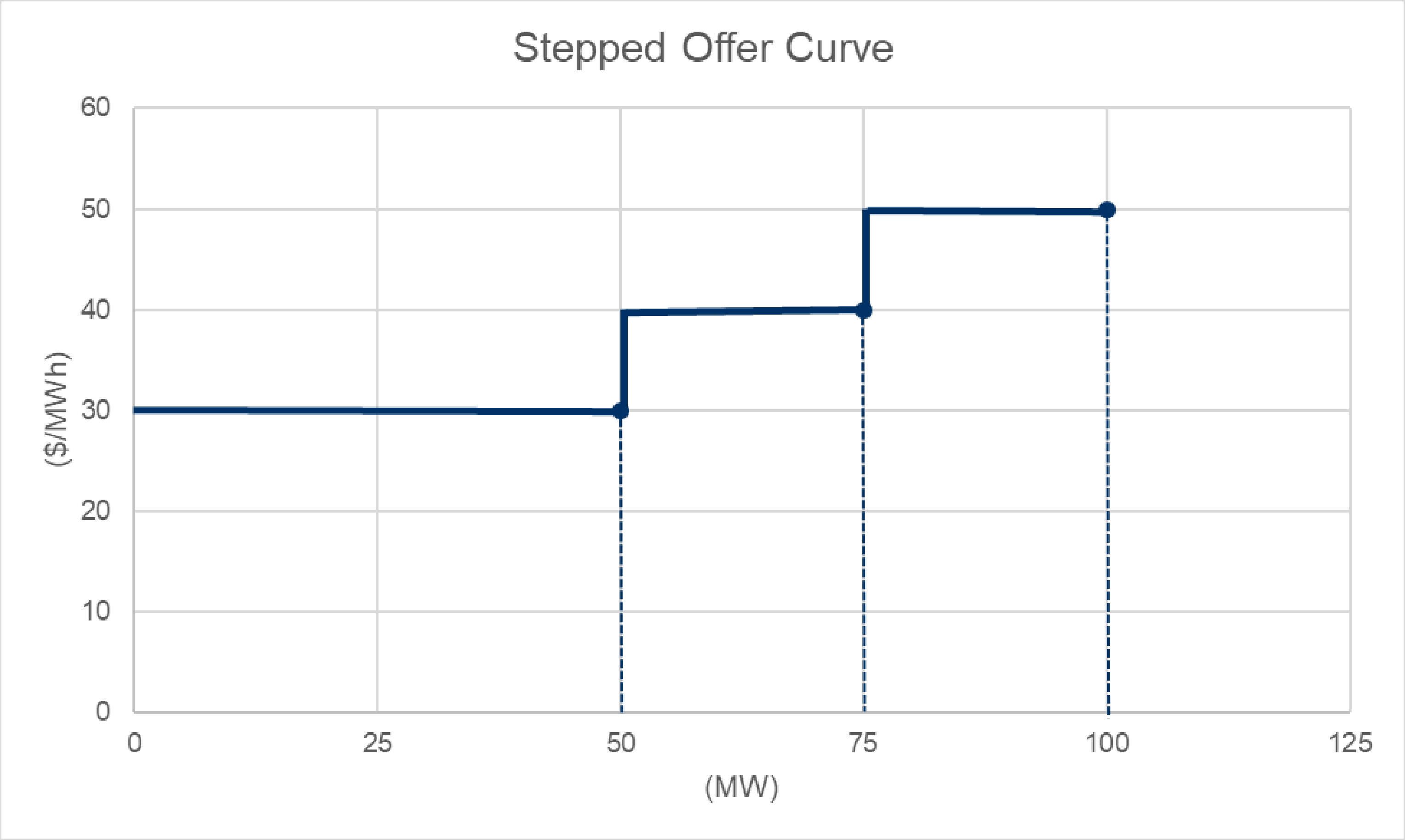
Hourly Production Example

Parameter	Unit X	
Hot Start Price ($)	500	
Intermediate Start Price ($)	1000	
Cold Start Price ($)	1500	
No-Load ($/hr)	500	
Offer Curve (max 10 points)	**MW**	**Price ($/MWh)**
segment 1	50	10
segment 2	75	50
segment 3	100	200
Eco Min (MW)	50	
Eco Max (MW)	100	
Min Run Time (hours)	16	

Generator Offer Curve – Using Stepped Load Offer

MW	Price
50	30
75	40
100	50

Hot Start Price ($)	1,000.00
Intermediate Start Price ($)	1,200.00
Cold Start Price ($)	1,500.00
No-Load ($/hr)	500.00



Hourly Production Cost - Using Stepped Offer

- Hourly No-Load = $500
- Cost of 1st segment:
  - 50 MW * $30/MWh = $1,500/hr
- Cost of 2nd segment:
  - (75MW – 50 MW)* $40/MWh = $1,000/hr
- Cost of 3rd segment (Eco Max):
  - (100 MW – 75 MW)* $50/MWh = $1,250/hr

Hourly Production Cost - Using Stepped Offer

- Hourly production Cost at Eco Min =
  - No Load + 1st Increment to Min = $500/hr + $1,500/hr = $2,000/hour
- Hourly production Cost at Eco Max =
  - No Load + 1st Segment + 2nd Segment + 3rd Segment = $4,250/hour
- Operating Rate =
  - (Hourly Production Cost at Eco Max / Eco Max MW) =

    $4,250/hour/100 MW = $42.50/MWH
- Production Cost Rate =
  - Hourly Production Cost at MW Output / MW Output

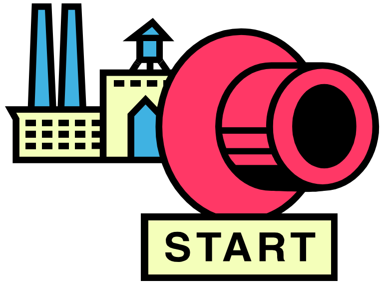
Total Production Cost

- Calculated by adding all of the costs associated with starting a unit and operating it over a period of time
- Two cost components:
  - Startup Costs
  - Hourly Production Costs

Total Production Cost
=
Startup Cost
+
(Hourly Production Cost
x
Number of Hours)

Start Cost

- Start Cost (or price) is associated with the cost to supply steam to operate the turbine and bring the generating unit to synchronous speed. There are three states for Start Costs (or prices):
  - Hot
  - Intermediate
  - Cold



- Start Cost is the dollars per start as determined from start fuel, total fuel-related cost, performance factor, electrical costs, start maintenance adder, and additional labor cost

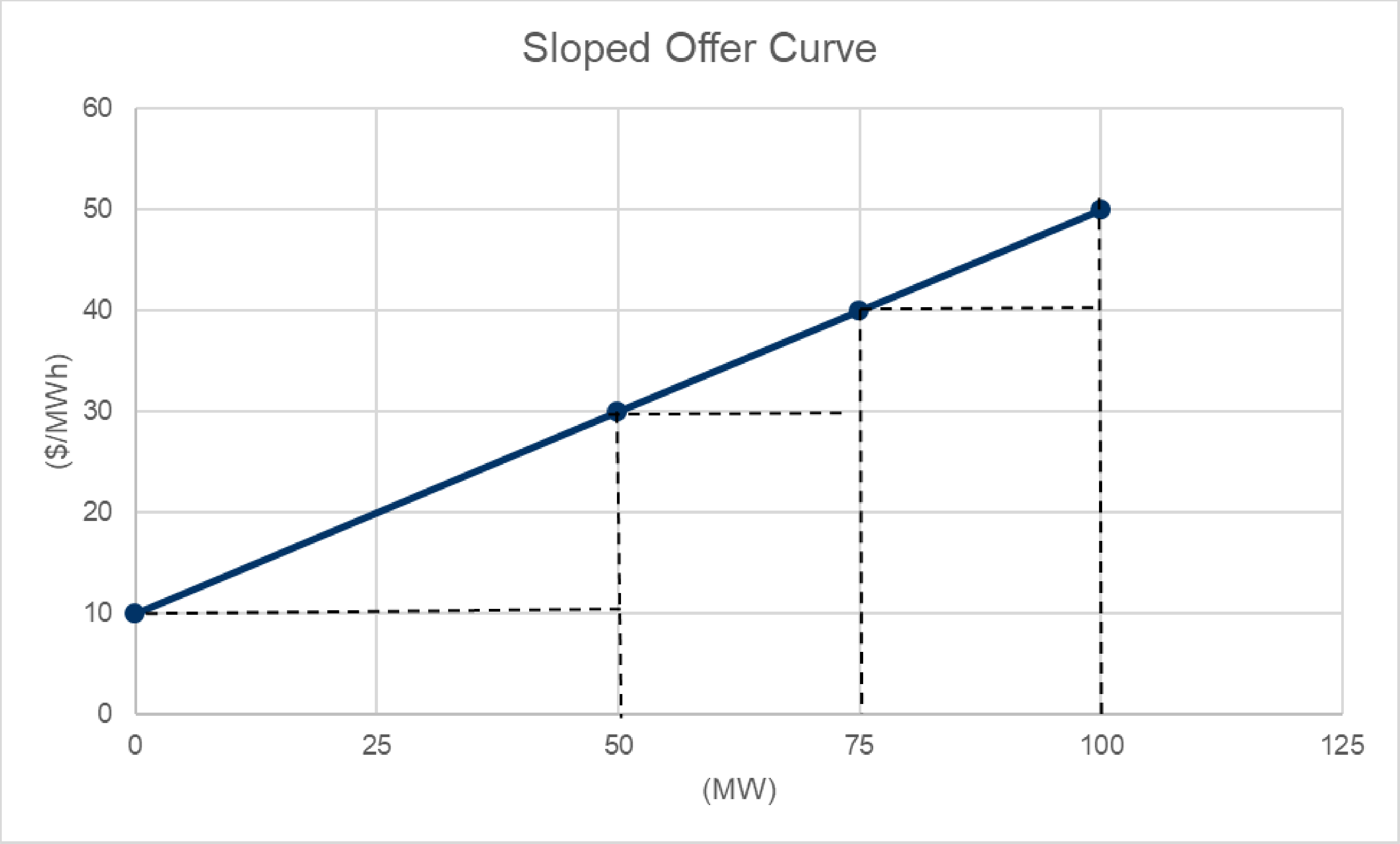
Total Production Cost - Using Stepped Offer

- Using the results from the hourly production cost problem with min run time of 16 hours, the range of production cost is:
  - 16 hours at Eco Min (50 MW):
    - $2,000/hour * 16 hours = $32,000
  - 16 hours at Eco Max (100 MW):
    - $4,250/hour * 16 hours = $68,000
  - Assume unit is still in a "hot" condition
    - Add the Hot Start Cost ($500)
  - Total production cost range:
    - $32,500 (eco min) to $68,500 (eco max) per day

Generator Offer Curve – Using Sloped Offer Curve

MW	Price
0	10
50	30
75	40
100	50

Hot Start Price ($)	1,000.00
Intermediate Start Price ($)	1,200.00
Cold Start Price ($)	1,500.00
No-Load ($/hr)	500.00



Hourly Production Cost - Using Sloped Offer Curve

- Hourly No-Load = $500
- Cost of 1st segment:
  - ➢ (50 MW * $10/MWh) + (50 MW * (30/MWh - $10/MWh)/2) = $1,000/hr
- Cost of 2nd segment:
  - ➢ ((75MW – 50 MW)* $30/MWh) + ((75 MW – 50 MW)*($40/MWh - $30/MWh) / 2) = $875/hr
- Cost of 3rd segment (Eco Max):
  - ➢ ((100 MW – 75 MW) * $40/MWh) + ((100 MW – 75 MW)*($50/MWh - $40/MWh) / 2) = $1,125

Hourly Production Cost - Using Sloped Offer Curve

- Hourly production Cost at Eco Min =
  - No-Load + 1st Increment to Min = \$500/hr + \$1,000/hr = \$1,500/hour
- Hourly production Cost at Eco Max =
  - No-Load + 1st Segment + 2nd Segment + 3rd Segment = \$3,500/hour
- Operating Rate =
  - (Hourly Production Cost at Eco Max / Eco Max MW) = \$3,500/hour/100 MW = \$35.00/MWH
- Production Cost Rate =
  - Hourly Production Cost at MW Output / MW Output

Total Production Cost - Using Sloped Offer Curve

- Using the results from the hourly production cost problem with min run time of 16 hours, the range of production cost is:
  - 16 hours at Eco Min (50 MW):
    - $1,500/hour * 16 hours = $24,000
  - 16 hours at Eco Max (100 MW):
    - $3,500/hour * 16 hours = $56,000
  - Assume unit is still in a “hot” condition
    - Add the Hot Start Cost ($500)
  - Total production cost range:
    - $24,500 (eco min) to $56,500 (eco max) per day

Production Cost Exercise

MW	Price				
0	20		Hot Start Price ($)		600.00
100	40		Intermediate Start Price ($)		1,200.00
150	50		Cold Start Price ($)		1,800.00
200	60		No-Load ($/hr)		250.00
			Eco Max = 200 MW		
			Min Run Time = 4 hours		

What is the total production cost to run Unit X at Maximum output?

Calculate the production cost for both Stepped and Sloped offer curve.

Assume Intermediate Start Price

Questions?

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Member Community

The Member Community is PJM's self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services