Objectives

• Explain the difference between Dispatch Rate and LMP
Agenda

• Generation Dispatch
**Dispatch Rate**

Definition:
The **Dispatch Rate** is expressed in dollars per MWh, calculated and transmitted to each generator to direct the output level of all generation resources dispatched by PJM based on the incremental offer data which was previously received from the Generators.
Dispatch Rate

The **Dispatch Rate** is determined by the PJM economic dispatch solution as calculated by PJM’s Security Constrained Economic Dispatch program (SCED)

![Graph showing Offer Price vs. MW]

**Offer Price**

- $35
- $30
- $25
- $20

**MW**

Economic Basepoint

- 0
- 50
- 100
- 150
- 200

**Dispatch Rate = $25**

The **Economic Basepoint** is the MW value sent to the generating unit that indicates to what level the unit should be loaded based on the economic dispatch solution and the units incremental price curve.
Transmission Losses

- Real Power (MW) Losses
  - Power flow converted to heat in transmission equipment
  - Heat produced by current (I) flowing through resistance (R)
  - Losses equal to $I^2R$
  - Heat loss sets the “thermal rating” of equipment

$Heat \ Disipated = I^2R$
Transmission Losses

• Real Power (MW) Losses
  – Increase with line length
    • Increased R
  – Increase with increased current flow (I)
  – Increase at lower voltages
    • Higher currents

\[
\text{Transmission Losses} = \text{Power} = \text{Current} \times \text{Voltage}
\]
Transmission Losses

Power In: 100 MW
Voltage In: 235 KV
Current In: 425.53 A

Power Out: 90.946 MW
Voltage out: 213.72 KV
Current Out: 425.53 A

Power Loss: 9.054 MW
Transmission Losses

Power In: 100 MW
Voltage In: 235 KV
Current In: 425.53 A

Power Out: 98.2 MW
Voltage out: 230.74 KV
Current Out: 425.53 A

Power Loss: 1.8 MW
The Incremental Loss for bus $i$ is used to calculate a factor that can be used to include the effect of losses in the dispatch.

This factor is called the Loss Penalty Factor, or Penalty Factor.

The Penalty Factors adjust the incremental cost of each generator so as to include the effects of losses.

Penalty factors applied to each and every location:
- Including generation, load, virtual transaction

\[
P_{fi} = \frac{1}{1 - \frac{\Delta P_L}{\Delta P_i}}
\]

Change in Losses

Change in Unit’s MW Output
Penalty Factors Effect on Dispatch

- If an increase in generation results in an increase in system losses then:
  - Penalty factor is greater than 1
  - Units offer curve is adjusted higher
    - Unit offer curve is multiplied by penalty factor
    - Unit looks less attractive to dispatch

\[
0 < \frac{\Delta P_L}{\Delta P_i} < 1
\]

Increase in injection will result in higher overall system losses

\[
P_{fi} = \frac{1}{1 - \frac{\Delta P_L}{\Delta P_i}} > 1.0
\]
Penalty Factors Effect on Dispatch

- If an increase in generation results in a decrease in system losses then:
  - Penalty factor is less than 1
  - Units offer curve is adjusted lower
    - Unit offer curve is multiplied by penalty factor
    - Unit looks more attractive to dispatch
    - Total LMP would still at least equal unit’s original offer

\[
\frac{\Delta P_L}{\Delta P_i} > -1
\]

Increase in injection will result in lower overall system losses

\[
P_{fi} = \frac{1}{1 - \frac{\Delta P_L}{\Delta P_i}} < 1.0
\]
### Penalty Factors Effect on Dispatch - Example # 1

**Offer Price** = $10.00

<table>
<thead>
<tr>
<th>Generating Unit # 1</th>
<th>Generating Unit # 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offer Price = $ 10.00 ----- 200 MW</td>
<td>Offer Price = $ 10.00 ----- 200 MW</td>
</tr>
<tr>
<td>$ 20.00 ----- 300 MW</td>
<td>$ 20.00 ----- 300 MW</td>
</tr>
<tr>
<td>$ 30.00 ----- 400 MW</td>
<td>$ 30.00 ----- 400 MW</td>
</tr>
<tr>
<td>$ 40.00 ----- 500 MW</td>
<td>$ 40.00 ----- 500 MW</td>
</tr>
<tr>
<td>Generating 300 MW</td>
<td>Generating 305 MW</td>
</tr>
<tr>
<td>Penalty Factor = 1.00</td>
<td>Penalty Factor = 0.97</td>
</tr>
<tr>
<td>$20 * 1.00 = $20.00</td>
<td>$20.50 * 0.97 = $19.89</td>
</tr>
</tbody>
</table>
## Dispatch Optimized to Least Production Cost

<table>
<thead>
<tr>
<th>Generating Unit 1</th>
<th>Generating Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Penalty Factor = 1.0</strong></td>
<td><strong>Penalty Factor = 0.97</strong></td>
</tr>
<tr>
<td><strong>Offer Price</strong></td>
<td><strong>MW</strong></td>
</tr>
<tr>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td>20</td>
<td>300</td>
</tr>
<tr>
<td>20.25</td>
<td>302.5</td>
</tr>
<tr>
<td>20.5</td>
<td>305</td>
</tr>
<tr>
<td>30</td>
<td>400</td>
</tr>
<tr>
<td>30.5</td>
<td>405</td>
</tr>
<tr>
<td>40</td>
<td>500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit 1 (MW)</th>
<th>Unit 2 (MW)</th>
<th><strong>Production Cost</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal Dispatch</td>
<td>300</td>
<td>305</td>
</tr>
<tr>
<td>Alternate Dispatch 1</td>
<td>200</td>
<td>405</td>
</tr>
<tr>
<td>Alternate Dispatch 2</td>
<td>302.5</td>
<td>302.5</td>
</tr>
</tbody>
</table>
Offer Curve for Both Units

($/MWh) vs. (MW)
Production Cost at 200 MW = $2,000

Production Cost at 300 MW = $2,000 + $1,000 + $500 = $3,500
Production Cost at 305 MW = $2,000 + $1,000 + $500 + $100 + $1.25 = $3,601.25
Linear Interpolation to determine the $/MW between 300 and 400 MW

Slope = \( m = \frac{dy}{dx} = \frac{\text{rise}}{\text{run}} \)

\[
m = \frac{\$(30-20)}{MW(400-300)} = \$ \frac{1}{\text{MW}}
\]

Therefore:

\[
0.1 = \frac{(y_1-20)}{(305-300)}
\]

\[
0.5 = (y_1 - 20)
\]

\[
y_1 = 20.5
\]
Alternate Dispatch 1 – Unit 2 Production Cost

Production Cost at 405 MW = $2,000 + $1,000 + $500 + $2000 + $500 + $150 + $1.25 = $6,151.25
Alternate Dispatch 1 – Unit 1 Production Cost

Production Cost at 200 MW = $2,000

Cost ($/MWh)

Production Cost at 200 MW = $2,000

(MW)
Alternate Dispatch 2 – Unit 1&2 Production Cost

Production Cost at 302.5 MW = $2,000 + $1,000 + $500 + $50 + $0.313 = $3,550.313
For questions related to this training, please contact:

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