Dispatch Signal and Locational Marginal Pricing

PJM Initial Training Program

Student Guide

Prepared by:
State & Member Training

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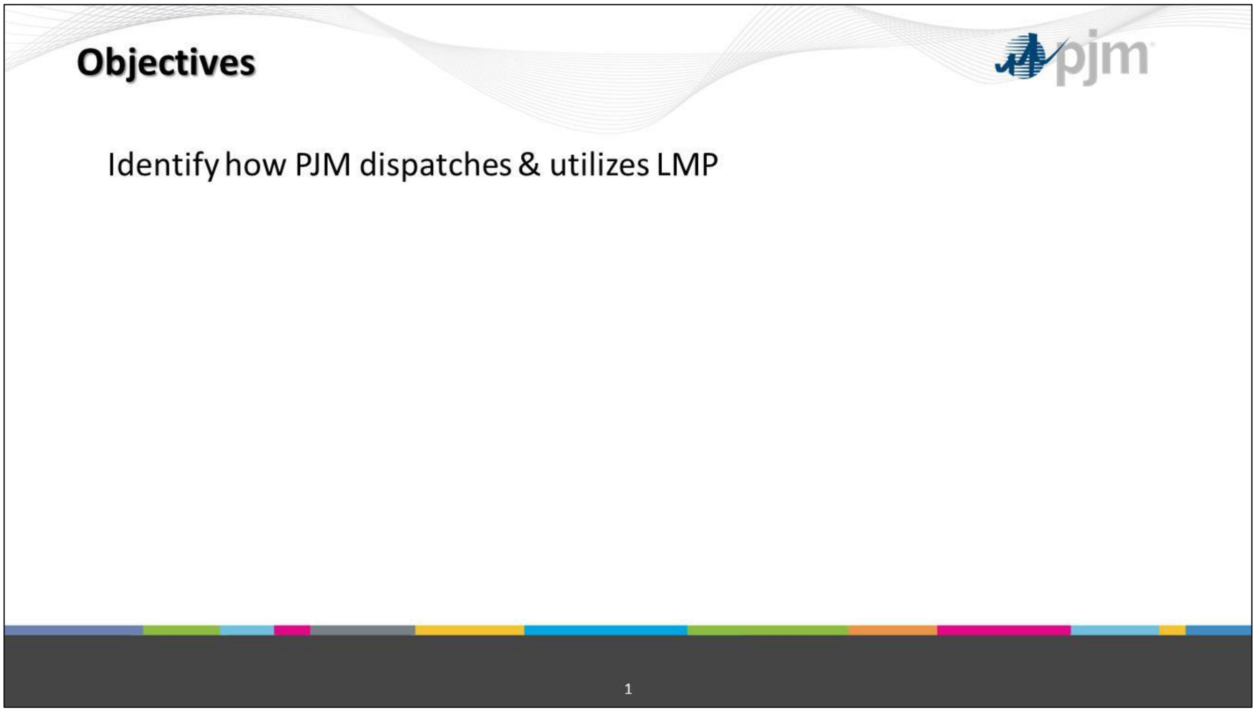
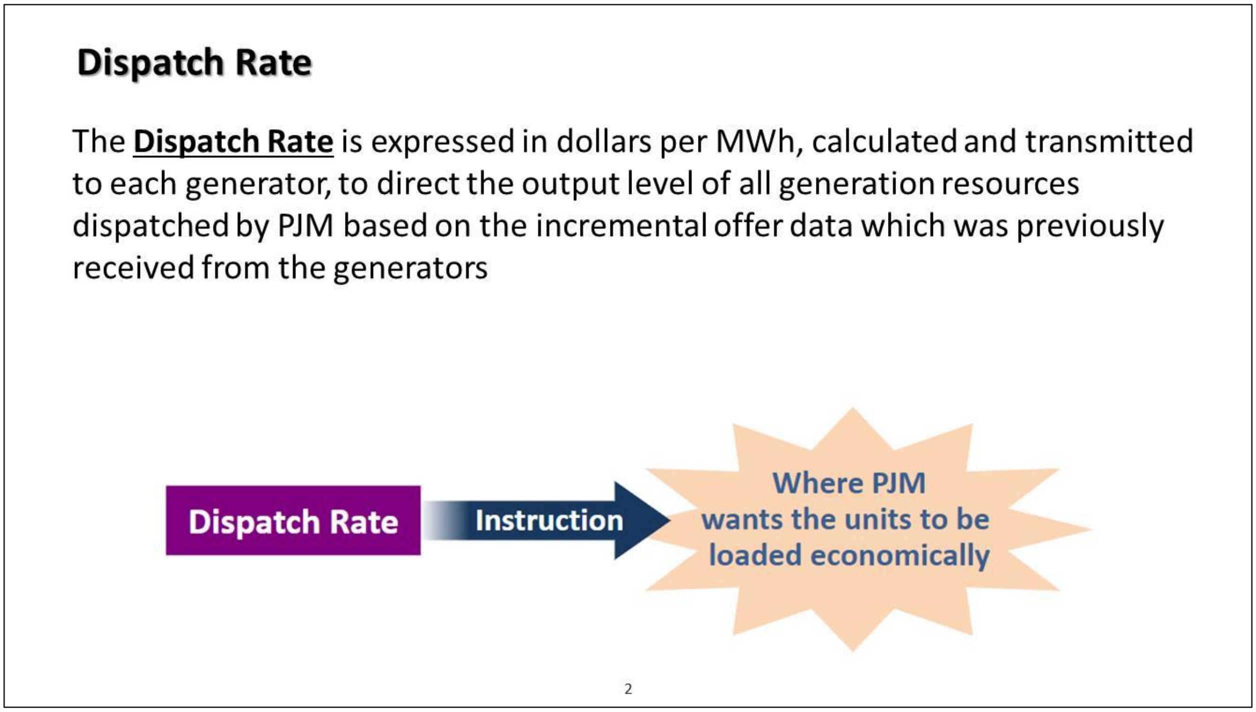
Objectives



Dispatch Rate

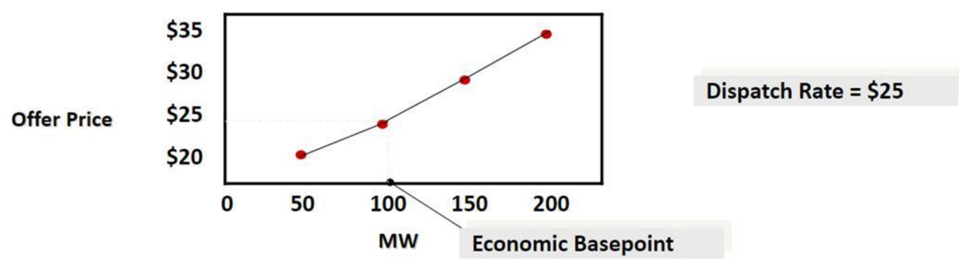


Dispatch Rate Cont.

Dispatch Rate Cont.

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

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



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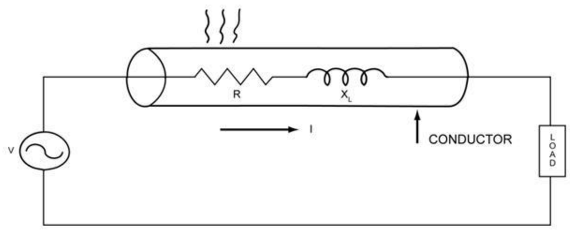
Transmission Losses

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

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



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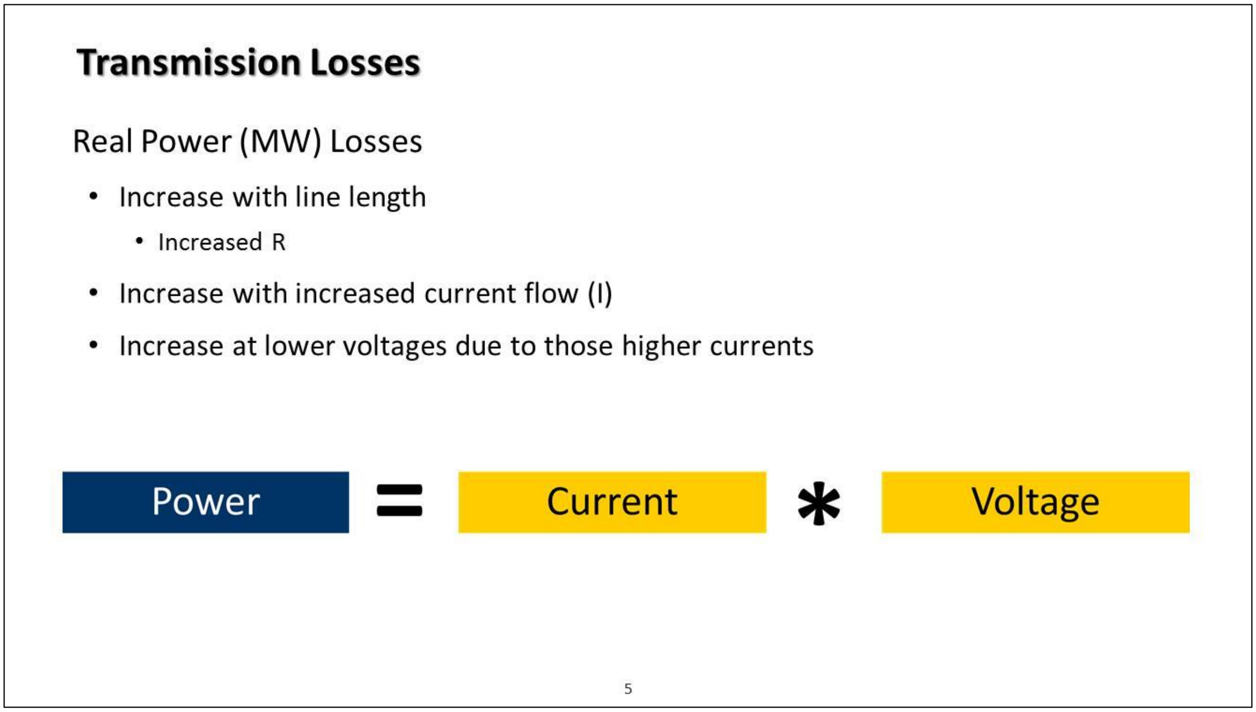
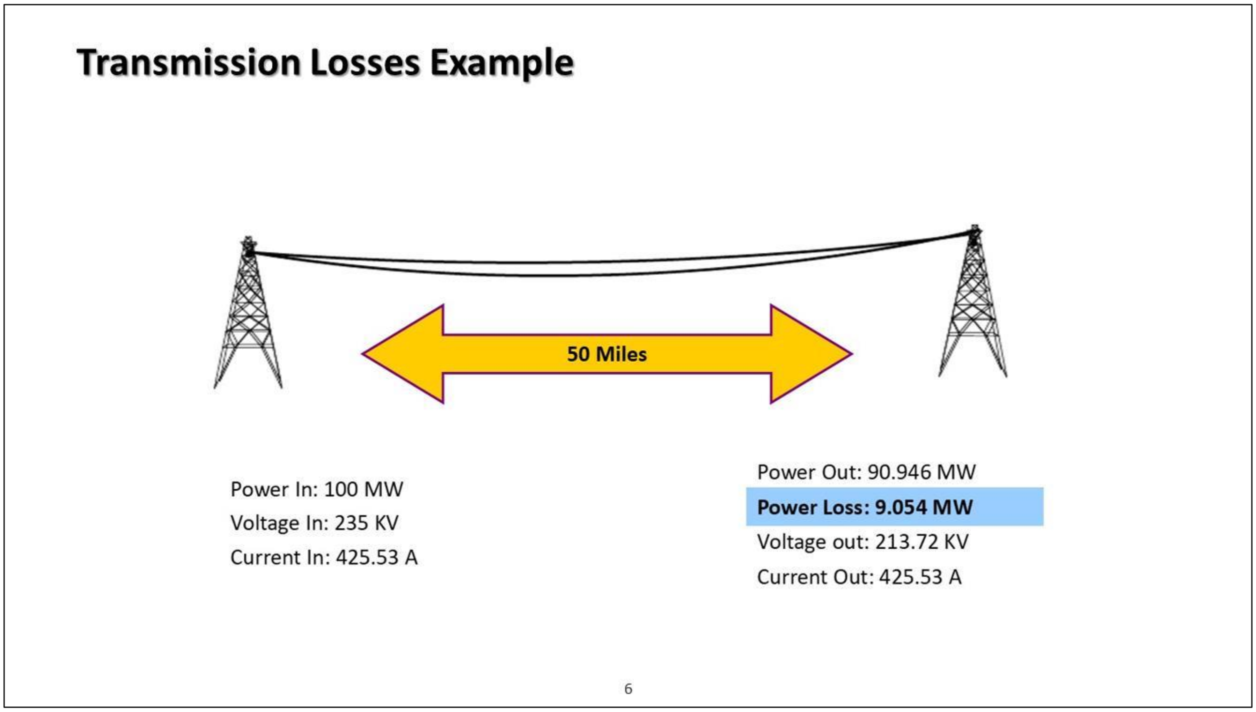
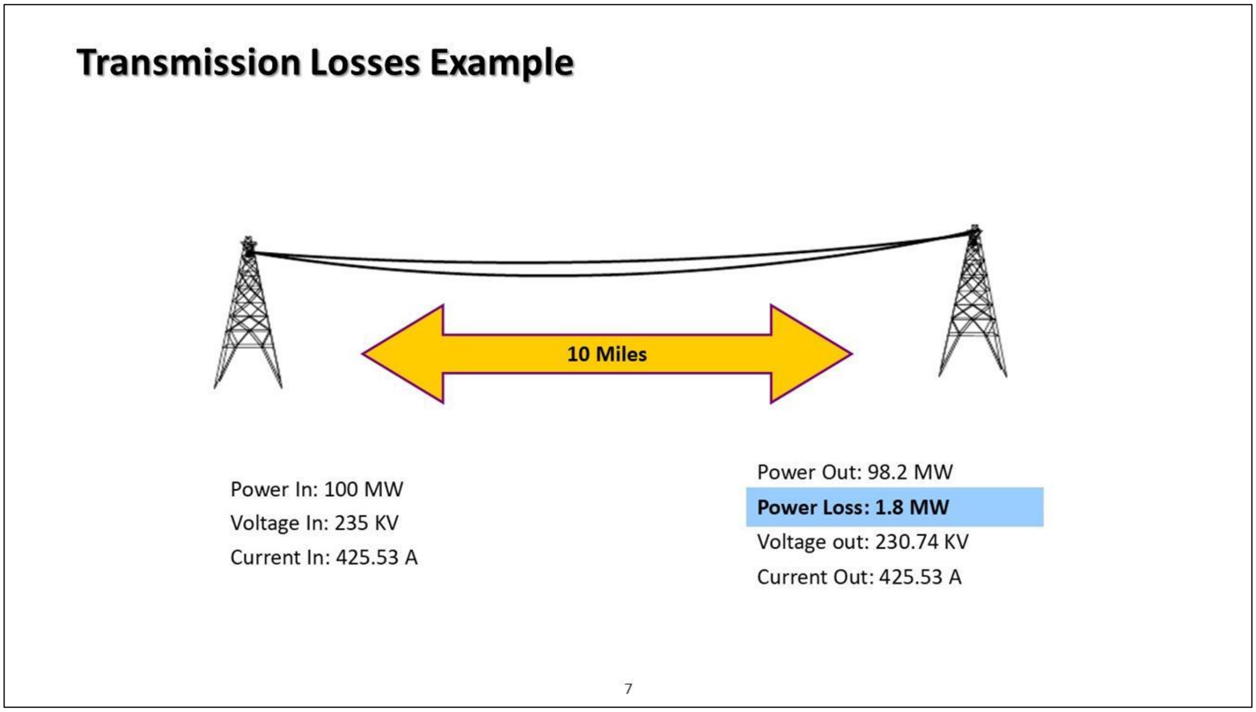
Transmission Losses



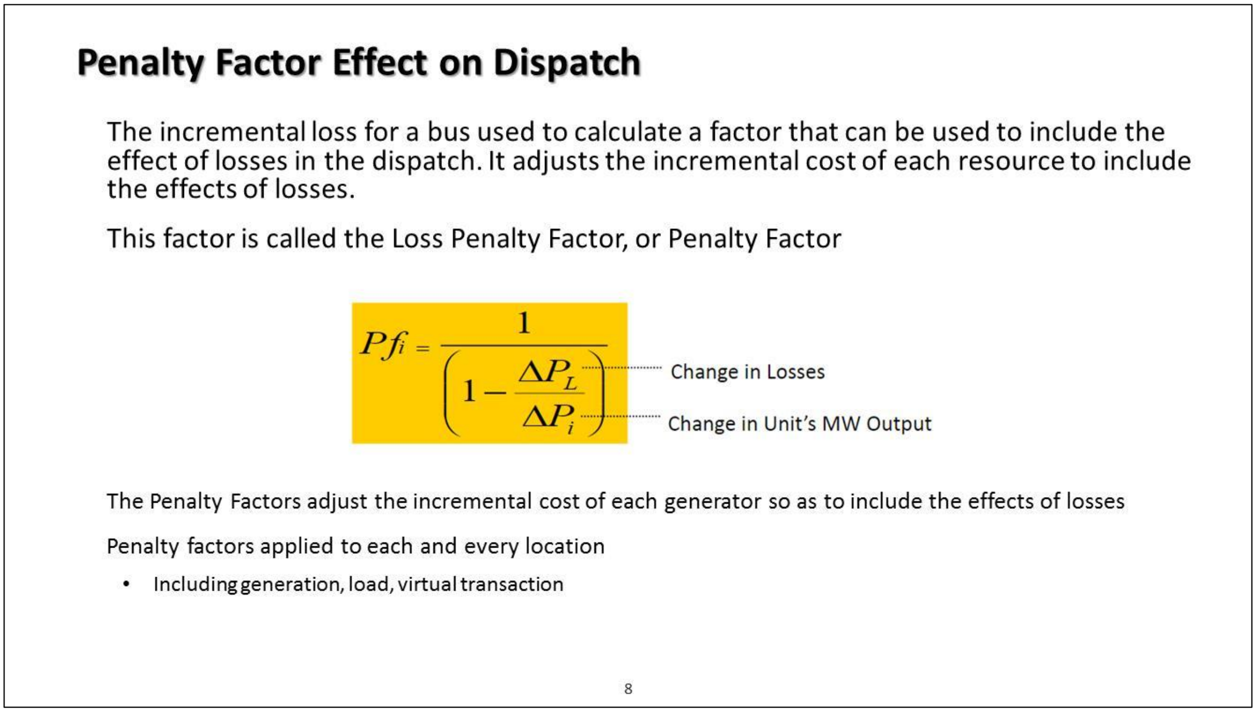
Transmission Losses Example



Transmission Losses Example



Penalty Factor Effect on Dispatch



Penalty Factor Effect on Dispatch

Penalty Factor 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

Loss Factor

$$0 < \frac{\Delta P_L}{\Delta P_i} < 1$$

Penalty Factor

$$Pf_i = \frac{1}{\left(1 - \frac{\Delta P_L}{\Delta P_i}\right)} > 1.0$$

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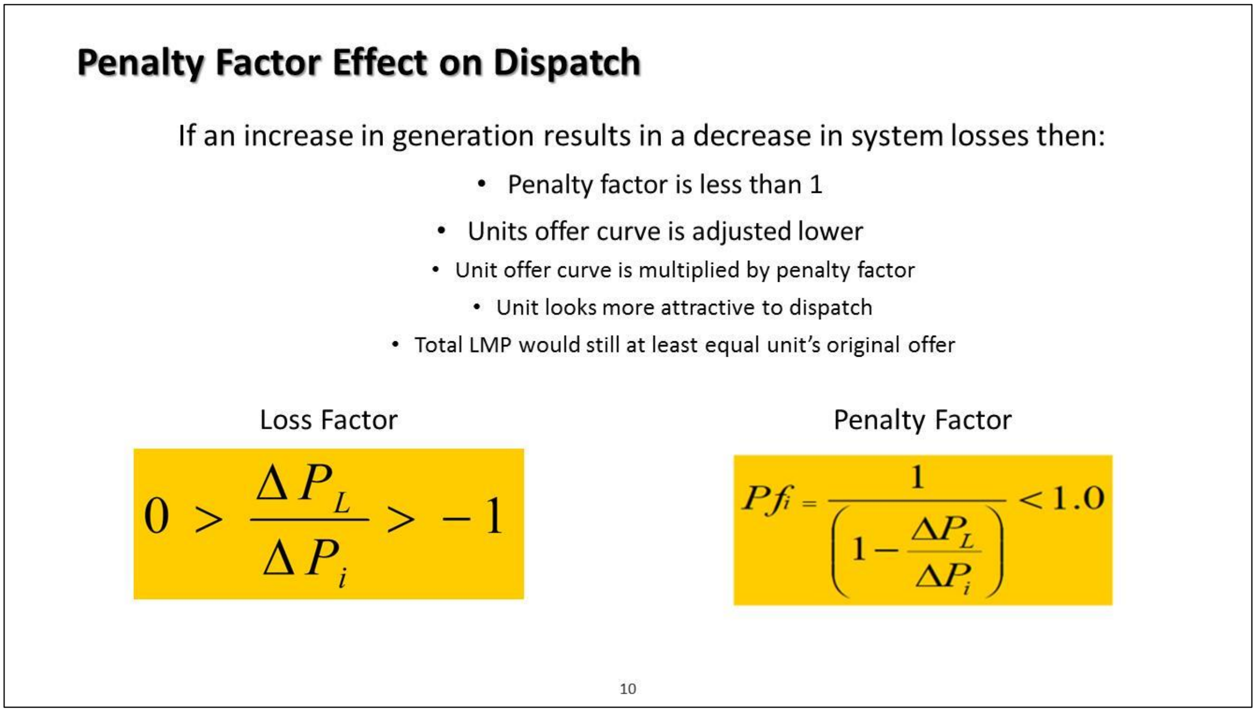
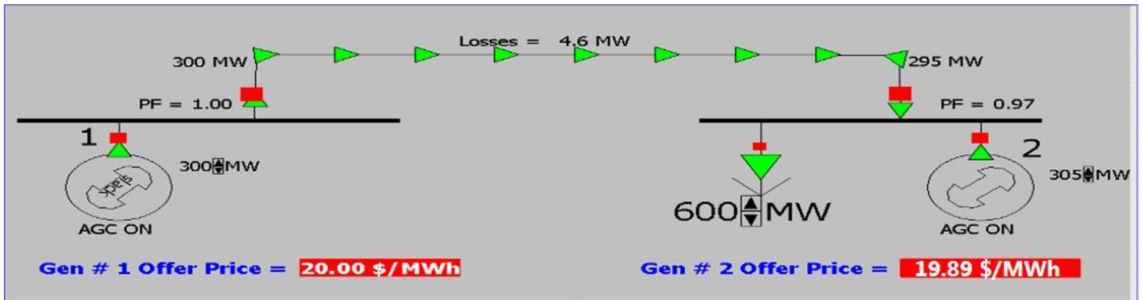
Penalty Factor Effect on Dispatch



Penalty Factor Effect on Dispatch - Example

Penalty Factor Effect on Dispatch - Example

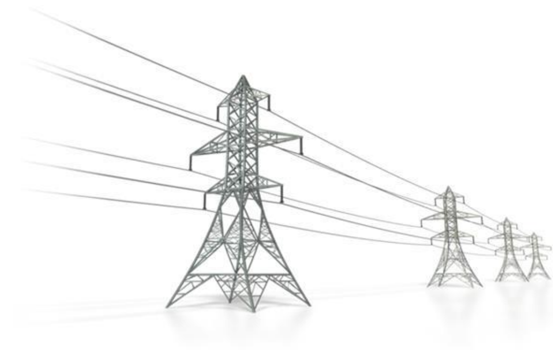


Generating Unit # 1	Generating Unit # 2
Offer Price = $ 10.00 ----- 200 MW $ 20.00 ----- 300 MW $ 30.00 ----- 400 MW $ 40.00 ----- 500 MW	Offer Price = $ 10.00 ----- 200 MW $ 20.00 ----- 300 MW $ 30.00 ----- 400 MW $ 40.00 ----- 500 MW
Generating 300 MW	Generating 305 MW
Penalty Factor = 1.00 $20 * 1.00 = $20.00	Penalty Factor = 0.97 $20.50 * 0.97 = $19.89

Operational Limits

Operational Limits

- Thermal Limits
- Voltage Limits
- Stability Limits



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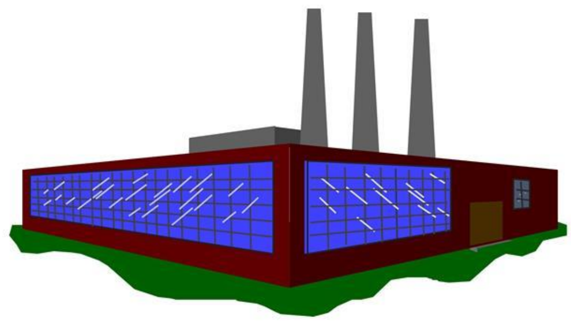
Control Actions

Control Actions

There are three basic types of actions that can be performed to control the flow of power on the electric system:

- System Reconfiguration
- Transaction Curtailments
- Generation Redispatch



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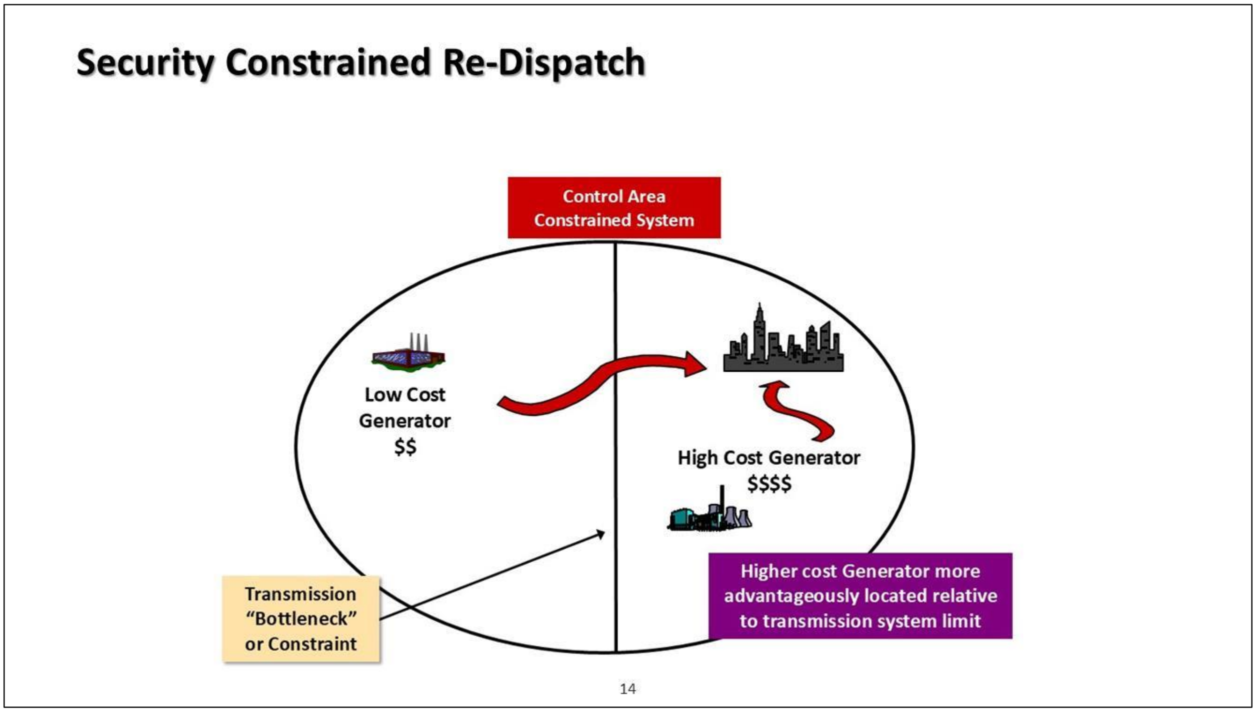
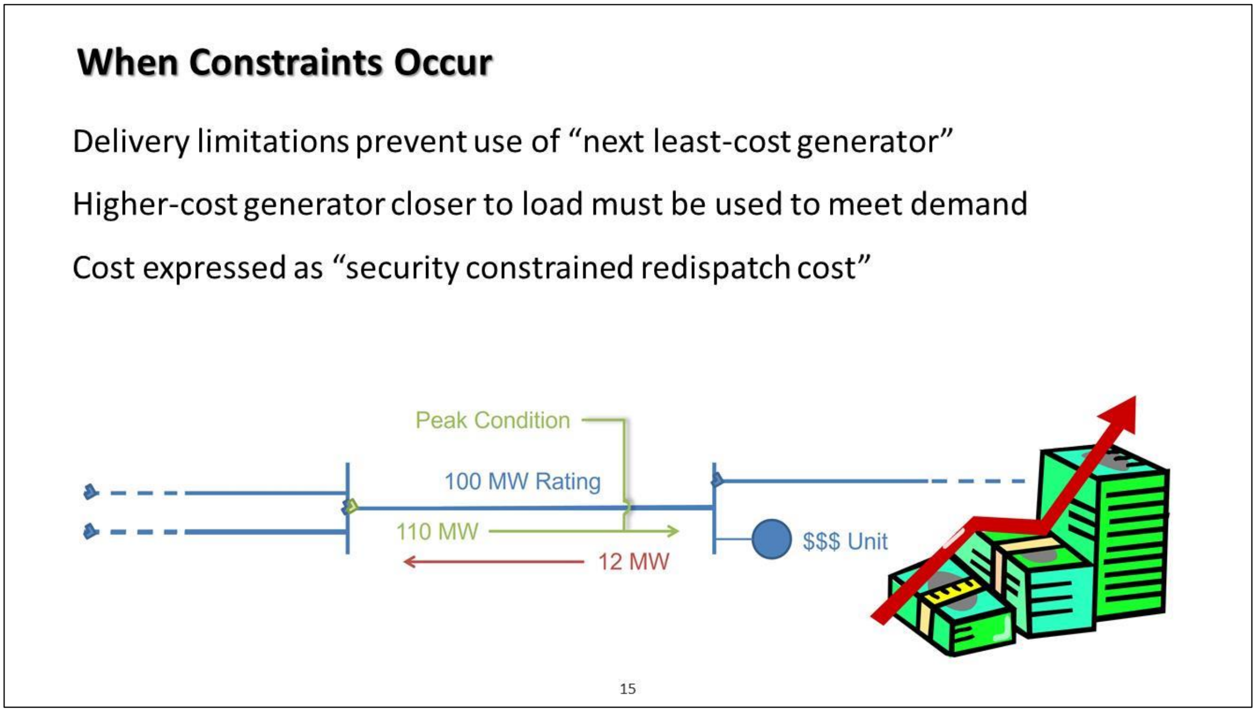
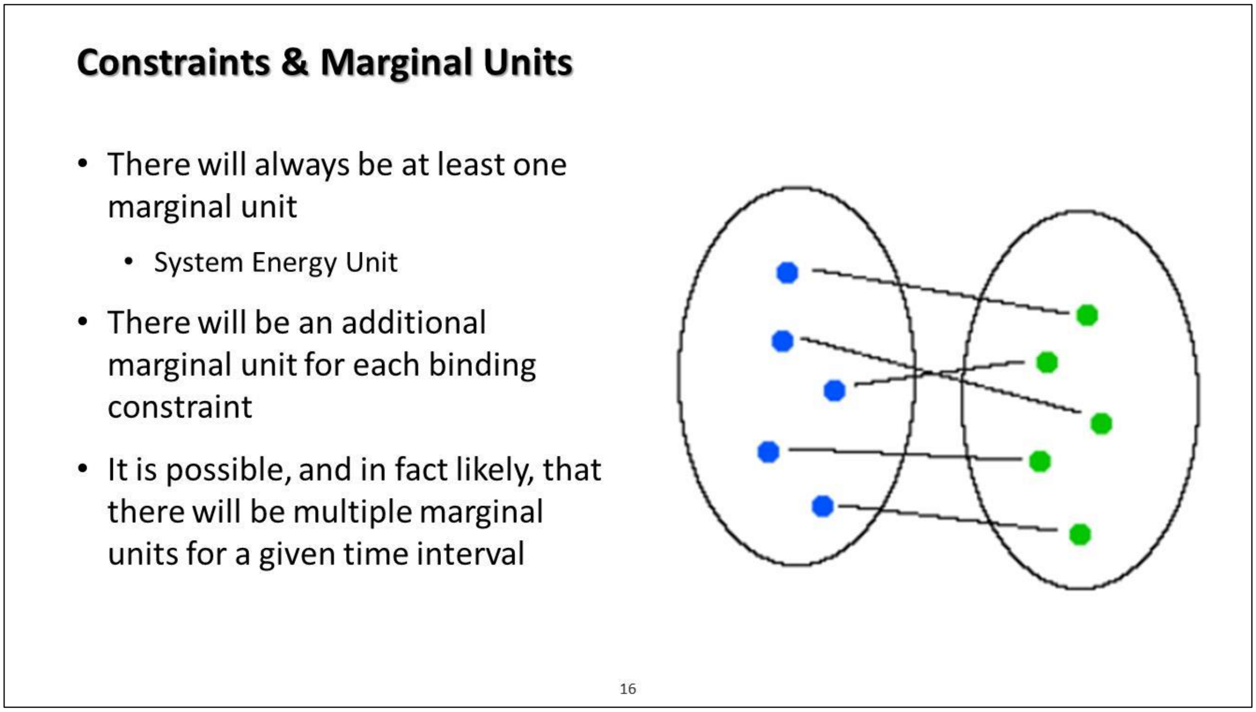
Security Constrained Re-Dispatch



When Constraints Occur



Constraints & Marginal Units



Contingency Analysis

Contingency Analysis

"What if" scenario simulator that evaluates, provides and prioritizes the impacts on an electric power system when problems occur.

- A contingency is a provision for an unforeseen event or circumstance
  - Loss or failure of a *small* part of the power system (e.g. a transmission line)
  - Loss or failure of individual equipment such as a generator or transformer

A computer application that uses a simulated model of the power system

- Evaluates the effects of an outage event
- Calculates any overloads that may result

This is referred to as maintaining system security

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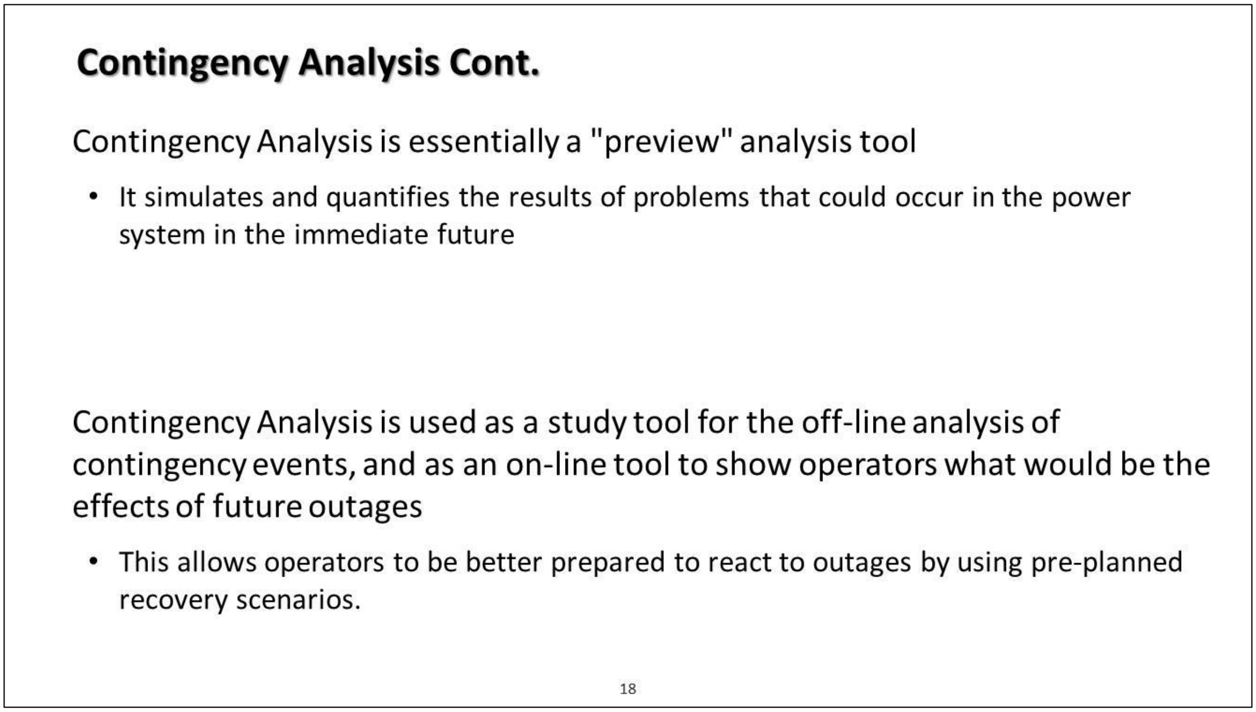
Contingency Analysis Cont.



How Contingency Analysis Works

How Contingency Analysis Works

Executes a power flow analysis for each potential problem that is defined on a contingency list

- A contingency list contains each of the elements that will be removed from the network model, one by one, to test the effects for possible overloads of the remaining elements
- The failure or outage of each element in the contingency list is simulated in the network model by removing that element
- The resulting network model is solved to calculate the resulting power flows, voltages, and currents for the remaining elements of the model

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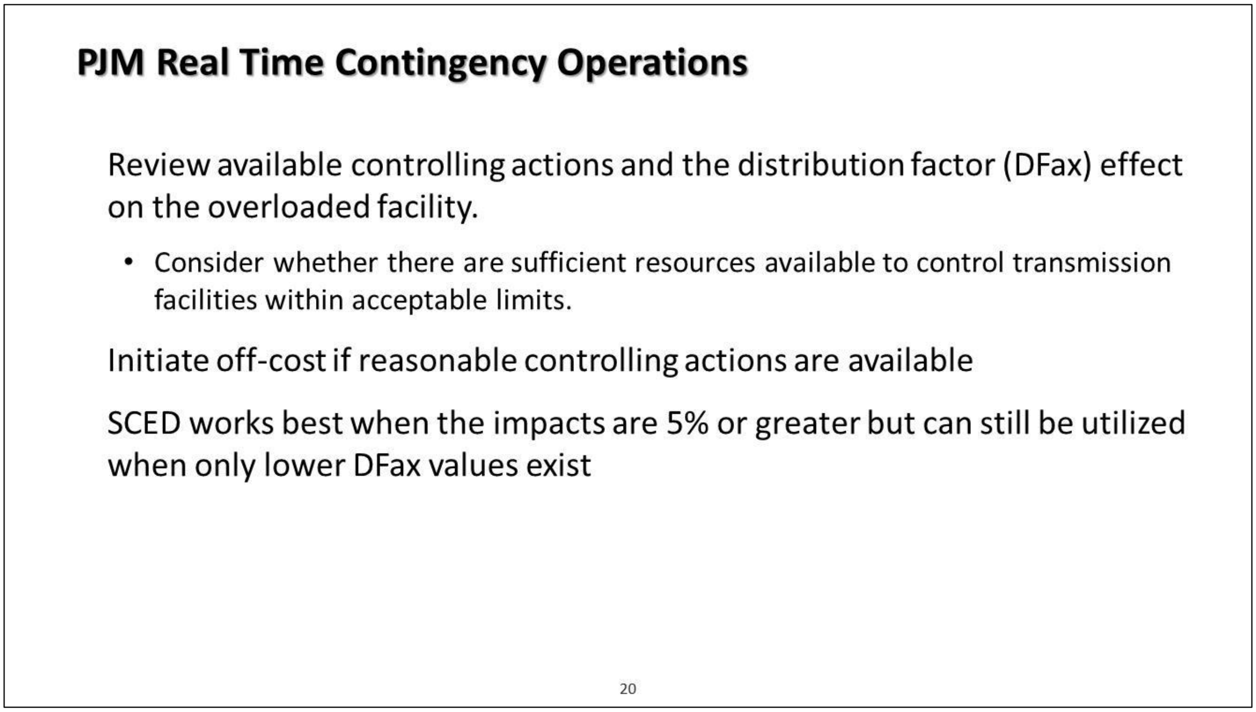
PJM Real Time Contingency Operations



PJM Real Time Contingency Operations

PJM Real Time Contingency Operations

Once off-cost is initiated, RT-SCED will redispatch generation based on its dollar per MW effect, considering all on-line flexible units with an impact of ~1% or greater

- –This percentage may be adjusted on a case by case basis

Initiate a Post Contingency Local Load Relief Warning/Action if post-contingency flows exceed designated ratings and insufficient resources are available to control the overloaded facilities

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PJM Real Time Contingency Operations

PJM Real Time Contingency Operations

During Constrained Operations, resources will re-dispatched cost-effectively based on their bid parameters

Cost-effective re-dispatch ($/MW Effect) = (Current Dispatch Rate – Unit Bid)/Unit Shift Factor

- SMP and Marginal Cost of Unit values are the result of optimization

Units with lowest $/MW effect are used to re-dispatched when the system is constrained

Unit parameters are taken into account and honored(i.e. eco min, eco max, min run time, etc.)

DFAX sign	$/MW Effect for Raising Output	$/MW Effect for Lowering Output
Negative DFAX = Raise Help	**Choose Lowest**	Choose Highest
Positive DFAX = Lower Help	Choose Highest	**Choose Lowest**

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What is LMP?

Generation Shift Factors

Generation Shift Factor: Fraction of change in generation MW output that will appear on a line or facility

- Used to predict the effect of generation changes on transmission line flow

Generation Shift Factors vs. Distribution Factors

- Similar to distribution factors
  - Decimal value
  - Used to analyze the effect of generation shifts on MW flow
- Unlike distribution factors
  - **Do not** add up to zero

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What is LMP?

What is LMP?

Locational Marginal Pricing (LMP) is the pricing mechanism used in PJM.

LMP is used to price:

- Energy purchases and sales
- Transmission congestion
- System losses

Physical, flow-based pricing system:

- How energy actually flows, NOT contract paths

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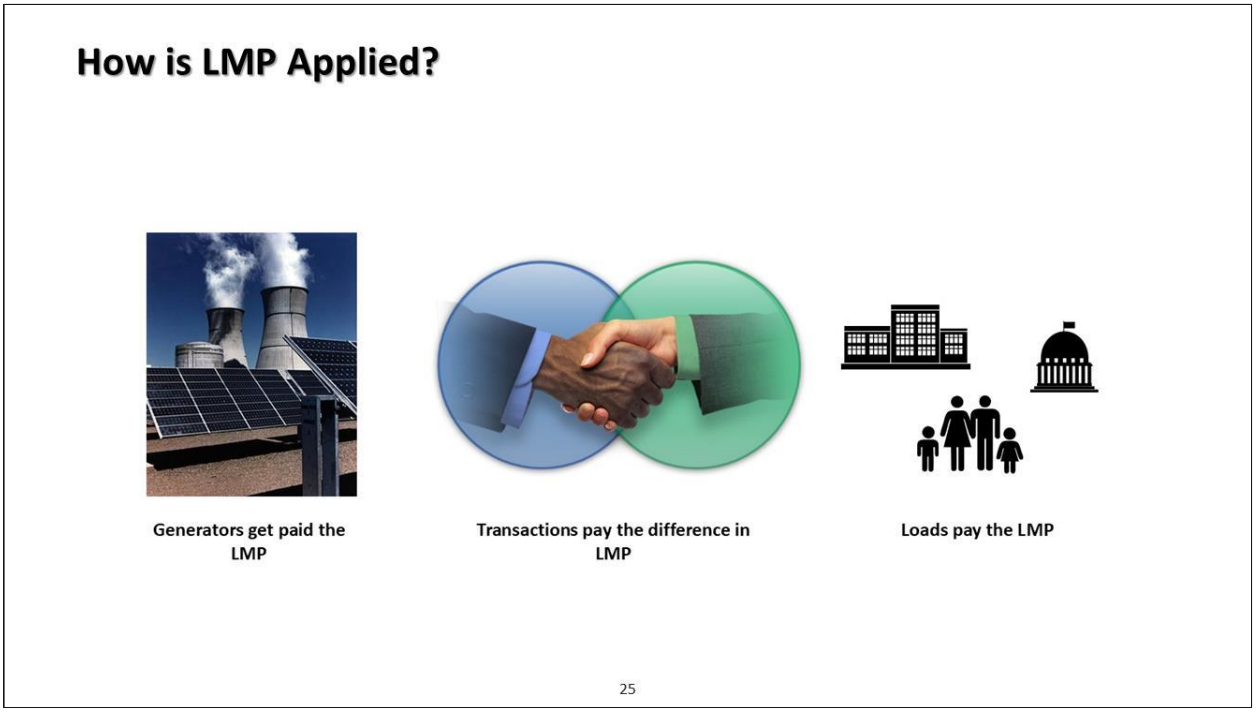
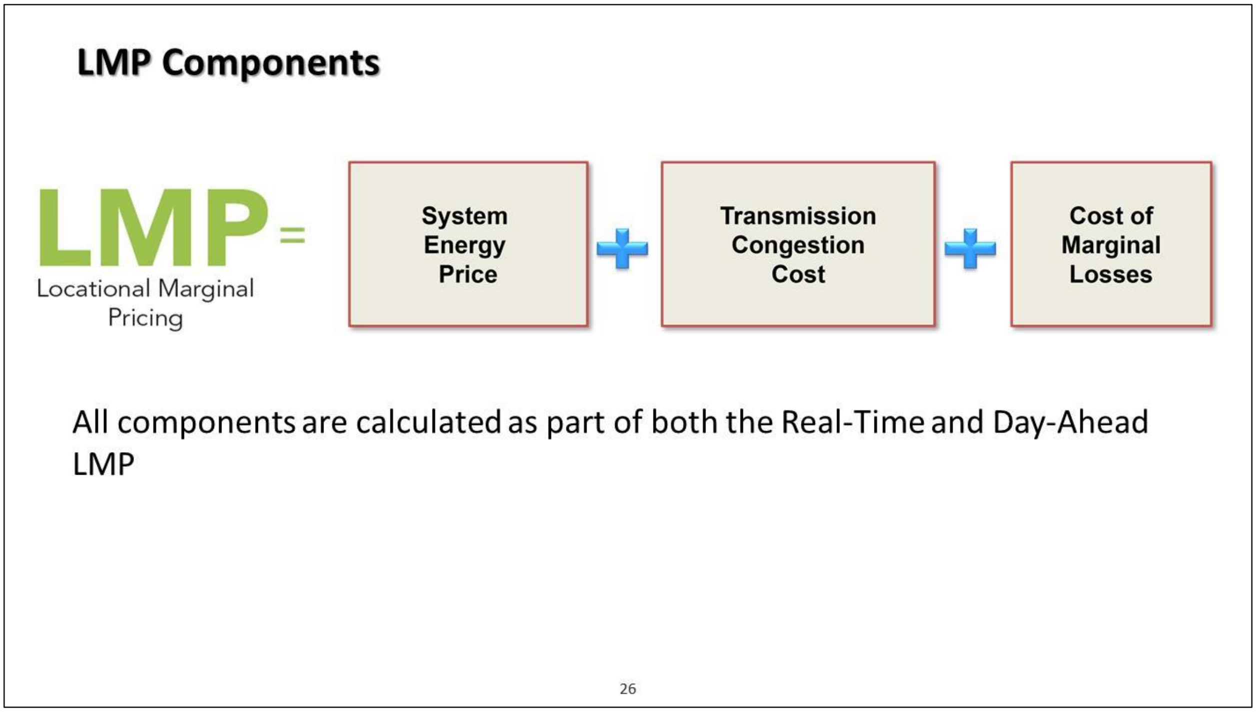
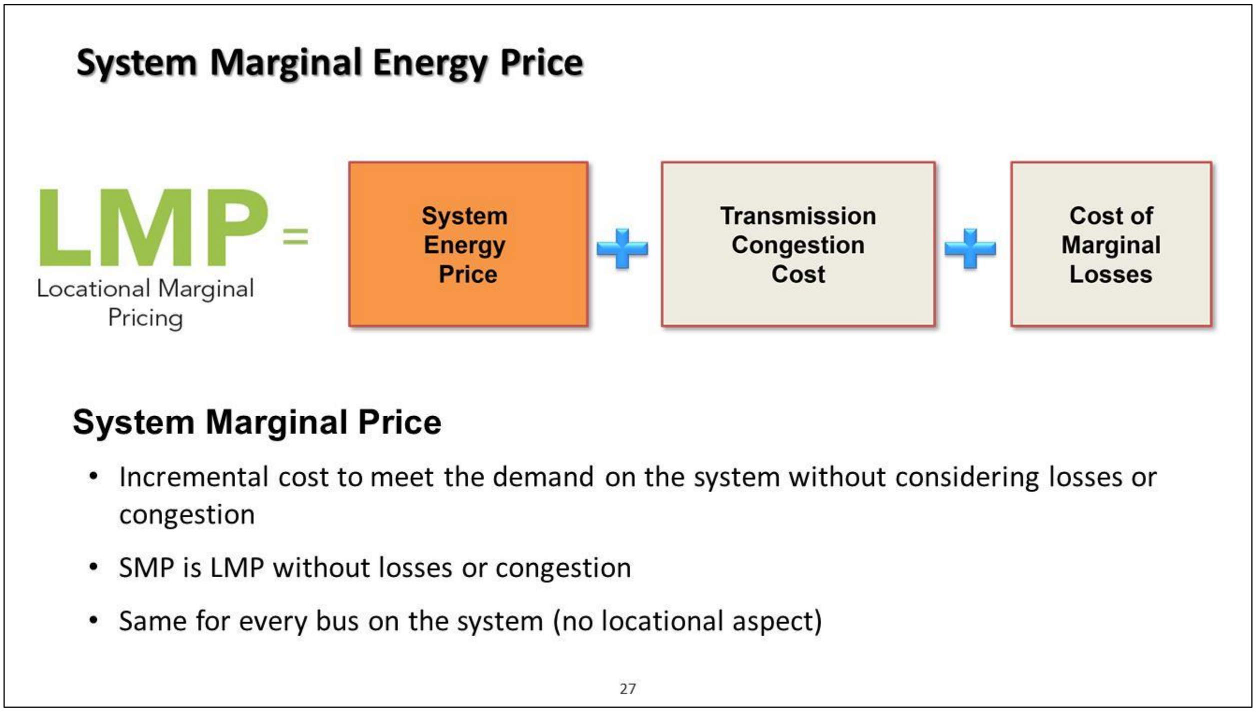
How is LMP Applied?



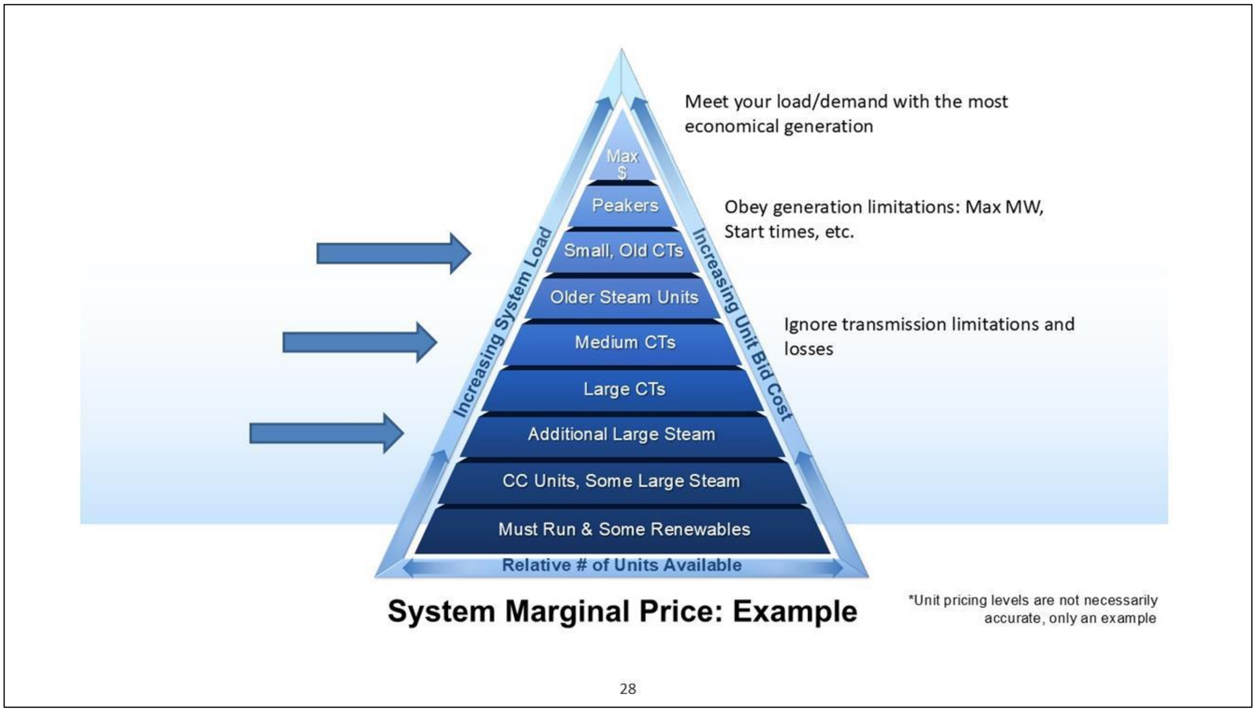
LMP Components



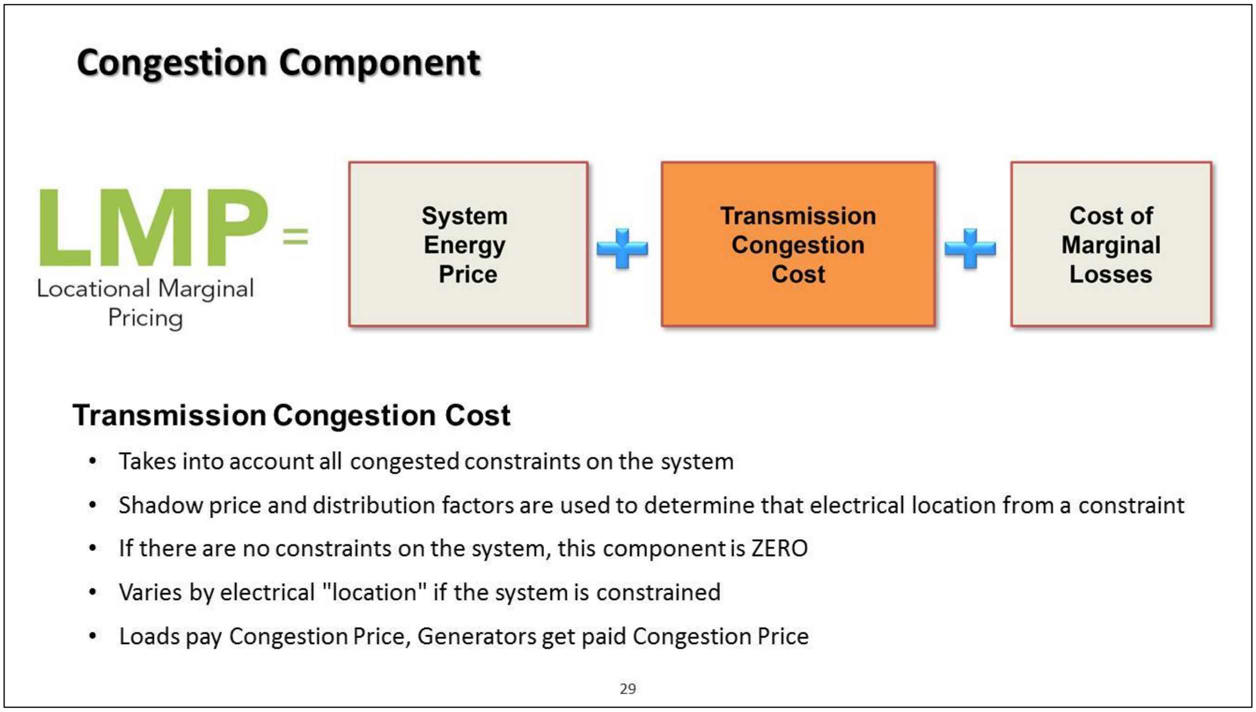
System Marginal Energy Price



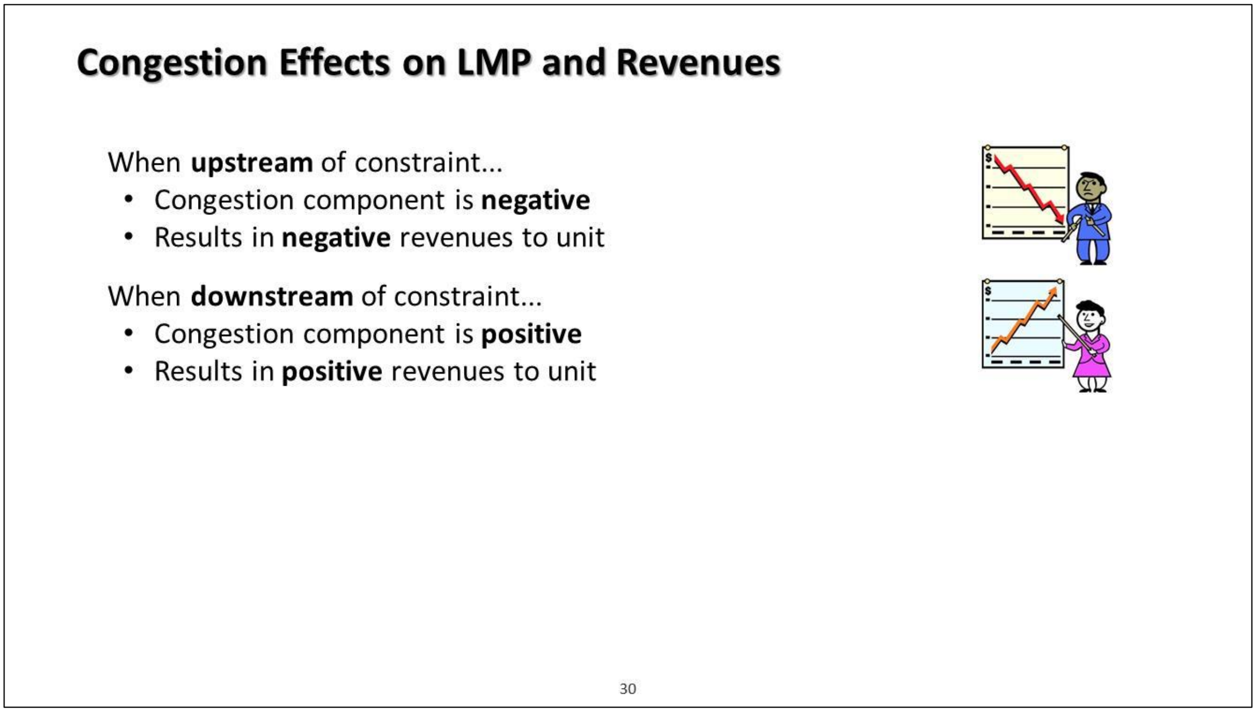
System Marginal Price - Example



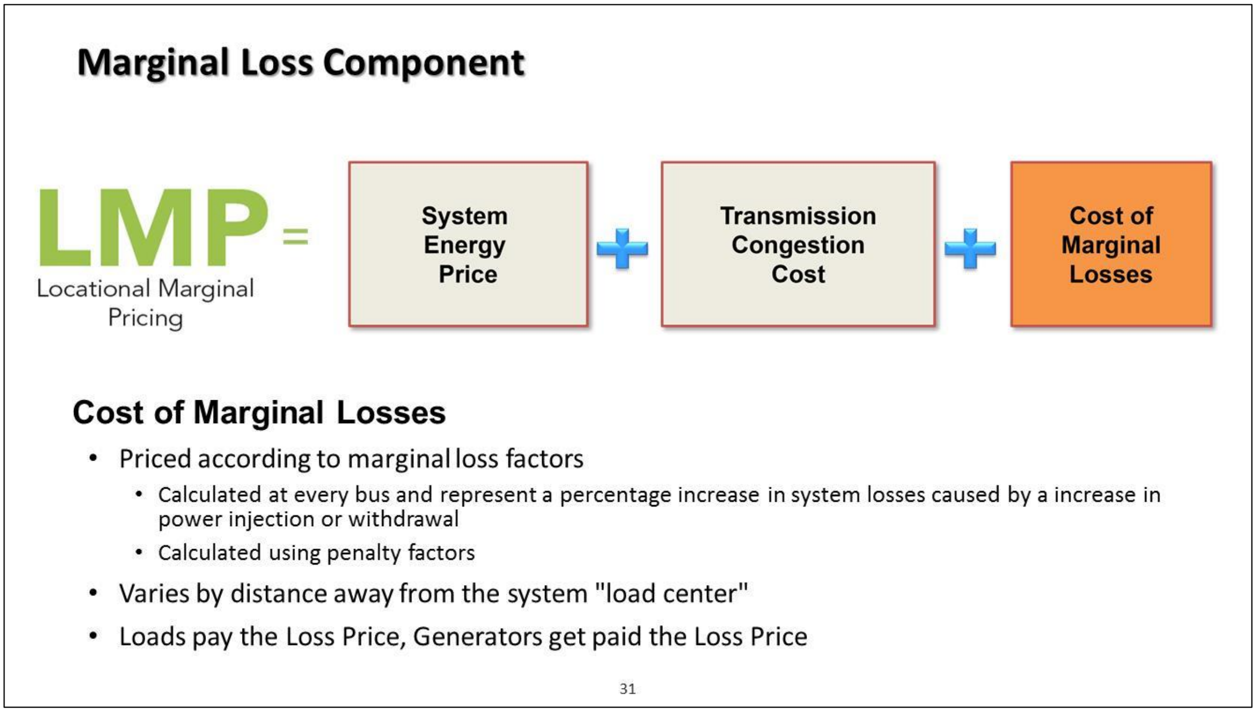
Congestion Component



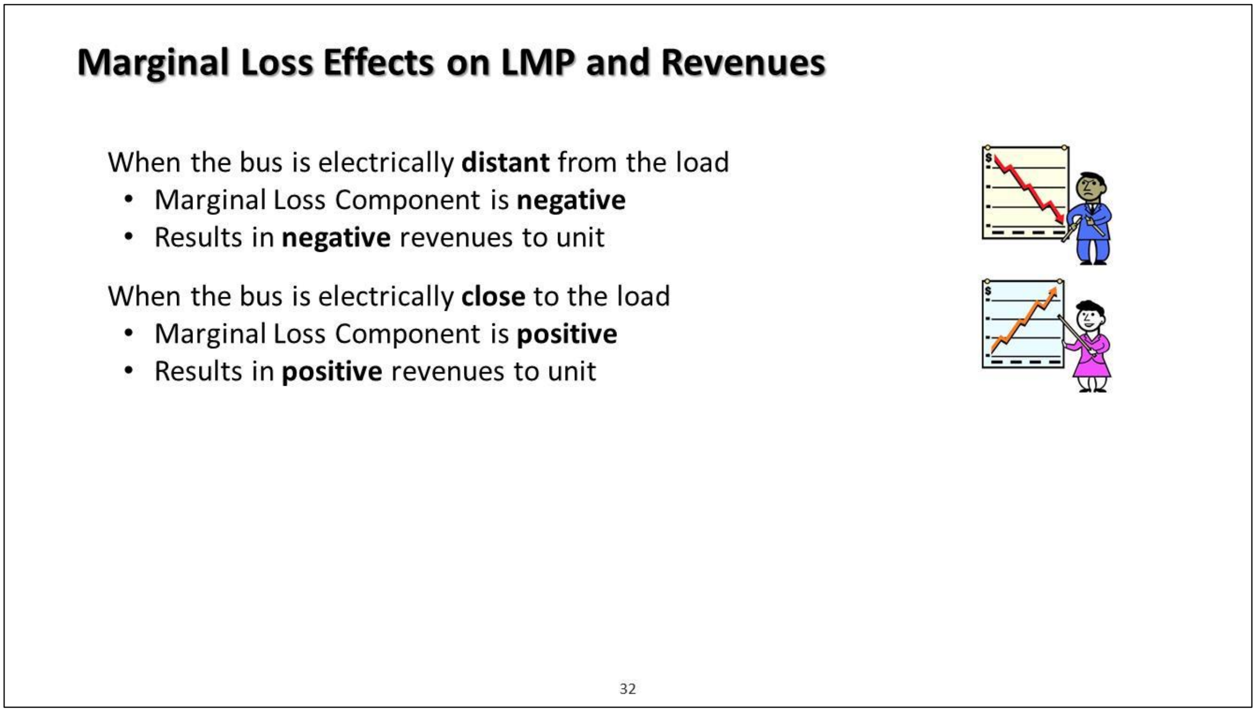
Congestion Effects on LMP and Revenues



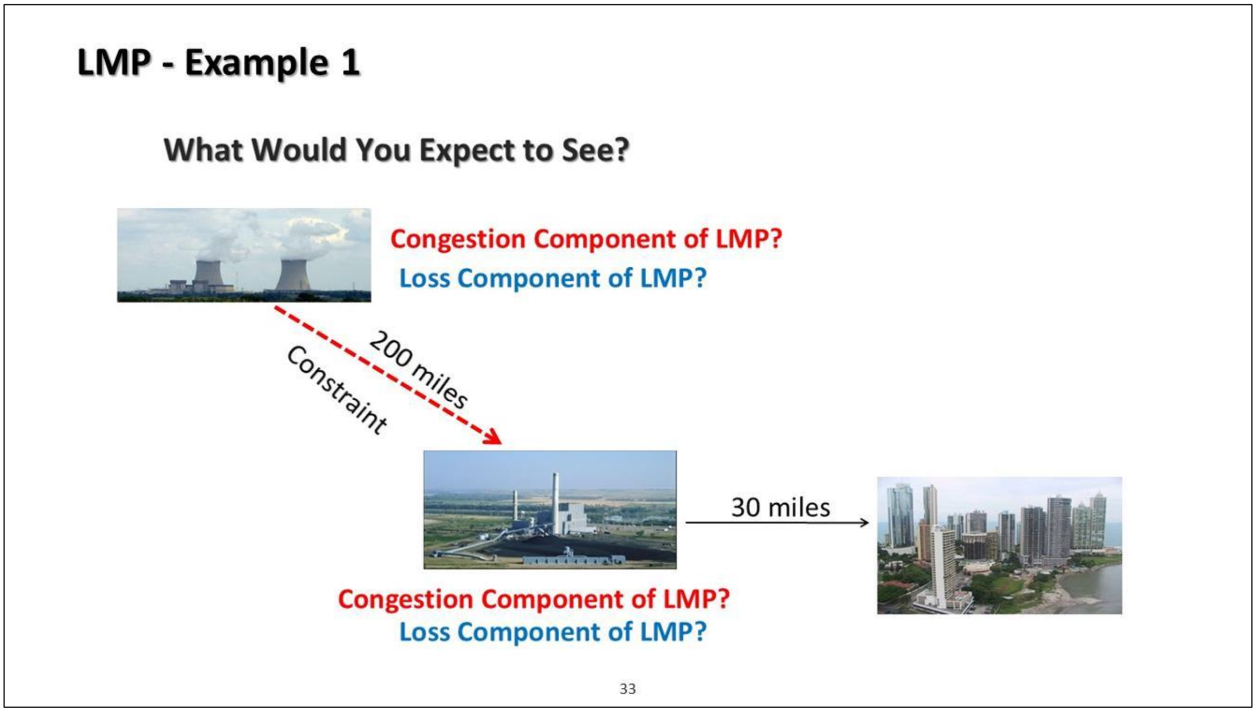
Marginal Loss Component



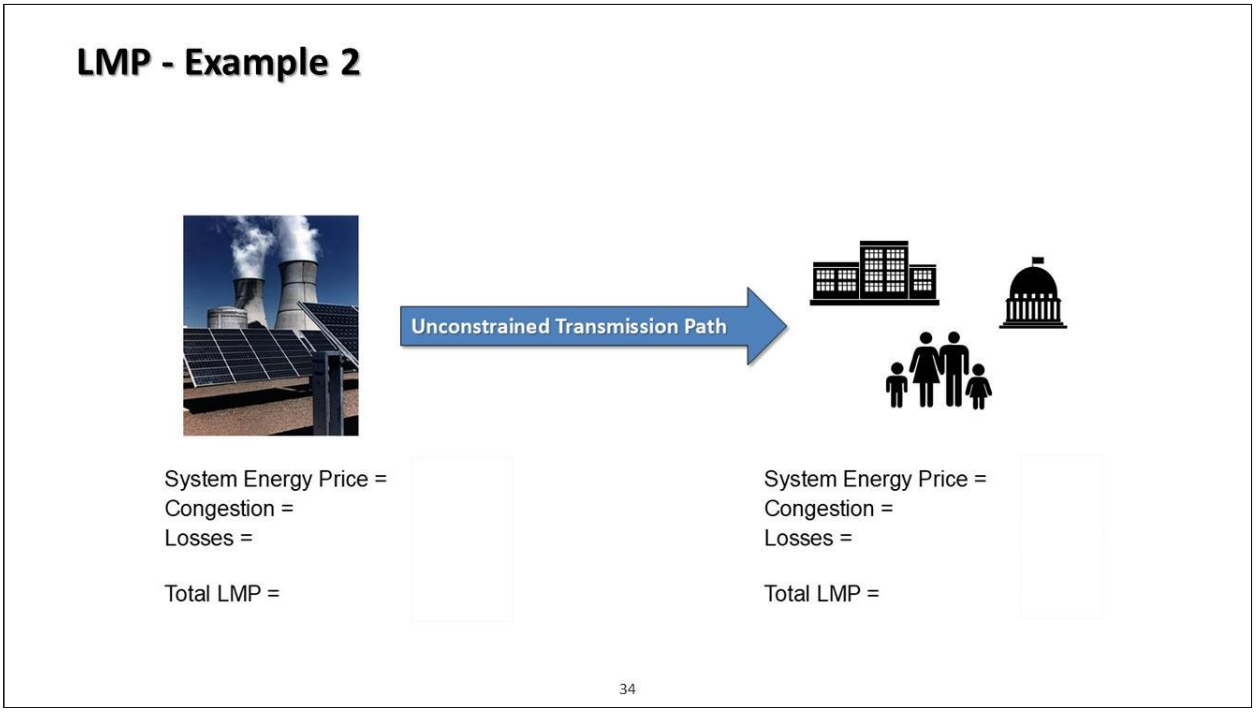
Marginal Loss Effects on LMP and Revenues

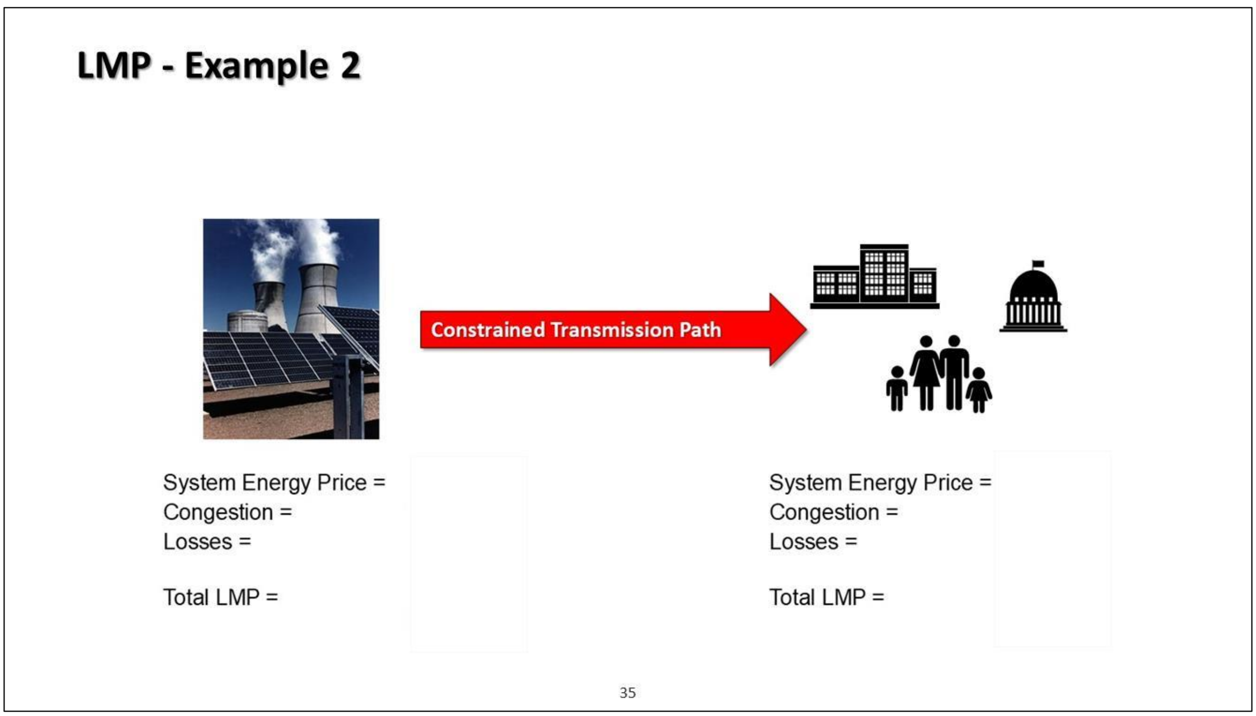


LMP - Example 1



LMP - Example 2





Knowledge Check!

1. **What is the primary purpose of the dispatch rate calculated by PJM?**

    a. *To determine transmission line ratings*

    b. *To assign congestion costs across the footprint*

    c. *To direct generator output based on submitted offers*

    d. *To calculate market clearing prices*

2. **In the context of Locational Marginal Pricing (LMP), what does the congestion component represent?**

    a. *The price impact of system constraints*

    b. *The marginal unit's minimum run time*

    c. *The change in voltage due to increased load*

    d. *The cost of energy at the reference bus*

3. **When is the penalty factor for a generator typically less than one?**

    a. *When the generator is electrically distant from the load*

    b. *When the generator is upstream of a constraint*

    c. *When the generator causes an increase in system losses*

    d. *When the generator reduces total system losses*

Questions

Questions?

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