ERCOT MARKET EDUCATION

Transmission 101
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Course Introduction
Protocol Disclaimer

This presentation provides a general overview of the Texas Nodal Market and is not intended to be a substitute for the ERCOT Protocols, as amended from time to time. If any conflict exists between this presentation and the ERCOT Protocols, the ERCOT Nodal Protocols shall control in all respects.

For more information, please visit:

http://www.ercot.com/mktrules/nprotocols/current
Legal Admonition

Antitrust Admonition

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Housekeeping

- Restrooms
- Refreshments
- Attendance sheet
- Questions

Please turn off cell phones & other electronics
Course Objectives

Upon completion of this course, you will be able to describe:

- overall structure of the ERCOT Nodal Market
- outage coordination rules & submission procedures
- network modeling process & procedures
- TSP activities and impacts of:
  - Congestion Revenue Rights (CRR)
  - Day-Ahead Market (DAM)
  - Adjustment Period
  - Real-Time Operations
Course Audience

This course is designed for:

• Transmission Service Provider Operators
• ERCOT Transmission System Operators

Other audiences:
– Outage planning & coordination personnel
– Operations support & planning engineers
– Engineering technicians
– IT staff, Management
Modules in this course include:

- **Module 1**: ERCOT Market Basics
- **Module 2**: Outage Coordination
- **Module 3**: Network Modeling
- **Module 4**: Congestion Revenue Rights
- **Module 5**: Day-Ahead through Real-Time
- **Module 6**: Additional Real-Time Topics
Module 1:

ERCOT Market Basics
Module Objectives

Upon completion of this module, you will:

• Describe Nodal Market Overview
• Describe ERCOT and TSP responsibilities
• Describe Locational Marginal Price (LMP) basics
• Describe relationships between Transmission outages and LMP calculations
Market Relationships
Nodal Market Overview

**Registration**
- Market Participants
- Qualifications
- Assets
- Relationships

**CRR Auction**
- Semi-Annual & Monthly
- CRR Offers and Bids
- PTP Options and Obligations

**Reliability Unit Commitment**
- Transmission Security Analysis
- Resource commitment
- Day-Ahead RUC
- Hourly RUC

**Real-Time Operations**
- Network Security Analysis
- Security Constrained Economic Dispatch (SCED)
- 5 Minutes Dispatch
- Load Frequency Control (LFC)

**Market Information System (MIS)**
- Access Market Reports
- Submit Market Inputs
- Download Information
- Review Market Outputs
- Submit Market Inputs
- Download Information
Nodal Market Overview

Registration
- Market Participants
- Qualifications
- Assets
- Relationships
Nodal Market Overview

Network Operations Model
- Semi-Annual & Monthly
- CRR Offers and Bids
- PTP Options and Obligations

Network Modeling
- Network Operations Model
- Network Operations Model Change Request (NOMCR)

Reliability Unit Commitment
- Transmission Security Analysis
- Resource commitment
- Day-Ahead RUC
- Hourly RUC

Real-Time Operations
- Network Security Analysis
- Security Constrained Economic Dispatch (SCED)
- 5 Minutes Dispatch
- Load Frequency Control (LFC)
Nodal Market Overview

CRR Auction

- Semi-Annual & Monthly
- CRR Offers and Bids
- PTP Options and Obligations
Nodal Market Overview

- Hourly Market
- Energy Offers and Bids
- Ancillary Service Offers
- DAM PTP Obligation Bids
Nodal Market Overview

Reliability Unit Commitment

- Transmission Security Analysis
- Resource commitment
- Day-Ahead RUC
- Hourly RUC
Adjustment Period

- Energy Offers
- Trades
- Current Operating Plans
- Supplemental Ancillary Services Market (SASM)
Nodal Market Overview

Real-Time Operations

• Network Security Analysis
• Security Constrained Economic Dispatch (SCED)
• 5 Minute Dispatch
• Load Frequency Control (LFC)
Nodal Market Overview

• CRR Auction
• Day-Ahead Market
  – 1 Hour Settlement Interval
• Real-Time Operations
  – 15 Minute Settlement Interval
Market Information System
Roles and Responsibilities

ERCOT Operations

• Facilitate markets
• Operate Ancillary Service, Day-Ahead and Real-Time Energy markets
• Provide timely information relevant to the operation of markets
• Ensure transmission system reliability
• Process outage and Network Model requests
• Coordinate transmission system planning
Transmission Service Providers (TSP)

- Keep ERCOT continually informed of transmission outages and updates
- Provide accurate and timely data
- Comply with ERCOT dispatch instructions
- Coordinate transmission system planning
- Update & validate Network Operations Models
What is **Locational Marginal Pricing (LMP)**?

**Pricing:** Cost

**Marginal:** to serve the next increment of Load

**Locational:** at an Electrical Bus
Locational Marginal Pricing

LMP Components

- Energy
- Congestion

In some markets, LMPs have a component for losses.
The Nodal Market does **NOT** include losses in LMPs.
How often are LMPs & Settlement Point Prices calculated?

LMPs and Settlement Point Prices

- Every Hour

LMPs

- Every 5 minutes*

Settlement Point Prices

- Every 15 minutes

* LMPs generated at each SCED cycle (possibly more often than 5 minutes)
Calculating LMPS

- Calculated at “Network Nodes”
- Points of connection to grid
  - Source (injection point)
  - Sink (withdrawal point)
  - Switching station
Calculating LMPS

- DC Power Flow model used to calculate LMPs

Constraints:
- Real Power
- Studies:
  - Voltage Stability
  - Transient Stability

Transmission Limits
Generic Limits

DC Model

LMPs
Three Types of Settlement Points:

- **Resource Nodes**
- **Load Zones**
- **Hubs**
What is a Resource Node?

An Electrical Bus where a Resource’s measured output is settled
Settlement Point Prices

Settlement Point Prices for Resource Nodes

Day-Ahead Market
• LMP at the Resource Node

Real-Time Operations
• Time-Weighted Averages of LMPs at Resource Node
What is a Load Zone?

A group of Electrical Buses assigned to the same Load Zone

All Load must be assigned to a Load Zone for Settlement purposes
Settlement Point Prices

Settlement Point Price for Load Zones

Day-Ahead Market
• Load-Weighted Average of LMPs at Electrical Buses in Load Zone

Real-Time Operations
• Load-Weighted and Time-Weighted Averages of LMPs at Electrical Buses in Load Zone
Three types of Load Zones

- Competitive Load Zones
- Non Opt-in Entity Load Zones
- DC Tie Load Zones
Competitive Load Zones

- North
- South
- West
- Houston

2003 Congestion Management zones
Non Opt-in Entity Load Zones

Established by one or more NOIE(s)

Some large NOIEs required to establish own NOIE Load Zones

NOIEs that don’t establish NOIE Load Zone are assigned to Competitive Load Zone
Settlement Point Prices

DC Tie Load Zones

- Used to settle exports across DC Ties
- One for each DC Tie
- Contains only the electrical bus connected to the DC Tie.

All Load must be assigned to a Load Zone for Settlement purposes
What is a Hub?

- Group of 345kV Hub-buses
- Defined by Protocols
Six Hubs in ERCOT Market

Four Regional Hubs
- North
- West
- South
- Houston

Two Average Hubs
- ERCOT Hub Average
- ERCOT Bus Average
Settlement Point Price for Hubs

Day-Ahead Market
• Simple average of LMPs at Hub Buses in each Hub

Real-Time Operations
• Simple average of Time-Weighted Average LMPs at the Hub Buses in the Hub
LMP Contour Map

- Day-Ahead Market SPPs
- Real-Time LMPs
- Real-Time SPPs
Impact of Outages on Prices

• Outages and limits impact Locational Marginal Prices (LMPs)
• Impact on Settlement Point Prices
• Price changes depend on affected transmission elements

Remember: Different LMPs provide a signal that something reliability related is limiting the network
In a **perfect** world there is… **no** Congestion, **no** Outages

G1 QSE offers 100 MW @ $30/MWh

G2 QSE offers 200 MW @ $10/MWh
In a **perfect** world there is…

**no** Congestion, **no** Outages

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G1 QSE offers 100 MW @ $30/MWh

0 MW dispatched @ $30/MWh

150 MW dispatched @ $10/MWh

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G2 QSE offers 200 MW @ $10/MWh
In a **perfect** world there is… **no** Congestion, **no** Outages

**G1 QSE offers 100 MW @ $30/MWh**

- 0 MW dispatched @ $30/MWh
- 150 MW dispatched @ $10/MWh

**G2 QSE offers 200 MW @ $10/MWh**

**LMP = $10 / MWh**

**Paid to Generators (G2)**

- G1 \((0 \text{ MW} \times \$30/\text{MWh})\) = $0
- G2 \((150 \text{ MW} \times \$10/\text{MWh})\) = $1500

**Charged to Loads (L1)**

- \((150 \text{ MW} \times \$10/\text{MWh})\) = $1500
In an *imperfect* world, Outages can cause Congestion.

**SCENARIO**

G1 QSE offers 100 MW @ $30/MWh

G2 QSE offers 200 MW @ $10/MWh

100 MW Limit

L1

150 MW Load

Module 1 : Slide 46
In an imperfect world, outages can cause congestion and cost increases.

Scenario: Outages and LMPs (continued)

G1 QSE offers 100 MW @ $30/MWh

- 50 MW dispatched @ $30/MWh
- 100 MW dispatched @ $10/MWh

G2 QSE offers 200 MW @ $10/MWh

150 MW Load

100 MW Limit
In an *imperfect* world Outages can cause Congestion and Cost Increases

**Scenario: Outages and LMPs (continued)**

- **G1 QSE** offers 100 MW @ $30/MWh
- **G2 QSE** offers 200 MW @ $10/MWh

LMP = $30 / MWh

Paid to Generators (G2)
- G1 \((50 \text{ MW} * \$30/\text{MWh}) = \$1500\)
- G2 \((100 \text{ MW} * \$10/\text{MWh}) = \$1000\)

Charged to Loads (L1)
- \((150 \text{ MW} * \$30/\text{MWh}) = \$4500\)
Scenario: Outages and LMPs (continued)

In an **imperfect** world, outages can cause congestion and cost increases.

### SCENARIO

**G1 QSE offers 100 MW @ $30/MWh**
- 50 MW dispatched @ $30/MWh
- 100 MW dispatched @ $10/MWh

**G2 QSE offers 200 MW @ $10/MWh**

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100 MW Limit

- Differences (between payments and charges) go into congestion rent
- Covered in more detail later
Sometimes Outages **do not** impact LMPs . . .

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**SCENARIO**

G1 QSE offers 100 MW @ $30/MWh

- 0 MW dispatched @ $30/MWh
- 50 MW dispatched @ $10/MWh

G2 QSE offers 200 MW @ $10/MWh

---

LMP = $10 / MWh
Sometimes Outages don’t impact LMPs . . .

G1 QSE offers 100 MW @ $30/MWh

- 0 MW dispatched @ $30/MWh
- 50 MW dispatched @ $10/MWh

G2 QSE offers 200 MW @ $10/MWh

- 50 MW flow
- LMP = $10 / MWh

Result:
- Either line can support load
- No change in LMPs
In this module we:

- Introduced the ERCOT Nodal Visual Process Map
- Identified key roles and responsibilities
- Discussed basics of Locational Marginal Prices (LMPs)
- Discussed outage impacts on LMPS