NODAL MARKET EDUCATION

ERCOT Nodal 101
Legal Disclaimers and Admonitions

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Housekeeping

- Attendance sheet
- Questions
- Exam
- Restrooms

Please turn off cell phones & other electronics
Training Curriculum

- ERCOT Nodal 101
- Load Serving Entity 201
- Congestion Revenue Rights
- ERCOT 101 for Wind Generation
- Settlements 301
- Basic Training Program
- Generation in RUC and Real-Time
- Generation in Day Ahead Market
- Transmission 101
ERCOT Nodal 101:

A high-level overview of the ERCOT Nodal Market for all Market Participants and ERCOT personnel.
Course Objectives

Upon completion of this course...

...you will be able to:

• Identify major components of the Nodal Market
• For each component of the Nodal Market, describe
  • Purpose
  • Inputs
  • Outputs
  • Processes
Introduction to ERCOT
Topics in this lesson . . .

• Key features of the ERCOT Grid
• ERCOT Responsibilities
  • Reliability and Markets
  • Capacity and Energy
  • Congestion Management
• Network Modeling
• Market Design
• Market Overview
Key Features of the ERCOT Grid

- Represents 85% of Texas Load
- 74,000 MW of generation capacity
- 40,530 miles of transmission lines
- Electrical island with several DC Ties
ERCOT’s Primary Responsibility is Reliability

- Match generation with demand
- Operate transmission system within established limits
Reliability and Competitive Markets

- Markets support reliability
- Reliability makes the markets possible

ERCOT finds the balance between Reliability and Economics.
Energy and Capacity

ERCOT dispatches *Energy* to follow the system demand.
ERCOT must also ensure sufficient *Capacity* is on-line to meet the forecasted demand.
ERCOT Responsibility

More about Capacity

Capacity Reserved for Ancillary Services

Ancillary Services needed to respond quickly to changing system conditions.

Forecast

System Capacity

System Demand
Ancillary Service Capacity

Acquired through competitive markets

System Capacity

Ancillary Service Capacity
Ancillary Service Capacity

Three types of Ancillary Services

- Regulation Reserve
- Responsive Reserve
- Non-Spin Reserve

System Capacity
Transmission Congestion

- Generators and Loads separated by distance
- Transmission system has limits

Congestion management keeps transmission system operating within limits
Models allow ERCOT to:

- “See” grid at any point in time
- Predict how various actions affect grid
Network Operations Model

• Physical characteristics
• Ratings
• Operational limits

Including

• Transmission Elements
• Resources
• Topology
• Telemetry
Market Design
Market Relationships

- LSE
- QSE
- Power Marketer
- IMM Independent Market Monitor
- PUCT Public Utility Commission of Texas
- ERCOT

Flow connections:
- Wholesale Settlement
- Operations & Settlement
- Trades
- Retail Settlement
- Operations & Settlement
- Reporting
- Data
- Oversight
- Operations
- Consumers
- TSP
- DSP
Commercial Markets

- Bilateral Market
- ERCOT Facilitated Markets
  - Day-Ahead Energy Market
  - Day-Ahead Ancillary Services Market
- Real-Time Energy Market
Nodal Market Design

Energy Dispatch
• Resource specific offers
• Resource specific dispatch

Goal
• Balance generation & demand
• Manage congestion

Energy Pricing
• Local prices for energy
• Prices include congestion costs
Congestion Costs

- All costs are directly assigned
- Congestion Revenue Rights available for hedging
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

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

**Day-Ahead Market**
- Hourly Market
- Energy Offers and Bids
- Ancillary Service Offers
- DAM PTP Obligation Bids

**Adjustment Period**
- Energy Offers
- Trades
- Current Operating Plans
- Supplemental Ancillary Services Market (SASM)

**Settlement**
- CRR Auction
- Day-Ahead Market
- 1 Hour Settlement Interval
- Real-Time Operations
- 15 Minute Settlement Interval

---

Monitor Credit • Monitor Performance • Update Outages • Update and Validate Current Operating Plans (COPs)
Nodal Market Overview

Registration

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Nodal Market Overview

Network Operations Model

- Network Operations Model
- Network Operations Model Change Request (NOMCR)
Nodal Market Overview

CRR Auction

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

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Nodal Market Overview

Reliability Unit Commitment

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

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Nodal Market Overview

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- Network Operations Model Change Request (NOM/CR)

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- Day-Ahead Market
  - 1 Hour Settlement Interval
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Monitor Credit • Monitor Performance • Update Outages • Update and Validate Current Operating Plans (COPs)
Locational Marginal Pricing
Topics in this lesson . . .

- Locational Marginal Prices (LMPs)
  - Define LMPs
  - Determination of LMPs
- Congestion Rent
- Settlement Point Prices
- Market Information
What is **Locational Marginal Pricing (LMP)**?

**Pricing:** Cost

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

**Locational:** at an Electrical Bus
In some markets, LMPs have a component for losses.

The Nodal Market does **NOT** include losses in LMPs.
Locational Marginal Pricing

EXAMPLE

Introducing the players...

Gen 1

Gen 2
Locational Marginal Pricing

EXAMPLE

Let’s solve for LMPs at each Bus:

Gen 1
10 MW ($4 per MWh)

Gen 2
20 MW ($2 per MWh)

LMP?

LMP?

LMP?

LMP?

10 MW
Locational Marginal Pricing

When there is no congestion, all LMPs are equal.

EXAMPLE

- **Gen 1**
  - 10 MW
  - ($4 per MWh)

- **Gen 2**
  - 20 MW
  - ($2 per MWh)

- 10 MW
  - ($2/MWh)
Example: No Congestion

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<tr>
<th></th>
<th>LMP</th>
<th>MW</th>
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<tr>
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<th>MW</th>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$20</strong></td>
<td></td>
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</tbody>
</table>
Now there is congestion.

EXAMPLE

10 MW ($4 per MWh)

Gen 1

20 MW ($2 per MWh)

Gen 2

4 MW constraint

10 MW
Locational Marginal Pricing

**EXAMPLE**

- **Gen 1**
  - 10 MW
  - ($4 per MWh)
- **Gen 2**
  - 20 MW
  - ($2 per MWh)

With congestion, LMPs are different.
### Locational Marginal Pricing

#### Example: Congestion

<table>
<thead>
<tr>
<th>Gen 1</th>
<th>Gen 2</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Gen 1" /></td>
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<tr>
<td><strong>LMP</strong></td>
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<td>4</td>
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</table>
Congestion Rent used to fund Congestion Revenue Rights (CRRs)
LMPs and Settlement Point Prices

- LMPs at Electrical Buses
- Settlement Points used for financial settlement
- Settlement Point Prices calculated using 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)
Settlement Point Prices

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
Settlement Point Prices

Three types of Load Zones

- Competitive Load Zones
- Non Opt-in Entity Load Zones
- DC Tie Load Zones
Settlement Point Prices

Competitive Load Zones

• North
• South
• West
• Houston

2003 Congestion Management zones
Settlement Point Prices

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
Settlement Point Prices

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
Market Information System

LMP Contour Map

• Day-Ahead Market SPPs
• Real-Time LMPs
• Real-Time SPPs
Nodal Market Operations
Nodal Market Operations

Market Components

- CRR Auction
- Day-Ahead Market
- Reliability Unit Commitment
- Real-Time Operations
Nodal Market Operations
Congestion Revenue Rights
Topics in this lesson . . .

• Purpose of CRRs
• CRR Account Holders
• Types of CRRs
• How CRRs are acquired
• Settlements
• Market Information System
Congestion Revenue Rights

- 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
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Market Information System (MIS)
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Purpose of Congestion Revenue Rights

- Financial instruments
- Hedge against congestion costs
- Financial investment
- Payment or charge when Grid is congested

A CRR is *not* a right to deliver physical energy
Congestion Costs

Congestion Cost exposure

Congestion costs are built in to the Settlement Point prices.

Resource Node A

$30/MWh

Load Zone

$40/MWh

Resource Node B

$45/MWh
Congestion Revenue Rights

Introducing a new player: CRR Account Holder
Congestion Revenue Rights

To own CRRs, Market Participants:

- Must be registered with ERCOT
- Must qualify as CRR Account Holders
Congestion Revenue Rights

Barred from owning CRRs:
- TSPs & DSPs
- ERCOT
Congestion Revenue Rights as Financial Instruments

- Designated point of injection (source) and point of withdrawal (sink)

- Settlement based on difference between sink and source Settlement Point Prices

- Two Instruments:
  - Point-to-Point Options
  - Point-to-Point Obligations
## Types of Congestion Revenue Rights

<table>
<thead>
<tr>
<th>Point-to-Point Obligations</th>
<th>Point-to-Point Options</th>
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<tbody>
<tr>
<td>Can result in <em>payment or charge</em></td>
<td>Can only result in a <em>payment</em></td>
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<tr>
<td>If price at sink is higher than at the source, owner is paid.</td>
<td>If price at sink is higher than at source, owner is paid.</td>
</tr>
<tr>
<td>If price at sink is lower than at the source, owner is charged.</td>
<td>If price at sink is lower, no payment or charge</td>
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</table>
Point-to-Point (PTP) Obligations

Source A

$5/MWh

Sink B

$10/MWh

Source C

$15/MWh

Obligation $_{AB}$ Payment = $5.00

Obligation $_{CB}$ Payment = ?
Point-to-Point (PTP) Options

- **Source A** to **Sink B**
  - Option $AB$ Payment = $\text{?}$
  - Cost $\text{?}$/MWh

- **Sink B** to **Source C**
  - Option $CB$ Payment = $\text{?}$
  - Cost $\text{?}$/MWh
Congestion Revenue Rights

Three ways of acquiring CRRs:

- CRR Auction
- Allocation (Special Case)
- Bilateral Trades
CRRs are auctioned and allocated by:

- Time-of-Use Blocks
- One month strips

<table>
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<tr>
<th>MONs</th>
<th>TUES</th>
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<th>THURS</th>
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<td><strong>Off-Peak (2300 – 2400)</strong></td>
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CRR Auction

- Monthly and Semi-Annual Auctions
- Based on Network Operations Model
Allocation of CRRs

Pre-Assigned CRRs (PCRRs)

• Allocated to Non-Opt-In Entities (NOIEs)
• Based on long-term supply contracts
• May be allocated as Options or Obligations
• No charge or a percentage of the Auction clearing price
Trading CRRs Bilaterally

- PTP Options
- PTP Obligations

- Characteristics remain unchanged

- Both parties must meet credit requirements.
Trading CRRs using Time-of-Use Blocks

Peak Weekday
0700–2200
Trading CRRs in smaller hourly increments

Original owner remains **Owner Of Record** in ERCOT’s registration system for financial settlement purposes.
CRR Settlements

Three Settlement Processes

• CRR Auction Settlement
• CRR Settlement
• CRR Balancing Account
CRR Auction Settlements

Congestion Revenue Rights Settlements

Auction

Clearing

Prices

Awarded

Bids

Awarded

Offers

Allocated

PCRRs

Settlements

Payments

Charges
CRR Auction Settlements Timeline

- **Auction Completed**
- **Day 1***: Auction Results
- **Day 2**: Auction Invoice
- **Day 3**: Payments Due to ERCOT
- **Day 4**: Payments Due to CRR Account Holders
- **Day 5**: Payments Due to CRR Account Holders

---

* Business Day
** Bank Business Day
*** Business Day and Bank Business Day
CRR Auction Settlement

CRR Auction Revenues + PCRR Revenues

Monthly

CRR Auction Revenues

Pay to QSEs representing Load
CRR Settlement

Congestion Revenue Rights Settlements

CRRs are settled in the Day-Ahead Market

Day-Ahead Settlement Point Prices

PTP Options

PTP Obligations

Settlements

Payments

Charges

CRR Settlement

ERCOT
CRR Settlement

Hourly Congestion Rent

Payment due to CRR Account Holders

CRR Balancing Account
Congestion Revenue Rights

CRR Settlement

Hourly

Congestion Rent

may be short paid in some hours

Payment due to CRR Account Holders

CRR Balancing Account
Congestion Revenue Rights

CRR Balancing Account

Payment due to CRR Account Holders

Pay to QSEs representing Load

Monthly
Congestion Revenue Rights

CRR Balancing Account

Payment due to CRR Account Holders

may remain short paid

Monthly

CRR Balancing Account
Market Information System

Posted after each Auction:

- CRRs awarded
- CRR Account Holders
- Auction clearing prices
- CRR Bids and offers
Nodal Market Operations
Day-Ahead Market
Topics in this lesson . . .

- Purpose of Day-Ahead Market
- Market Participants
- Day-Ahead Market Process
- Process Inputs and Outputs
- Settlements
- Market Information System
Purpose of the Day-Ahead Market

- Centralized Forward Market
- Buy and sell Energy
- Sell Ancillary Services to ERCOT
- Forward market provides price certainty
Only QSEs participate in the Day-Ahead Market.
Day-Ahead Market

CRRs are settled with Day-Ahead Market Prices
Day-Ahead Market

When does the Day-Ahead Market occur?

- Market opens at 0600
- Clearing Process begins at 1000
- Results posted by 1330
Day-Ahead Market

A Bid is a proposal to buy:
• A Product
• At a Location
• For a Price

An Offer is a proposal to sell:
• A Product
• At a Location
• For a Price
The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

Pricing

Awards
The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

- Pricing
- Awards
The Day-Ahead Market

Types of Offers:
- Three-Part Supply Offer
- Ancillary Service (AS) Offer
- Day-Ahead Market Energy-Only Offer
Day-Ahead Market

Three-Part Supply Offer

- **Startup Offer**
  - $ / Start

- **Minimum-Energy Offer**
  - $ / MWh (at LSL)

- **Energy Offer Curve**
  - $ / MWh (above LSL)

Energy Offer Curve can be submitted without Start-up or Minimum Energy Offers
Ancillary Service (AS) Offers:

- Resource specific
  - Regulation Reserve
  - Responsive Reserve
  - Non-Spinning Reserve

- A Resource may be offered
  - For multiple Ancillary Services
  - For Energy and Ancillary Services
Day-Ahead Market Energy-Only Offer

- Proposal to sell energy in DAM
- Offered at any Settlement Point

Valid only in the Day-Ahead Market

Financial obligation in Real-Time
The Day-Ahead Market

Types of Bids:
- Energy Bid
- PTP Obligation Bid
Day-Ahead Market Energy Bid

- Proposal to buy energy
- Submitted at any Settlement Point

Valid only in the Day-Ahead Market

Financial credit in Real-Time
Day-Ahead Market PTP Obligation Bids

- Purpose of DAM PTP Obligations
  - Hedge against congestion costs in Real-Time
  - Charge or payment when Grid is congested in Real-Time
Day-Ahead Market PTP Obligation Bids

- Like coupled Energy Bid and Energy Offer
- Purchased at DAM Settlement Point Price Spread
- Settled at Real-Time Settlement Point Price Spread
The Day-Ahead Market

Day-Ahead Market PTP Obligations

PTP Obligation

Source A → Sink B

DAM:

- $10/MWh

Real-Time:

- $8/MWh

Settlement Point Prices:

- $12/MWh
- $15/MWh

QSE charge in Day Ahead Market = ?

QSE payment in Real Time = ?
The Day-Ahead Market

- CRR Auction
  - Acquired in CRR Auction

- Day-Ahead Market
  - Acquired in Day-Ahead Market
  - Settled at DAM Price Spread

- Real-Time
  - Settled at RT Price Spread

PTP Obligations
DAM PTP Obligations
Day-Ahead Market

The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

Pricing

Awards
The Current Operating Plan (COP)

- Anticipated Resource operating conditions
  - Resource Status
  - Resource Limits
  - Ancillary Service Commitments

- Submitted by QSE

QSE must maintain the COP for each hour of the next 7 days
The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

- Pricing
- Awards
The Network Model in the Day-Ahead Market

- Day-Ahead Market does not solve reliability issues
- System must support the Day-Ahead Market solution

The Network Operations Model ensures that DAM solution respects system limits
The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

- Pricing
- Awards
The Day-Ahead Market

Cleared Offers = Costs
Cleared Bids = Revenues
The Day-Ahead Market clearing process

Maximize The Gap

Bid-based Revenues

Offer-based Costs
The Day-Ahead Market clearing process

The Day-Ahead Market is a *Co-optimized* Market

Maximize The Gap

Bid-based Revenues

Energy & Ancillary Service Costs
The Day-Ahead Market

- Offers
- Bids
- Current Operating Plans
- Network Operations Model

Day-Ahead Market

- Pricing
- Awards
After Day-Ahead Market

- QSEs may update COP
  - Awarded Energy Offers
  - Ancillary Service Commitments

- QSEs may submit Trades
Day-Ahead Market

Trades

- QSE-QSE transactions
- Transfers financial responsibility
- Types
  - Capacity
  - Energy
  - Ancillary Service

Trades are used only in Settlements

Slide 125
Day-Ahead Market Settlements

Settlements

Awarded Bids

Awarded Offers

Payments

Charges

Ancillary Service Prices (MCPCs)

Settlement Point Prices
Day-Ahead Settlement Timeline

- Daily statements include
  - Payments due
  - Charges incurred

Day-Ahead Market
Single Daily Settlement Invoice

- Daily invoices include
  - DAM Statements
  - RTM Statements
Market Information System

Posted on by 0600 Day-Ahead:

- Network Operations Model
- Load Profiles

- Weather assumptions
- Load zone forecasts (next 7 days)
- List of transmission constraints
Market Information System

Posted by 1330 Day-Ahead:

- LMPs
- Settlement Point Prices
- MCPCs for each Ancillary Service
- Energy bought and sold
Nodal Market Operations
Reliability Unit Commitment
Topics in this lesson . . .

- Purpose of Reliability Unit Commitment (RUC)
- Market Participants involved
- The RUC Process
- Settlements
- Capacity Shortfall
- Market Information System
Reliability Unit Commitment

- 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
Purpose of Reliability Unit Commitment (RUC)

It ensures:

• Enough capacity is committed to serve the forecasted load

• Committed capacity is in the right locations
Reliability Unit Commitment

Operational impacts on:
QSEs with Resources
Funds collected from:
- Capacity-Short QSEs
- QSEs representing Load
The Reliability Unit Commitment Process

- Current Operating Plans
- Network Operations Model
- Contingencies
- Load Forecast
- Offers
  - Three-Part Supply Offers
- Transmission Security Analysis
- Reliability Unit Commitment
- Commissions
  - Resource Commitments
  - Resource Decommitments
Reliability Unit Commitment

Committing Enough Capacity

- Offers
  - Three-Part Supply Offers

- Current Operating Plans
- Network Operations Model
- Contingencies
- Load Forecast

Transmission Security Analysis → Reliability Unit Commitment

Commitments
- Resource Commitments
- Resource Decommitments
Reliability Unit Commitment

Committing Capacity in the Right Locations

- Current Operating Plans
- Network Operations Model
- Contingencies
- Load Forecast

1. Offers
   - Three-Part Supply Offers

2. Transmission Security Analysis

3. Reliability Unit Commitment

4. Commitments
   - Resource Commitments
   - Resource Decommitments
Reliability Unit Commitment

What if ERCOT must commit additional capacity?
Reliability Unit Commitment

Potential Results of RUC Process:

- Resource Commitments
- Resource Decommitments
- No additional Commitments
Reliability Unit Commitment

When does Reliability Unit Commitment (RUC) occur?

Day-Ahead Reliability Unit Commitment (DRUC)
Hourly Reliability Unit Commitment (HRUC)
Day-Ahead Reliability Unit Commitment (DRUC)

- Occurs once a day
- Ensures enough capacity committed for next Operating Day

DRUC studies all hours of Day 2

Day 1

Day 2

1430 DRUC runs
**Hourly Reliability Unit Commitment (HRUC)**

- Occurs hourly
- Reviews all hours already studied by DRUC

**Graphical Representation:**
- HRUC runs each hour from 0000 to 1800
- DRUC Study Period
- 1430 DRUC runs

**Timeline:**
- Day 1
- Day 2
Reliability Unit Commitment Settlements

*RUC-Committed Resources
Make-Whole Payments
RUC-committed Resources recover their commitment costs
QSEs with Capacity Shortfall are assessed Capacity Short Charges
What is included in the QSE’s capacity obligation?

- Load (Adjusted Metered Load)
- Capacity Trades where the QSE is a seller
- Energy Trade where the QSE is a seller
- Cleared DAM Energy Offer
How can a QSE arrange to meet these obligations?

- Show capacity from its Resources in its COP
- Capacity Trades where the QSE is a buyer
- Energy Trades where the QSE is a buyer
- Cleared DAM Energy bids
To Minimize Capacity Short Charges…
QSE must arrange for enough Capacity to meet Obligations
Revenues may not be enough for make-Whole Payments
Difference uplifted to QSEs representing Load
RUC Payments and Charges are included in Real-Time Settlements.

Reliability Unit Commitment

Resource Costs
Resource Revenues

Capacity Obligations
Capacity Supplies

Make-Whole Payments
Make-Whole Uplift Charges
Capacity Short Charges

Settlements
Market Information System

Posted after process completion:

- Resources committed
- Resources decommitted
- Active transmission constraints
Nodal Market Operations
Real-Time Operations
Topics in this lesson . . .

- Purpose of Real-Time Operations
- Market Participants
- Real-Time Operations Process
  - Security Constrained Economic Dispatch
  - Load Frequency Control
- Settlements
- Market Information System
Real-Time Operations
Purpose of Real-Time Operations

- Manage reliability
- Match generation with demand
- Operate transmission system within established limits
- Operate the system at least cost
ERCOT provides dispatch instructions to QSEs with Resources.
ERCOT may also provide dispatch instructions to TSPs.
When do Real-Time Operations occur?

- Operating Period
- Includes Operating Hour and Hour-Ahead
The Operating Period includes:

- Operating Hour - Real-Time dispatch of energy
- Hour-Ahead – Preparations for Real-Time Operations
Real-Time Operations

Offers
- Energy Offer Curves
- Proxy Energy Offer Curves

Telemetry
- Network Security Operations Model
- Contingencies

Real-Time Network Security Analysis

Security-Constrained Economic Dispatch

Pricing
- Locational Marginal Prices

Dispatch Instructions
- Base Points
Real-Time Operations

Network Security Analysis and SCED

- Network Security Analysis identifies transmission constraints
- Security Constrained Economic Dispatch (SCED) determines least-cost solution
Provide Real-Time system data

Real-Time Operations

- Energy Offer Curves
- Proxy Energy Offer Curves

Telemetry

Network Operations Model

Contingencies

Pricing
- Locational Marginal Prices

Dispatch Instructions
- Base Points
Real-Time Operations

Identify **Constraints**, both **Transmission & Resource**

- Energy Offer Curves
- Proxy Energy Offer Curves

- Telemetry
- Network Operations Model
- Contingencies

- Pricing
  - Locational Marginal Prices

- Dispatch Instructions
  - Base Points

Real-Time Operations

Transmission Constraints & Resource Dispatch Limits
SCED evaluates **Offers** to determine least-cost solution
SCED uses Energy Offer Curves:

Submitted by QSEs:
- Three-Part Supply Offer
- Stand Alone Energy Offer Curve

During:
- Day-Ahead Market
- Adjustment Period
SCED produces **Prices** and **Dispatch Instructions**
How often does all this happen?

**LMPs every 5 minutes***
- Electrical buses
- Load Zones
- Hubs

**Settlement Point Prices every 15 minutes**
- Resource Nodes
- Load Zones
- Hubs

* LMPs generated at each SCED cycle (possibly more often than 5 minutes)
SCED Dispatch Instructions

- Every 5 minutes
- Based on economics
Load Frequency Control (LFC)
- Matches generation with demand
- Responds to frequency deviations
- Deploys Regulation Reserve Service

60.0000
Frequency (Hz)
Real-Time Operations Settlements

- Settlement point prices
- Energy Supplies
- Obligations
- Payment for Net Supply
- Charge for Net Obligation
- Settlements
Real-Time Operations Settlements

Examples

• ____________________________
• ____________________________
• ____________________________
Real-Time Operations Settlements

Examples

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Real-Time Settlement Timeline

- Daily statements include
  - Payments due
  - Charges incurred
Single Daily Settlement Invoice

- Daily invoices include
  - DAM Statement
  - RTM Statements

Real-Time Operations Settlements

 ERCOT Issues Invoice
- DAM
- RTM Initial
- RTM Final
- RTM True-up

Payment Due (to ERCOT)

Payment Due (to Market Participant)
Posted after completion of SCED:

- Locational Marginal Prices
- Settlement Point Prices
- Active transmission constraints
Additional Resources

ERCOT Nodal Market Protocols
http://www.ercot.com/mktrules/nprotocols/

ERCOT Training
http://www.ercot.com/services/training/

Market Education Contact
Training@ercot.com
Course Conclusion