ERCOT Market Education

Settlements 301

Module 5: Reliability Unit Commitment
It ensures:

• Enough capacity is committed to serve the forecasted load

• Committed capacity is in the right locations
If ERCOT commits a Resource through RUC

• ERCOT provides QSE with a payment guarantee
• May provide Make-Whole Payment
• May clawback “excess revenues”

Cost recovery

• Capacity-short QSEs responsible for Make-Whole (Up to a limit)
• Some costs may be socialized across all QSEs
A QSE may Opt Out of RUC settlement

Operational

- Update Telemetry – ONOPTOUT
- Must start resource if available
- May provide ancillary services

Financial

- No RUC Make-Whole Payments
- No Clawback Charges
Reliability Unit Commitment: Settlements

RUC

Commitment
• Make-Whole
• Clawback

Decommitment
QSE’s Representing RUC committed resources may receive a Make-Whole payment

Outcome #1

What: Payment when the Real-Time revenues are less than actual costs for a RUC-Committed Resource

Why: To ensure that a QSE recovers its costs to run a RUC-Committed Resource
Calculating RUC Make-Whole Payment

- Incremental Energy Costs
- Minimum Energy Costs
- Start-up Costs
Calculating RUC Make-Whole Payment

- **Real-Time Revenues**
- **Incremental Energy Costs**
- **Minimum Energy Costs**
- **Start-up Costs**
Real-time Revenues = RT SPP \times \text{Metered Generation}

- **Revenues Received**
  - Real-Time Revenues

- **Costs Incurred**
  - Incremental Energy Costs
  - Minimum Energy Costs
  - Start-up Costs
What if revenues are less than cost?
What if revenues are less than cost?

Difference = Make-Whole Payment

- Real-Time Revenues
- Incremental Energy Costs
- Minimum Energy Costs
- Start-up Costs

Make-Whole Payment
Now we re-arrange the balance sheet slightly ...

Subtract Incremental Energy Costs from *both columns*...
What if revenues are less than cost?

Real-Time Revenues – Incremental Energy Costs

\[ \text{Real-Time Revenues} - \text{Incremental Energy Costs} = \text{RT SPP} \times \text{Metered Generation} - \text{AIEC} \times \text{Metered Generation Above LSL} \]
What if revenues are less than cost?

- **Make-Whole Payment**
  - Real-Time Revenues
  - Incremental Energy Costs

- **Costs Incurred**
  - Minimum Energy Costs
  - Start-up Costs

- **RUC Guaranteed Amount**
A QSE is paid the Real-time Settlement Point Price for all energy produced by its Resource.

A QSE will also receive a Make-Whole Payment if its Resource’s net revenues are less than its Startup and Minimum Energy Costs.
RUC Make-Whole Payment

Trigger #1

( Resource Revenues ) < ( RUC Guaranteed Amount )

RUC: QSE To Do

☐ Submit:
  ☐ Three-Part Supply Offer in DAM
  ☐ Verifiable Costs

☑ Resource is RUC-Committed
☑ Resource starts & runs during RUC-Committed hours

RUC: ERCOT To Do

☐ Calculate RUC Guaranteed Amount
☐ Startup Costs
☐ Minimum Energy Costs

☐ Calculate Resource Revenues
☐ Calculate Minimum Energy Revenue
☐ Calculate Revenue Less Cost Above LSL During RUC-Committed Hours
☐ Calculate Revenue Less Cost During QSE-Clawback Intervals
Calculate RUC Guaranteed Amount

\[ \text{RUC Guaranteed Amount} = (\text{Startup costs} + \text{Minimum energy costs}) \]

- **Startup Offer**
  - \$ to Start Up

- **Minimum-Energy Offer**
  - \$/MWh at LSL

- **Energy Offer Curve**
  - \$/MWh Above LSL
Startup and Minimum Energy costs subject to caps

If ERCOT has Verifiable Costs

- Startup Cap = Verifiable Startup Costs
- Minimum Energy Cap = Verifiable Minimum-Energy Costs

Otherwise

- Startup Cap = Resource Category Startup Offer Generic Cap
- Minimum Energy Cap = Resource Category Minimum-Energy Generic Cap
If QSE submitted valid Three-Part Supply Offer,

\[
\text{SUPR} = \min(\text{SUO, SUCAP}) \\
\text{MEPR} = \min(\text{MEO, MECAP})
\]

Otherwise,

\[
\text{SUPR} = \text{SUCAP} \\
\text{MEPR} = \text{MECAP}
\]
RUC: ERCOT To Do

☐ Calculate RUC Guaranteed Amount
  ☑ Startup Costs
  ☑ Minimum Energy Costs

☐ Calculate Resource Revenues
  ☐ Calculate Minimum Energy Revenue
  ☐ Calculate Revenue Less Cost Above LSL During RUC-Committed Hours
  ☐ Calculate Revenue Less Cost During QSE-Clawback Intervals
### RUC Make-Whole Payment

**Trigger #1**

\[
\text{RUCG}_{q,r,d} = \sum_s (\text{SUPR}_{q,r,s} \times \text{RUCSUFLAG}_{q,r,s}) + \sum_i (\text{MEPR}_{q,r,i} \times \text{Min}((\text{LSL}_{q,r,i} \times \frac{1}{4}), \text{RTMG}_{q,r,i}))
\]

<table>
<thead>
<tr>
<th><strong>Startup Price (SUPR)</strong></th>
<th>$5000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUC Startup Flag (RUCSUFLAG)</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Minimum Energy Price (MEPR)</strong></td>
<td>$10/MWh</td>
</tr>
<tr>
<td><strong>Low Sustained Limit (LSL)</strong></td>
<td>20MW</td>
</tr>
<tr>
<td><strong>Real-Time Metered Generation (RTMG)</strong></td>
<td>50MWh</td>
</tr>
</tbody>
</table>

QSE4’s Resource is committed for 5 hours.
RUCG = (SUPR * RUCSUFLAG) + \sum(MEPR * \text{Min} ((LSL * \frac{1}{4}), \text{RTMG}))

RUCG = ($5000 \times 1) + ($10/\text{MWh} \times \text{Min}(20\text{MW} \times \frac{1}{4}\text{h}, 50\text{MWh}) \times 4\text{i/h} \times 5\text{h})

= $5000 + ($10/\text{MWh} \times (20\text{MW} \times \frac{1}{4}\text{h}) \times 4\text{i/h} \times 5\text{h})

= $5000 + ($10/\text{MWh} \times 100\text{MWh})

= $6000
RUC Make-Whole Payment

Trigger #1

( Resource Revenues ) < ( RUC Guaranteed Amount )

<table>
<thead>
<tr>
<th>RUC Guaranteed Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE1</td>
</tr>
<tr>
<td>$4,000</td>
</tr>
<tr>
<td>QSE4</td>
</tr>
<tr>
<td>$6,000</td>
</tr>
<tr>
<td>QSE6</td>
</tr>
<tr>
<td>$8,000</td>
</tr>
</tbody>
</table>

- Per QSE
- Per Resource
- Per Operating Day with RUC Commitment
RUC: ERCOT To Do

- Calculate RUC Guaranteed Amount
  - Startup Costs
  - Minimum Energy Costs

- Calculate Resource Revenues
  - Calculate Minimum Energy Revenue
  - Calculate Revenue Less Cost Above LSL During RUC-Commited Hours
  - Calculate Revenue Less Cost During QSE-Clawback Intervals
RUC Make-Whole Payment

Resource Revenues =

Minimum-Energy Revenue up to LSL
+ Revenue Less Cost above LSL
+ Revenue Less Cost during QSE-Clawback intervals

Resource Revenues < RUC Guaranteed Amount

Trigger #1
Calculate Resource Revenues

- Per QSE
- Per Resource
- Per Operating Day with RUC Commitment
Calculate Resource Revenues

Minimum-Energy revenue up to LSL

RUC Minimum Energy Revenue
= (Price)\times (Quantity)

Quantity = Minimum of:

Real-Time Metered Generation

¼ of LSL
Calculate Resource Revenues

Minimum-Energy revenue up to LSL

\[ \text{RUCMEREV}_{q,r,d} = \sum \left( \text{RTSPP}_{p,i} \times \text{Min} \left( \text{RTMG}_{q,r,i}, \left( \text{LSL}_{q,r,i} \times \left(\frac{1}{4}\right)\right) \right) \right) \]

Determinants

- RUC Minimum-Energy Revenue
- Real-Time Settlement Point Price
- Real-Time Metered Generation
- Low Sustained Limit
Calculate Resource Revenues

\[ \text{RUCMEREV} = \sum (\text{RTSPP} \times \text{Min} (\text{RTMG}, (\text{LSL} \times (\frac{1}{4})))) \]

\[
\text{RUCMEREV} = \frac{50}{\text{MWh}} \times \text{Min} (50\text{MWh}, (20\text{MW} \times \frac{1}{4}\text{h})) \times 4\text{i/h} \times 5\text{h} \\
= \frac{50}{\text{MWh}} \times (20\text{MW} \times \frac{1}{4}\text{h}) \times 4\text{i/h} \times 5\text{h} \\
= \frac{50}{\text{MWh}} \times 100\text{MWh} \\
= 5000 \text{ } \$ \]

Minimum-Energy revenue up to LSL
### RUC Make-Whole Payment

**Trigger #1**: $(\text{Resource Revenues}) < (\text{RUC Guaranteed Amount})$

<table>
<thead>
<tr>
<th></th>
<th>RUC Guaranteed Amount</th>
<th>Minimum-Energy revenue up to LSL</th>
<th>Revenue Less Cost Above LSL During RUC-Committed Hours</th>
<th>Revenue Less Cost During QSE-Clawback Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE1</td>
<td>$4,000</td>
<td>$2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSE4</td>
<td>$6,000</td>
<td>$5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSE6</td>
<td>$8,000</td>
<td>$4,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Energy Offer Curves for RUC-Committed Resources have a $1500 floor price

Calculate Resource Revenues

Revenue Less Cost Above LSL During RUC-Committed Hours

- Per QSE
- Per Resource
- Per Operating Day with RUC Commitment

Energy Offer Curve

- Costs (AIEC)
- Revenues
- EOCPRCAP
- SPP
- $1500
## Calculate Resource Revenues

Revenue Less Cost Above LSL During RUC-Committed Hours

<table>
<thead>
<tr>
<th>Revenues</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Revenue above LSL</td>
<td>Average Incremental Energy Cost above LSL</td>
</tr>
<tr>
<td>Voltage Support Service</td>
<td></td>
</tr>
<tr>
<td>Emergency Power Increase</td>
<td></td>
</tr>
</tbody>
</table>
Calculate Resource Revenues

Revenue Less Cost Above LSL During RUC-Committed Hours

\[
RUC_{EXRR}^{q,r,d} = \max \left\{ 0, \sum [RTSPP_{p,i} \cdot \max (0, RTMG_{q,r,i} - (LSL_{q,r,i} \cdot \frac{1}{4})) + (-1) \cdot (VSSVARAMT_{q,r,i} + VSSEAMT_{q,r,i}) + (-1) \cdot EMREAMT_{q,r,i} - RTAIEC_{q,r,i} \cdot \max (0, RTMG_{q,r,i} - (LSL_{q,r,i} \cdot \frac{1}{4}))) \right\}
\]

Additional Determinants

<table>
<thead>
<tr>
<th>Revenue Less Cost Above LSL (RUCEXRR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Support Service VAR Amount</td>
</tr>
<tr>
<td>Voltage Support Service Energy Amount</td>
</tr>
<tr>
<td>Emergency Energy Amount</td>
</tr>
<tr>
<td>Real-Time Average Incremental Energy Cost</td>
</tr>
</tbody>
</table>
RUC Make-Whole Payment

Calculate Resource Revenues

Revenue Less Cost Above LSL During RUC-Committed Hours

\[
RUCEXRR_{q,r,d} = \max \left\{ 0, \sum_{p,i} \left[ RTSPP_{p,i} \cdot \max (0, RTMG_{q,r,i} - (LSL_{q,r,i} \times \frac{1}{4})) \right]
+ (-1) \cdot (VSSVARAMT_{q,r,i} + VSSEAMT_{q,r,i})
+ (-1) \cdot EMREAMT_{q,r,i}
- RTAIEC_{q,r,i} \cdot \max (0, RTMG_{q,r,i} - (LSL_{q,r,i} \times \frac{1}{4}))) \right\}
\]

<table>
<thead>
<tr>
<th>Real-Time Metered Generation (RTMG)</th>
<th>50MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Incremental Energy Cost (RTAIEC)</td>
<td>$20/MWh</td>
</tr>
<tr>
<td>RT Settlement Point Price (RTSPP)</td>
<td>$50/MWh</td>
</tr>
</tbody>
</table>
Calculate Resource Revenues

Revenue Less Cost Above LSL During RUC-Committed Hours

\[
\text{RUCEXRR} = \max \left\{ 0, \sum [\text{RTSP} \times \max(0, \text{RTMG} - (\text{LSL} \times \frac{1}{4})) - \text{RTAIEC} \times \max(0, \text{RTMG} - (\text{LSL} \times \frac{1}{4})))] \right\}
\]

\[
\text{RUCEXRR} = \max \left\{ 0, \left[50/\text{MWh} \times \max(0, 50\text{MWh} - (20\text{MW} \times \frac{1}{4})) - 20/\text{MWh} \times \max(0, 50\text{MWh} - (20\text{MW} \times \frac{1}{4}))) \right] \times 4\text{i/h} \times 5\text{h} \right\}
\]

\[
\text{RUCEXRR} = \max \left\{ 0, \left[50/\text{MWh} \times \max(0, 45\text{MWh}) - 20/\text{MWh} \times \max(0, 45\text{MWh}) \right] \times 4\text{i/h} \times 5\text{h} \right\}
\]

\[
\text{RUCEXRR} = \max \left\{ 0, 45\text{MWh} \times (50/\text{MWh} - 20/\text{MWh}) \right\} \times 4\text{i/h} \times 5\text{h}
\]

\[
\text{RUCEXRR} = 1350 \times 4\text{i/h} \times 5\text{h}
\]

\[
\text{RUCEXRR} = 27,000
\]
## RUC Make-Whole Payment

**Trigger #1**

![Resource Revenues](Resource Revenues)

**RUC Guaranteed Amount**

<table>
<thead>
<tr>
<th>Trigger</th>
<th>RUC Guaranteed Amount</th>
<th>Minimum-Energy revenue up to LSL</th>
<th>Revenue Less Cost Above LSL During RUC-Committed Hours</th>
<th>Revenue Less Cost During QSE-Clawback Intervals</th>
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<tr>
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<td></td>
</tr>
<tr>
<td>QSE4</td>
<td>$6,000</td>
<td>$5,000</td>
<td>$27,000</td>
<td></td>
</tr>
<tr>
<td>QSE6</td>
<td>$8,000</td>
<td>$4,000</td>
<td>$4,000</td>
<td></td>
</tr>
</tbody>
</table>
Calculate Resource Revenues

Revenue Less Cost During QSE Clawback Intervals

- QSE-Committed Interval
- Contiguous block with one RUC-Committed hour
- QSE-Committed AFTER RUC-Commitment
## Calculate Resource Revenues

### Revenue Less Cost During QSE Clawback Intervals

<table>
<thead>
<tr>
<th>Revenues</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Revenue</td>
<td>Minimum Energy Costs</td>
</tr>
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<td>Average Incremental Energy Cost above LSL</td>
</tr>
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<td>Emergency Power Increase</td>
<td></td>
</tr>
</tbody>
</table>
Calculate Resource Revenues

Revenue Less Cost During QSE Clawback Intervals

\[
\text{RUCEXRQC}_{q,r,d} = \max\{0, \sum [(\text{RTSPP}_{p,i} \times \text{RTMG}_{q,r,i}) + (-1) \times (\text{VSSVARAMT}_{q,r,i} + \text{VSSEAMT}_{q,r,i}) + (-1) \times \text{EMREAMT}_{q,r,i} - [\text{MEPR}_{q,r,i} \times \min (\text{RTMG}_{q,r,i}, (\text{LSL}_{q,r,i} \times (\frac{1}{4})))] - \text{RTAIEC}_{q,r,i} \times \max (0, \text{RTMG}_{q,r,i} - (\text{LSL}_{q,r,i} \times (\frac{1}{4}))))]\}
\]

Additional Determinants

| Revenue Less Cost (\text{RUCEXRQC}) |
Calculate Resource Revenues

Revenue Less Cost During QSE Clawback Intervals

\[
\text{RUCEXRQC}_{q,r,d} = \max \left\{ 0, \sum \left[ \left( \text{RTSPP}_{p,i} \cdot \text{RTMG}_{q,r,i} \right) + (-1) \cdot \left( \text{VSSVARAMT}_{q,r,i} + \text{VSSEAMT}_{q,r,i} \right) + (-1) \cdot \text{EMREAMT}_{q,r,i} \right] - \left[ \text{MEPR}_{q,r,i} \cdot \min \left( \text{RTMG}_{q,r,i}, \left( \text{LSL}_{q,r,i} \cdot \left( \frac{1}{4} \right) \right) \right) \right] - \left( \text{RTAIEC}_{q,r,i} \cdot \max \left( 0, \text{RTMG}_{q,r,i} - \left( \text{LSL}_{q,r,i} \cdot \left( \frac{1}{4} \right) \right) \right) \right] \right\}
\]

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<td>$50/MWh</td>
</tr>
</tbody>
</table>
Calculate Resource Revenues

Revenue Less Cost During QSE Clawback Intervals

\[
\text{RUCEXRQC} = \max \left\{ 0, \sum [(\text{RTSPP} \times \text{RTMG}) - [\text{MEPR} \times \min (\text{RTMG}, (\text{LSL} \times \frac{1}{4}))] - \text{RTAIEC} \times \max (0, \text{RTMG} - (\text{LSL} \times \frac{1}{4}))] \right\}
\]

\[
\text{RUCEXRQC} = \max \left\{ 0, [(50/\text{MWh} \times 50\text{MWh}) - (10/\text{MWh} \times \min (50\text{MWh}, (20\text{MW} \times \frac{1}{4}))) - 20/\text{MWh} \times \max (0, 50\text{MWh} - (20\text{MW} \times \frac{1}{4}))] \times 4\text{h} / \text{h} \times 2\text{h} \right\}
\]

\[
= \max \left\{ 0, [(50/\text{MWh} \times 50\text{MWh}) - 10/\text{MWh} \times 5\text{MWh}] - (20/\text{MWh} \times 45\text{MWh})] \times 4\text{h} / \text{h} \times 2\text{h} \right\}
\]

\[
= \max \left\{ 0, [2500 - 50 - 900] \times 4\text{h} / \text{h} \times 2\text{h} \right\}
\]

\[
= 1550 \times 4\text{h} / \text{h} \times 2\text{h} = 12,400
\]
### RUC Make-Whole Payment

**Trigger #1**

#### Resource Revenues

#### RUC Guaranteed Amount

<table>
<thead>
<tr>
<th>RUC Guaranteed Amount</th>
<th>Minimum-Energy revenue up to LSL</th>
<th>Revenue Less Cost Above LSL During RUC-Committed Hours</th>
<th>Revenue Less Cost During QSE-Clawback Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE1</td>
<td>$4,000</td>
<td>$2,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>QSE4</td>
<td>$6,000</td>
<td>$5,000</td>
<td>$27,000</td>
</tr>
<tr>
<td>QSE6</td>
<td>$8,000</td>
<td>$4,000</td>
<td>$4,000</td>
</tr>
</tbody>
</table>
### RUC Make-Whole Payment

**Trigger #1**

<table>
<thead>
<tr>
<th>RUC Guaranteed Amount</th>
<th>Resource Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QSE1</strong></td>
<td>$4,000</td>
</tr>
<tr>
<td></td>
<td>$2,000 + $1,000 + $0 = <strong>$3,000</strong></td>
</tr>
<tr>
<td><strong>QSE4</strong></td>
<td>$6,000</td>
</tr>
<tr>
<td></td>
<td>$5,000 + $27,000 + $12,400 = <strong>$44,400</strong></td>
</tr>
<tr>
<td><strong>QSE6</strong></td>
<td>$8,000</td>
</tr>
<tr>
<td></td>
<td>$4,000 + $4,000 + $8,000 = <strong>$16,000</strong></td>
</tr>
</tbody>
</table>
RUC: ERCOT To Do

- Calculate RUC Guaranteed Amount
  - Startup Costs
  - Minimum Energy Costs
- Calculate Resource Revenues
  - Calculate Minimum Energy Revenue
  - Calculate Revenue Less Cost Above LSL During RUC-Committed Hours
  - Calculate Revenue Less Cost During QSE-Clawback Intervals
RUC Make-Whole Payment

**Trigger #1**

(RUC Guaranteed Amount) < (Resource Revenues)

**Outcome #1**

<table>
<thead>
<tr>
<th>QSE</th>
<th>RUC Guaranteed Amount</th>
<th>Resource Revenues</th>
<th>Eligible for Make-Whole Payment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE1</td>
<td>$4,000</td>
<td>$3,000</td>
<td>?</td>
</tr>
<tr>
<td>QSE4</td>
<td>$6,000</td>
<td>$44,400</td>
<td>?</td>
</tr>
<tr>
<td>QSE6</td>
<td>$8,000</td>
<td>$16,000</td>
<td>?</td>
</tr>
</tbody>
</table>
• QSE1 Resource is RUC-Committed

• QSE1 is eligible for a Make-Whole Payment

\[
\text{RUCMWAMT} = (-1) \times \max(0, \text{RUCG} - \text{RUCMEREV} - \text{RUCEXRR} - \text{RUCEXRQC}) / \sum \text{RUCHR}
\]

RUCHR will be set to 1 for each RUC-Committed hour of the day.
• QSE1 is RUC-Committed
• QSE1 is eligible for a Make-Whole Payment

\[
\text{RUCMWAMT} = (-1) \times \frac{\text{Max}(0, \text{RUCG} - \text{RUCMEREV} - \text{RUCEXRR} - \text{RUCEXRQC})}{\sum \text{RUCHR}}
\]

\[
\text{RUCMWAMT} = (-1) \times \frac{\text{Max}(0, \$4000 - \$2000 - \$1000 - 0)}{5}
\]

= - $200 per hour
What if the RUC-committed Resource is part of a Combined Cycle Plant?

- Make-Whole is paid at the Train level
- RUC Guaranteed Amount
  - Start-up Costs
  - Minimum Energy Costs
  - May include Transition Cost

RUC may start any offered CCGR and transition from one offered CCGR to another
RUC Guaranteed Amount may include Transition Cost from CCGR1 to CCGR2
Eligible Transitions:

- ON to RUC
- RUC to RUC
- RUC to ON

Train must be in RUC-Committed configuration for at least 1 minute
RUC Make Whole - Combined Cycle Resources

\[ RUCG_{q,r,d} = \sum (SUPR_{q,r,s} \times RUCSUFLAG_{q,r,s}) + \sum \text{(Transition costs)} + \sum (MEPR_{q,r,i} \times \text{Min}((LSL_{q,r,i} \times \frac{1}{4}), RTMG_{q,r,i})) \]

Transition costs:

\[
\begin{align*}
\text{Max}(0, SUPR_{\text{afterCCGR}} - SUPR_{\text{beforeCCGR}}) \quad &\text{Transition to RUC} \\
\text{--and--} \\
\text{Max}(0, SUPR_{\text{beforeCCGR}} - SUPR_{\text{afterCCGR}}) \quad &\text{Transition from RUC}
\end{align*}
\]
Reliability Unit Commitment: Settlements

RUC

Commitment
• Make-Whole
• Clawback

Decommitment
To remain revenue neutral, ERCOT will first try to directly assign all costs incurred for Make-Whole Payments.

Costs are distributed based on QSE’s shortfalls in each 15-minute interval.
Outcome

#1 Charge to a QSE that was capacity-short in a RUC

<table>
<thead>
<tr>
<th>What:</th>
<th>Charge to QSEs that are capacity short</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why:</td>
<td>Collect funds to pay the Make-Whole Payments to eligible QSEs</td>
</tr>
</tbody>
</table>
RUC Capacity Short Charge

When a QSE does not provide enough capacity to meet its obligations, it may be assessed a Capacity Short Charge.
Measure QSE Shortfall twice for each hour:

- Execution of RUC
- End of Adjustment Period

\[ \text{RUC (DRUC / HRUC)} \]

\[ \text{Worst case wins!} \]
RUC Capacity Short Charge

All QSEs who were capacity short in each RUC will pay a portion of the RUC Make Whole Payments for that particular RUC:

\[
\text{RUC Capacity Short Charge} = \frac{\text{RUC Capacity Shortfall Ratio Share}}{\text{RUC Make Whole Total} \times 15\text{-Minute Settlement Interval}}
\]
Short Charge Cap

The charge to each QSE is capped at

$$2 \times \text{RUC Capacity Shortfall} \times \frac{\text{RUC Make Whole Total}}{\text{RUC Capacity Total}}$$

... which is the same as

$$2 \times \text{RUC Capacity Shortfall} \times \left( \frac{\text{Price / MW of RUC Procurement}}{} \right)$$
RUC Capacity Short Charge

A QSE with a capacity shortfall will pay the lesser of

\[
\text{RUC Capacity Shortfall Ratio Share} \times \left( \text{RUC Make Whole Total} \right)
\]

or their cap

\[
2 \times \text{RUC Capacity Shortfall} \times \left( \frac{\text{Price / MW}}{\text{of RUC Procurement}} \right)
\]
RUC Capacity Short Charge

\[
RUCCSAMT = (-1) \times \text{Max} \left[(RUCSFRS \times RUCMWAMTRUCTOT), \right.
\left. (2 \times RUCSF \times (RUCMWAMTRUCTOT / RUCCAPTOT))\right] / 4
\]

<table>
<thead>
<tr>
<th>RUCCSAMT _ruc, i, q</th>
<th>RUC Capacity Shortfall Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUCSF_ruc, i, q</td>
<td>RUC Shortfall Ratio Share</td>
</tr>
<tr>
<td>RUCMWAMTRUCTOT_ruc, h</td>
<td>RUC Make Whole Amount Total per RUC</td>
</tr>
<tr>
<td>RUCSF_ruc, i, q</td>
<td>RUC Shortfall</td>
</tr>
<tr>
<td>RUCCAPTOT_ruc, h</td>
<td>RUC Capacity Total</td>
</tr>
</tbody>
</table>
RUC Capacity-Short Charge

RUC Shortfall Ratio Share

- Per RUC process
- Per QSE
- Per 15-minute Interval

\[
\text{RUCSF}_{\text{ruc},i,q} = \frac{\text{RUCSF}_{\text{ruc},i,q}}{\text{RUCSFTOT}_{\text{ruc},i}}
\]

Determinants

<table>
<thead>
<tr>
<th>RUC Shortfall Ratio Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUC Shortfall</td>
</tr>
<tr>
<td>RUC Shortfall Total</td>
</tr>
</tbody>
</table>
Determining a QSE’s RUC Shortfall

ERCOT takes Snapshots:

- QSE’s market position each time RUC is executed
- QSE’s market position at end of each Adjustment Period
RUC Snapshot (DRUC)

Looks at QSE’s market position for each hour during the RUC Study Period.
Adjustment Period Snapshot

Looks at QSE’s market position at the end of each Adjustment Period
Determine QSE’s RUC Shortfall

For each hour:

- ERCOT compares the Adjustment Snapshot with the corresponding hour in the RUC Snapshot
- The QSE’s RUC shortfall is based on the snapshot that is the most short
**RUC Shortfall**

\[
\text{RUCSF}_{ruc,i,q} = \text{Max} \left( 0, \text{Max} \left( \text{RUCSFSNAP}_{ruc,q,i}, \text{RUCSFADJ}_{ruc,q,i} \right) \right) - \sum_{\text{Prior RUCs}} \text{RUCCAPCREDIT}_{q,i,z}
\]

- **RUCSFSNAP**
  - Snapshot of the QSEs market position each time a RUC is executed
  - Different RUCSNAP for each RUC

**Determinants**

- **RUC Shortfall**
- **RUC Short Fall at Snapshot**
- **RUC Short Fall at Adjustment Period**
- **RUC Capacity Credit**
RUC Shortfall

\[ \text{RUCSFSNAP}_{ruc,q,i} = \max(0, ((\sum RTAML_{q,p,i} \times 4) + \sum RTDCEXP_{q,p,i} - \text{RUCCAPSNA}_{ruc,q,i})) \]

Capacity at snapshot:

- QSE-to-QSE Energy Purchases – QSE-to-QSE Energy Sales (Energy Trades)
- Day-Ahead Energy Purchases – Day-Ahead Energy Sales
- Capacity Purchase – Capacity Sales (Capacity Trades)
- High Ancillary Service Limits + DC Tie Imports
RUC Capacity-Short Charge

RUC Shortfall

\[
\text{RUCSFSNAP}_{ruc,q,i} = \max(0, ((\sum \text{RTAML}_{q,p,i} \times 4) + \sum \text{RTDCEXP}_{q,p,i} - \text{RUCCAPSNA}_{ruc,q,i}))
\]

\[
\text{RUCCAPSNA}_{ruc,q,i} = \sum \text{HASLSNA}_{q,r,h} + (\text{RUCCPSNA}_{q,h} - \text{RUCCSSNA}_{q,h}) + (\sum \text{DAEP}_{q,p,h} - \sum \text{DAES}_{q,p,h}) + (\sum \text{RTQQEPSNA}_{q,p,i} - \sum \text{RTQQESSNA}_{q,p,i}) + \sum \text{DCIMPSNA}_{q,p,i}
\]

Determinants

- **Real-Time DC Tie Export** (Oklaunion Exemption)
- **RUC Capacity Snap** shot at time of RUC
- **High Ancillary Service Limit** at Snapshot
- **RUC Capacity Purchase**
- **RUC Capacity Sale**
- **Day-Ahead Energy Purchase**
- **Day-Ahead Energy Sale**
- **QSE-to-QSE Energy Purchase**
- **QSE-to-QSE Energy Sale**
- **DC Import at Snapshot**
RUC Capacity-Short Charge

RUC Shortfall

\[ RUCSF_{ruc,i,q} = \text{Max} \left( 0, \text{Max} \left( RUCSF_{SNAP,ruc,q,i}, RUCSF_{ADJ,ruc,q,i} \right) - \sum_{\text{Prior RUCs}} \text{RUCCAPCREDIT}_{q,i,z} \right) \]

**Determinants**

<table>
<thead>
<tr>
<th>RUC Shortfall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUC Short Fall at Snapshot</strong></td>
</tr>
<tr>
<td><strong>RUC Short Fall at Adjustment Period</strong></td>
</tr>
<tr>
<td><strong>RUC Capacity Credit</strong></td>
</tr>
</tbody>
</table>
RUC Shortfall

\[
RUCSFADJ_{ruc,q,i} = \text{Max} \left(0, \left(\sum RTAML_{q,p,i} \times 4 \right) + \sum RTDCEXP_{q,p,i} - \sum \text{HASLSNAP}_{ruc,q,r,h} - RUCCAPADJ_{q,i} \right)
\]

Capacity at Adjustment Period:

- QSE-to-QSE Energy Purchases – QSE-to-QSE Energy Sales (Energy Trades)
- Day-Ahead Energy Purchases – Day-Ahead Energy Sales
- Capacity Purchase – Capacity Sales (Capacity Trades)
- High Ancillary Service Limits + DC Tie Imports
RUC Capacity-Short Charge

RUC Shortfall

\[
RUCSFADJ_{ruc,q,i} = \text{Max} \left( 0, \left( \sum RTAML_{q,p,i} \times 4 \right) + \sum RTDCEXP_{q,p,i} - \sum HASLSNAP_{ruc,q,r,h} - RUCCAPADJ_{q,i} \right)
\]

\[
RUCCAPADJ_{q,i} = \sum HASLADJ_{q,r,h} + (RUCPADJ_{q,h} - RUCCSADJ_{q,h}) + (\sum DAEP_{q,p,h} - \sum DAES_{q,p,h}) + (\sum RTQQEPADJ_{q,p,i} - \sum RTQQESADJ_{q,p,i}) + \sum DCIMPADJ_{q,p,i}
\]

Determinants

- Real-Time DC Tie Export (Oklahoma Exemption)
- RUC Capacity Snapshot at Adjustment Period
- High Ancillary Service Limit at Adjustment Period
- RUC Capacity Purchase
- RUC Capacity Sale
- Day-Ahead Energy Purchase
- Day-Ahead Energy Sale
- QSE-to-QSE Energy Purchase
- QSE-to-QSE Energy Sale
- DC Import at Adjustment Period
Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RUC1

You have 10 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.
RUC Shortfall

\[
RUCSF_{ruc,i,q} = \max (0, \max (RUCSFSNAP_{ruc,q,i}, RUCSFADJ_{ruc,q,i})) - \sum \text{RUCCAPCREDIT}_{q,i,z}
\]

Capacity Credit

- Credit to QSEs to ensure not charged twice for the same capacity shortage

<table>
<thead>
<tr>
<th>Determinants</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUC Shortfall</td>
</tr>
<tr>
<td>RUC Short Fall at Snapshot</td>
</tr>
<tr>
<td>RUC Short Fall at Adjustment Period</td>
</tr>
<tr>
<td>RUC Capacity Credit</td>
</tr>
</tbody>
</table>
RUC Shortfall

\[
\text{RUCCAPCREDIT}_{ruc,i,q} = \text{Min} \left[ \text{RUCSF}_{ruc,i,q}, (\text{RUCCAPTOT}_{ruc,h} \times \text{RUCSFRS}_{ruc,i,q}) \right]
\]
Refer to your Settlements Workbook

In a small group, respond to the questions that relate to Scenario #RUC2.

You have 5 minutes to complete your questions.

If you cannot complete all questions, don’t worry – all questions will be reviewed as a class.
RUC Shortfall Ratio Share

QSE3 is capacity-short for a RUC process

- 20 MW

Total short is

- 100 MW

\[
\text{RUCSFRS} = \frac{\text{RUCSF}}{\text{RUCSFTOT}}
\]

\[
= \frac{20 \text{ MW}}{100 \text{ MW}}
\]

\[
= 0.20
\]
• QSE3:
  • RUC Shortfall: 20 MW
  • RUC Shortfall Ratio Share of: 20%
• ERCOT-wide Values
  • Total RUC Make-Whole Payments: -$800
  • RUC Capacity Total: 400 MW

\[
\text{RUCCSAMT} = (-1) \times \max \left[ \left( \text{RUCSFRS} \times \frac{\text{RUCMWAMTRUCTOT}}{\text{RUCCAPTOT}} \right), \left( 2 \times \text{RUCSF} \times \frac{\text{RUCMWAMTRUCTOT}}{\text{RUCCAPTOT}} \right) \right] / 4
\]

\[
\begin{align*}
\text{RUCCSAMT} &= (-1) \times \max \left[ \left( .20 \times -$800 \right), \left( 2 \times 20 \text{ MW} \times \frac{-800}{400 \text{ MW}} \right) \right] / 4 \\
&= (-1) \times \max \left[ (-$160), (-$80) \right] / 4 \\
&= $20
\end{align*}
\]
RUC Capacity-Short Charge

- QSE3:
  - RUC Shortfall: 20 MW
  - RUC Shortfall Ratio Share of: 20%
- ERCOT-wide Values
  - Total RUC Make-Whole Payments: -$800
  - RUC Capacity Total: 400 MW

RUC Capacity Short Charge is limited to $20 by the Short Charge Cap.

Without cap, charge would have been $40.
If after all the Capacity-Short charges have been collected ...

... then ERCOT needs additional funds for Make-Whole Payments.
What: If the revenues from the Capacity-Short Charge don’t cover all RUC Make-Whole Payments then additional funds will be uplifted to QSEs on a Load Ratio Share basis

Why: Keep ERCOT revenue neutral

Outcome #1: Charge to all QSEs to collect enough funds to pay the RUC Make-Whole Payments
\[ \text{LARUCAMT}_{q,i} = (-1) \times \left( \frac{\text{RUCMWAMTTOT}_h}{4} + \text{RUCCSAMTTOT}_i \right) \times \text{LRS}_{q,i} \]

<table>
<thead>
<tr>
<th>Determinants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUC</strong> Make-Whole Uplift Charge</td>
</tr>
<tr>
<td><strong>RUC Make-Whole Amount Total</strong></td>
</tr>
<tr>
<td><strong>RUC Capacity Amount Total</strong></td>
</tr>
<tr>
<td><strong>Load Ratio Share</strong></td>
</tr>
</tbody>
</table>
QSE5 represents Load

- Load Ratio Share = .25

ERCOT-wide Values

- Total RUC Make-Whole Payments: -$800
- RUC Capacity-Short Charge Total: $100

ERCOT needs additional funds to pay Make-whole Payments

**LARUCAMT**

\[
\text{LARUCAMT} = (-1) \times \left( \frac{\text{RUCMWAMTTOT}}{4} + \frac{\text{RUCCSAMTTOT}}{4} \right) \times \text{LRS}
\]

\[
\text{LARUCAMT} = (-1) \times \left( \frac{-800}{4} + \frac{100}{4} \right) \times .25
\]

\[
= (-1) \times (-200 + 25) \times .25
\]

\[
= (-1) \times (-175) \times .25
\]

\[
= 25
\]
Reliability Unit Commitment: Settlements

RUC

Commitment
- Make-Whole
- Clawback

Decommitment
RUC Clawback Charge

Charge to all QSEs whose revenues exceed the RUC Guarantee

What: Collects a portion of revenue above costs

Why: Resource was committed for reliability. Excess revenue should be returned to Load
What if revenues are greater than cost?

- **Real-Time Revenues**
  - Incremental Energy Costs
- **Costs Incurred**
  - Minimum Energy Costs
  - Start-up Costs
What if revenues are greater than cost?

But how does ERCOT determine how much to clawback?

Revenues Received

- Real-Time Revenues
- Incremental Energy Costs

Costs Incurred

- Minimum Energy Costs
- Start-up Costs

Clawback Charge
## Clawback Factors

<table>
<thead>
<tr>
<th></th>
<th>Three-Part Supply Offer in DAM</th>
<th>No Three-Part Supply Offer in DAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUC Clawback Factor for RUC hours</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>RUC Clawback Factor for QSE hours</td>
<td>0%</td>
<td>50%</td>
</tr>
</tbody>
</table>
### RUC Clawback Charge

#### Trigger #1

\[
\begin{align*}
\text{Resource Revenues} & \geq \text{RUC Guaranteed Amount} \\
\end{align*}
\]

#### Outcome #1

<table>
<thead>
<tr>
<th>QSE</th>
<th>RUC Guaranteed Amount</th>
<th>Resource Revenues</th>
<th>Receive a RUC Clawback Charge?</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSE1</td>
<td>$4,000</td>
<td>$3,000</td>
<td>?</td>
</tr>
<tr>
<td>QSE4</td>
<td>$6,000</td>
<td>$44,400</td>
<td>?</td>
</tr>
<tr>
<td>QSE6</td>
<td>$8,000</td>
<td>$16,000</td>
<td>?</td>
</tr>
</tbody>
</table>

QSE1: No
QSE4: Yes
QSE6: It depends...
Calculate Clawback Amount

\[
\text{RUCCBAMT} = \frac{[(\text{RUCMEREV} + \text{RUCEXRR} - \text{RUCG}) \times \text{RUCCBFR} + (\text{RUCEXRQC} \times \text{RUCCBFC})]}{\sum \text{RUCHR}}
\]

| \(\text{RUCCBAMT}_{q, r, h}\) | RUC Clawback Charge Amount |
| \(\text{RUCMEREV}_{q, r, d}\) | RUC Minimum-Energy Revenue |
| \(\text{RUCEXRR}_{q, r, d}\) | Revenue Less Cost Above LSL from RUC Hours |
| \(\text{RUCG}_{q, r, d}\) | RUC Guarantee |
| \(\text{RUCEXRQC}_{q, r, d}\) | Revenue Less Cost from QSE Clawback Intervals |
| \(\text{RUCCBFR}_{q, r, d}\) | RUC Clawback Factor for RUC-Committed Hours |
| \(\text{RUCCBFC}_{q, r, d}\) | RUC Clawback Factor for QSE Clawback Intervals |
| \(\text{RUCHR}\) | RUC Hour |
RUC Clawback Charge

- QSE4’s Resource Revenues are greater than its RUC Guaranteed Amount
- QSE4’s Resource was committed with a Three-Part Supply Offer
- QSE4’s Resource was offered in DAM

RUCCBAMT = \[
\frac{(RUCMEREV + RUCEXRR - RUCG) \times RUCCBFR + (RUCEXRQC \times RUCCBFC)}{\sum RUCHR}
\]

\[
= \frac{[($5,000 + $27,000 - $6000) \times 0.5 + ($12,400 \times 0)]}{5}
\]

\[
= \frac{[$26,000 \times 0.5]}{5}
\]

\[
= $2600 \text{ per hour}
\]
RUC Clawback Payment

Outcome #1

Payment to all QSEs that represent Load

<table>
<thead>
<tr>
<th>What:</th>
<th>Revenue collected above costs through Clawback charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why:</td>
<td>Keep ERCOT revenue neutral</td>
</tr>
</tbody>
</table>
• ERCOT receives funds from Clawback charges
• QSE5 represents Load
  • Load Ratio Share (LRS) of 30%

RUC Clawback Payment

\[
\text{LARUCCBAMT} = (-1) \times (\text{RUCCBAMTTOT} \times \frac{1}{4} \times \text{LRS})
\]

\[
= (-1) \times ($2600 \times \frac{1}{4} \times 0.30)
\]

\[
= (-1) \times ($650 \times 0.30)
\]

\[
= -$195
\]
Reliability Unit Commitment: Settlements

RUC

Commitment
- Make-Whole
- Clawback

Decommitment
Payment to QSE for a QSE-committed Resource that the RUC process decommitted

If all criteria met:

- ERCOT pays QSE for decommitment
- Payment occurs only for Operating Day of decommitment
- QSE gets RUC Capacity Credit
RUC Payment for Decommitment

Decommitment of a QSE-Committed Resource

RUC Decommitment Payment

- Start-up Cost (SUPR)
- Less cost savings (MEPR – RTSPP), if any
- Distributed across Decommitted Hours (NCDCHR)

Where,

\[
\text{SUPR} = \min(\text{SUO}, \text{SUCAP})
\]
\[
\text{MEPR} = \min(\text{MEO}, \text{MECAP})
\]
ERCOT decommits QSE1 Unit 1
- QSE-Committed Resource
- Resource is NOT scheduled to shutdown within the Operating Day

RUCDCAMT

= (-1) * Max {0, [SUPR - (Max (0, MEPR – RTSPP)) * (LSL * (1/4))]} / NCDCHR

RUCDCAMT

= (-1) * Max {0, [$1200 - (Max (0, $30 – $40)) * (10MW * (1/4))]} / 6

= (-1) * $1200 / 6 = -$200
RUC Payment for Decommitment

• ERCOT decommits QSE1 Unit 1
• QSE-Committed Resource
• Resource IS scheduled to shutdown within the Operating Day

QSE will not receive payment for decommitment
### RUC Decommitment Charge

**What:** Charge to fund Decommitment Payments

**Why:** Keep ERCOT revenue neutral

**Outcome #1:** Charge to QSEs that represent Load
• Resource are decommitted by the RUC process and are eligible to receive a decommitment payment

• QSE5 represents Load

• Load Ratio Share of 30%

RUC Decommitment Charge

\[ \text{LARUCDCAMT}_{q,i} = (-1) \times \left( \frac{(\text{RUCDCAMTTOT}_h)}{4} \times \text{LRS}_{q,i} \right) \]

= \((-1) \times \left( \frac{(-$200)}{4} \times 0.30 \right)\]

= \((-1) \times [ -$50 \times 0.30 ] \)

= $15
Module Conclusion

CRR Auction
- Charges & Payments for CRRs
- Revenue Distribution

CRR Balancing Account
- Reconcile CRR Short payments

DAM
- Participation in DAM
  - Energy
  - AS
  - PTP Obligations
- DAM Commitment
  - Make-Whole
- Settlement of CRRs purchased in the Auction

RUC
- Commitment
  - Make-Whole
  - Clawback
- Decommitment

Real-Time
- Real-Time Activities
  - Imbalances
  - Base Point Deviations
  - Other odds & ends
- Settlement of PTP Obligations purchased in the DAM
- Real Time Ancillary Service Settlements
- Revenue Neutrality