Module Objectives

• What are Verifiable Costs and why are they important?

• How are Verifiable Costs derived from Resource Cost data?

• How are Verifiable Costs submitted?

• What is the review and approval process?

• Other Relevant Issues

• Process of revising the Verifiable Cost Manual
What are Verifiable Costs?

Why are they important?
Verifiable Costs Definition

Verifiable Costs

• Proxy for operating costs

• Fuel Costs
• Operation and Maintenance ("O&M") costs.
Verifiable Costs include:

- Fuel consumption rates
- Incremental Operation & Maintenance (O&M) costs:
  ✓ Variable O&M
  ✓ Emission credit costs
Non-Permissible Verifiable Costs

Verifiable Costs do not include:

• Fixed costs
• Capital costs
• Costs without sufficient documentation
How Verifiable Costs are Used

Verifiable Costs:

- Used in the three stages of the power generation cycle:
  - Startup to LSL
    - Startup Fuel and Incremental O&M
  - Operation at LSL
    - Fuel at LSL and Incremental O&M
  - Operation above LSL
    - Mitigated Offer Curve for Incremental Cost Above LSL
How Verifiable Costs are Used

Startup Fuel and Incremental O&M

- Verifiable Startup Offer costs:
  - Replace generic caps on Startup Offers
  - Are calculated using:
    - FIP/FOP
    - Verifiable fuel rates
    - Incremental O&M

[Diagram showing the relationship between QSE’s Startup Offer and Startup Offer Cap calculated using verifiable costs]
Minimum-Energy Fuel and Incremental O&M

- Minimum Energy Operating Costs:
  - Replace generic caps on Minimum Energy Offers
  - Are calculated using:
    - FIP/FOP
    - Verifiable fuel rates at LSL
    - Incremental O&M

QSE’s Minimum Energy Offer \( \leq \) Minimum Energy Offer cap calculated using verifiable costs
Three Part Supply Offer

- Startup Offer
- Minimum-Energy Offer
- Energy Offer Curve

$ to Startup
$/MWh to operate at sustained level
$/MWh to operate at given MW quantities above sustained level
Day Ahead Market (DAM)

- Verifiable costs used to cap offers when evaluating Resources for commitment
  - Verifiable Startup Costs
  - Verifiable Minimum Energy Operating Costs
Reliability Unit Commitment (RUC)

- Verifiable costs used:
  - To cap offers during evaluation for RUC commitment
    - Verifiable Startup Costs
    - Verifiable Minimum Energy Operating Costs
  - To create Three-Part Supply Offers for Resources that are available for commitment but have not submitted offers.
Where Verifiable Costs are Used

Reliability Unit Commitment (RUC)

• Verifiable costs used to determine:
  ✓ Proxy Energy Offer Curves to evaluate Resources for commitment
  ✓ RUC Guarantee Price for committed Resources for Resources not offered in the DAM
    ◦ Generic values used unless verifiable costs have been approved
Real-Time Operations

- Verifiable costs used in creation of Resource-specific Mitigated Offer Cap curves:
  - Used for Real-Time Energy Offer Mitigation
  - Based on Resource’s Verifiable Incremental Heat Rate (IHR) Curve, Fuel Adder and Verifiable variable O&M cost.
Verifiable Startup Costs ($/Start)

Verifiable Startup Offer Cap = Fuel Quantity * Fuel Price + VOMS

- Calculated for each Startup Type
  - Cold Start
  - Hot Start
  - Intermediate Start
How are Verifiable Costs used

Verifiable Fuel Quantity to Start (MMBtu/Start)

\[ \text{AFCRS} = \text{Max} \left( (\text{RAFCRS} - \text{PHR} \times \text{AVGEN} + \text{RAFCRS} \times \text{VOXR}), 0 \right) \]

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFCRS</td>
<td>Actual Fuel Consumption Rate per Start</td>
<td>MMBtu/Start</td>
</tr>
<tr>
<td>RAFCRS</td>
<td>Raw Fuel Consumption Rate per Start</td>
<td>MMBtu/Start</td>
</tr>
<tr>
<td>PHR</td>
<td>Proxy Heat Rate</td>
<td>MMBtu/MWh</td>
</tr>
<tr>
<td>AVGEN</td>
<td>Average Generation per start</td>
<td>MWh</td>
</tr>
<tr>
<td>VOXR</td>
<td>Value of X per Resource</td>
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</table>
## How are Verifiable Costs used

### Verifiable Fuel Price to Start ($/MMBtu)

**Fuel Price** = **FIP** * **GASPERSU** + **FOP** * **OILPERSU**

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>FIP</td>
<td>Fuel Index Price</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>GASPERSU</td>
<td>Percentage of Gas used per Start</td>
<td>%</td>
</tr>
<tr>
<td>FOP</td>
<td>Fuel Oil Price</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>OILPERSU</td>
<td>Percentage of Oil used per Start</td>
<td>%</td>
</tr>
</tbody>
</table>
How are Verifiable Costs used

Verifiable O&M to Start ($/Start)

VOMS = RVOMS + Emissions Costs

Emissions Costs = RAFCRS (SO2RS*SO2P/SO2PPA + NOXRS*NOXP/NOXPPA)

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>VOMS</td>
<td>Verifiable O&amp;M per Start</td>
<td>$/Start</td>
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<tr>
<td>RVOMS</td>
<td>Raw Verifiable O&amp;M per Start</td>
<td>$/Start</td>
</tr>
<tr>
<td>RAFCRS</td>
<td>Raw Fuel Consumption Rate per Start</td>
<td>MMBtu/Start</td>
</tr>
<tr>
<td>SO2RS</td>
<td>SO2 Rate per Start</td>
<td>Lb/MMBtu</td>
</tr>
<tr>
<td>SO2P</td>
<td>SO2 Price</td>
<td>$/Allowance</td>
</tr>
<tr>
<td>SO2PPA</td>
<td>SO2 pounds per Allowance</td>
<td>Lb/Allowance</td>
</tr>
<tr>
<td>NOXRS</td>
<td>NOX Rate per Start</td>
<td>Lb/MMBtu</td>
</tr>
<tr>
<td>NOXP</td>
<td>NOX Price</td>
<td>$/Allowance</td>
</tr>
<tr>
<td>NOXPPA</td>
<td>NOX pounds per Allowance</td>
<td>Lb/Allowance</td>
</tr>
</tbody>
</table>
How are Verifiable Costs used

Verifiable Startup Costs ($/Start)

Verifiable Startup Offer Cap = AFCRS + (FIP * GASPERSU + FOP * OILPERSU) + VOMS
How are Verifiable Costs used

Verifiable Minimum Energy Costs ($/MWh)

Verifiable Minimum Energy Offer Cap = Fuel Quantity * Fuel Price + VOMLSL

• Calculated only for Costs at LSL
How are Verifiable Costs used

Verifiable Minimum Energy Fuel Quantity at LSL (MMBtu/MWh)

\[ VFCLSL = RVFCLSL \times (1 + VOXR) \]

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFCLSL</td>
<td>Verifiable Fuel Consumption at LSL</td>
<td>MMBtu/MWh</td>
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<tr>
<td>RVFCLSL</td>
<td>Raw Verifiable Fuel Consumption at LSL</td>
<td>MMBtu/MWh</td>
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<tr>
<td>VOXR</td>
<td>Value of X per Resource</td>
<td>None</td>
</tr>
</tbody>
</table>
How are Verifiable Costs used

Verifiable Fuel Price at LSL ($/MMBtu)

Fuel Price = FIP * GASPERICAN + FOP * OILPERME

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIP</td>
<td>Fuel Index Price</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>GASPERICAN</td>
<td>Percentage of Gas used at LSL</td>
<td>%</td>
</tr>
<tr>
<td>FOP</td>
<td>Fuel Oil Price</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>OILPERME</td>
<td>Percentage of Oil used at LSL</td>
<td>%</td>
</tr>
</tbody>
</table>
How are Verifiable Costs used

Verifiable O&M at LSL ($/MWh)

\[
\text{VOMLSL} = \text{RVOMLSL} + \text{Emissions Costs}
\]

\[
\text{Emissions Costs} = \text{RVFCLSL} \times \left( \frac{\text{SO2RL} \times \text{SO2P}}{\text{SO2PPA}} + \frac{\text{NOXRL} \times \text{NOXP}}{\text{NOXPPA}} \right)
\]

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOMLSL</td>
<td>Verifiable O&amp;M at LSL</td>
<td>$/MWh</td>
</tr>
<tr>
<td>RVOMLSL</td>
<td>Raw Verifiable O&amp;M at LSL</td>
<td>$/MWh</td>
</tr>
<tr>
<td>RVFCLSL</td>
<td>Raw Fuel Consumption at LSL</td>
<td>MMBtu/MWh</td>
</tr>
<tr>
<td>SO2RL</td>
<td>SO2 Rate at LSL</td>
<td>Lb/MMBtu</td>
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<td>SO2P</td>
<td>SO2 Price</td>
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<td>NOXRL</td>
<td>NOX Rate at LSL</td>
<td>Lb/MMBtu</td>
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<tr>
<td>NOXP</td>
<td>NOX Price</td>
<td>$/Allowance</td>
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<td>NOXPPA</td>
<td>NOX pounds per Allowance</td>
<td>Lb/Allowance</td>
</tr>
</tbody>
</table>
How are Verifiable Costs used

Verifiable Minimum Energy Costs ($/MWh)

Verifiable Minimum Energy Offer Cap = VFCLSL + (FIP * GASPERME + FOP * OILPERME) + VOMLSL

- Calculated only for Costs at LSL
How are Verifiable Costs used

Mitigated Offer Curve

• Energy Offer Curves may be subject to mitigation in Real-Time operations using a Mitigated Offer Cap (MOC)

• ERCOT will construct an incremental MOC

• For Generation Resources that commence commercial operations after January 1, 2004, the MOC will be the greater of (point by point):

  14.5 MMBtu/MWh x FIP
  OR
  \[ IHR \times (((GASPEROL \times FIP) + (OILPEROL \times FOP))/100 + Fuel Adder) + OM \] * Multiplier

• For Generation Resources that commence commercial operations on or before January 1, 2004 the MOC will be the greater of (point by point):

  10.5 MMBtu/MWh x FIP
  OR
  \[ IHR \times (((GASPEROL \times FIP) + (OILPEROL \times FOP))/100 + Fuel Adder) + OM \] * Multiplier
How are Verifiable Costs used

Mitigated Offer Curve

- MMBtu/MWh
- Generic Heat Rate Value
- IHR Curve
- Output Level
How are Verifiable Costs used

Mitigated Offer Curve
Who Needs to Submit the Data?

• Resources that receive 5 RUC instructions in one calendar year

• Resources are required to resubmit VC data if:
  ✓ Received 50 RUC instructions in one calendar year
  ✓ At least five years have passed since last approved VC submission

• Must be submitted by the QSE representing the Resource
Where Verifiable Costs are Used

Protocol Requirements for Calculating Make-Whole Payments

- Price used for Make-Whole payments is as follows:

<table>
<thead>
<tr>
<th>Before ERCOT Approval</th>
<th>After ERCOT Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Generic Startup Offer Cap for the Resource Category; and</td>
<td>• Startup Offer Cap based on approved verifiable unit-specific costs; and</td>
</tr>
<tr>
<td>• Generic Minimum-Energy Offer Cap for the Resource Category</td>
<td>• Minimum-Energy Offer Cap based on approved verifiable unit-specific costs</td>
</tr>
</tbody>
</table>
How are Verifiable Costs Derived from Resource Cost Data?
Verifiable Cost Submissions must include:

- Incremental Operation and Maintenance (O&M) Costs
  - Actual, or
  - Standard
- Emission Quantities (optional)
- Fuel Consumption Rate
- Heat Rate Curve and Supporting Equation (I/O)
General Incremental O&M Criteria

• All O&M costs are incremental; no fixed or capital costs
• O&M costs must not include fuel costs
• Submitted O&M documentation is Resource-specific
  ✓ Detailed individual Resource-specific costs are required, shown as $/start or $/MWh
  ✓ Maintenance cost calculations should include total maintenance history regardless of unit ownership
    ❑ Up to 10 years if available

Incremental Operation and Maintenance Costs
General Incremental O&M Calculation Criteria

• Maintenance Costs
  ✓ Costs associated with maintenance, repair, inspection or upkeep of resources.
  ✓ Are a proportionate share of future maintenance costs
  ✓ Allocated using hours-based, starts-based or equivalent-operating-hours criteria
Operation Costs

• Captures various other non-fuel, incremental (marginal) costs a Resource incurs while generating power in a given period:
  ✓ Submitted by QSE or Resource Entity
  ✓ Verified by ERCOT

• Operating costs per-start and per hour of operation at LSL may include, but are not limited to:
  ✓ Water consumption
  ✓ Chemical (non-fuel)
  ✓ Emission credits
  ✓ Consumables, etc.
Verifiable Startup O&M Cost

- O&M startup costs must be provided for each startup type ($/start)
  - Hot
  - Cold
  - Intermediate
- QSE must provide:
  - Incremental Startup costs with documentation ($/start)
  - Emission rates by emission type (lbs/MMBtu) (optional)
Verifiable O&M Costs at LSL

- QSE or Resource Entity must provide:
  - LSL (MW)
  - Incremental O&M costs at LSL ($/MWh)
  - Fuel consumption rate at LSL (MMBtu/Hr)
  - Emission rates by emission type (lbs/MMBtu) (optional)
General O&M Calculation Conditions

- QSE may submit only one value for:
  - O&M cost for each startup type ($/Start)
    - cold, hot and intermediate
  - O&M cost at LSL ($/MWh)
  - Average O&M cost of operation above LSL ($/MWh)
Verifiable Startup O&M Cost

- ERCOT calculates emission component of Verifiable O&M Costs using
  - Submitted emission rates (lbs/MMBtu)
  - Published emission credit price indices ($/lb)
  - Fuel consumption rate per start (MMBtu/Start)

Verifiable Startup O&M Cost = Incremental O&M Cost + Emission component
Variable O&M Costs at LSL

- ERCOT calculates the emission component of Variable O&M Costs at LSL using:
  - Emission rates (lbs/MMBtu)
  - Published emission credit price indices ($/lb)
  - Fuel consumption rate at LSL (MMBtu/Hr)

\[
\text{Variable O&M Costs at LSL} = \text{Incremental O&M Costs} + \text{Emission component}
\]
Appendix 1A: Methodology for Determining Maintenance Costs of Nuclear and Fossil Steam Units. This procedure is not subject to WMS approval since only ERCOT has the authority to approve all methodologies as per Protocol section 5.6.1 (3) (iii).

Sample Calculation of Total Maintenance Dollars using Operating Year of 2015

\[ TMD = (C_{14} \times F_{14}) + (C_{13} \times F_{13}) \ldots + (C_{11} \times F_{11}) \]

Where:

- \( C \) = Total dollars spent on maintenance during a particular year
- \( F \) = Escalation Factor for a particular year, as approved by ERCOT and based on the Cost Escalation Factors as shown in the verifiable costs submission template (http://www.ercot.com/content/mktinfo/settlements/Coms_Verifiable_Costs_Submission_Template_V14.xls)

*Note:* TMD must be calculated for the same historical period as Equivalent Service Hours.
How to Calculate Equivalent Service Hours (ESH)

ESH = (A_c * NS_c + A_i * NS_i + A_h * NS_h) + Z hours

Where:

A_c = Cold starting factor = 30.0 Hrs.

This implies that the incremental maintenance charged to one cold start is equivalent to the incremental maintenance attributable to thirty hours of base load operation.

A_i = Intermediate starting factor = 0.7 * 30.0 = 21.0
A_h = Hot starting factor = 0.5 * 30.0 = 15.0
NS_c = Number of cold starts over the historical period
NS_i = Number of intermediate starts over the historical period
NS_h = Number of hot starts over the historical period
Z = Total unit operating hours at any load level over the historical period
How to Calculate Equivalent Hourly Maintenance Cost (EHMC)

EHMC = TMD / ESH

Where:

1. TMD = Total maintenance dollars as approved by ERCOT ($)
2. ESH = Equivalent service hours (hrs.)
3. EHMC is in terms of ($/hour)
Incremental Operation and Maintenance Costs Methodology

Applying Equivalent Hours Maintenance Costs to Calculate Maintenance Start Rates

Cold Start Maintenance Cost ($/Cold-Start) = \( A_c \times \text{EHMC} \)

Intermediate Start Maintenance Cost ($/Intermediate-Start) = \( A_i \times \text{EHMC} \)

Hot Start Maintenance Cost ($/Hot-Start) = \( A_h \times \text{EHMC} \)

Where:
\( A_c, A_i, A_h \) = Individual starting factors as defined above (Hrs.)

\( \text{EHMC} \) = Hourly Maintenance Cost ($/Hour)
How to Calculate Maintenance Cost Rate (MCR) for Energy Produced

\[ MCR = \frac{(TMD - TSD)}{TMWH} \]

Where:

- **MCR** = Maintenance Cost Rate, $/MWh
- **TSD** = Total Start maintenance Dollars over the historical period
  - \[ TSD = NS_c \times A_c \times EHMC + NS_i \times A_i \times EHMC + NS_h \times A_h \times EHMC \]
- **TMWH** = Total energy generation over the historical period, MWh
Appendix 1B: Methodology for Determining the Maintenance Costs of CT and CCP Units. This procedure is not subject to WMS approval since only ERCOT has the authority to approve all methodologies as per Protocol section 5.6.1 (3) (iii).

Example Calculation of Total Maintenance Dollars using Operating Year of 2015

\[
TMD = (C_{14} \times F_{14}) + (C_{13} \times F_{13}) \ldots + (C_{11} \times F_{11})
\]

Where:

- \(C\) = Total dollars spent on maintenance during a particular year
- \(F\) = Escalation Factor for a particular year, as approved by ERCOT and based on the Cost Escalation Factors as shown in the verifiable costs submission template (http://www.ercot.com/content/mktinfo/settlements/Coms_Verifiable_Costs_Submission_Template_V14.xls)

\(Note: TMD\) must be calculated for the same historical period as Equivalent Service Hours.
How to Calculate Equivalent Service Hours (ESH)

ESH = (A * NS) + Z hours

Where:

A = Cyclic starting factor (A = 5.0 for aircraft - type CT's; A = 10.0 for industrial - type CT's)

For example, the incremental maintenance charged to one start on an industrial - type CT is equivalent to the incremental maintenance attributable to ten hours of base load operation.

NS = Number of Starts over the historical period

Z = Total unit operating hours at any load level over the historical period
How to Calculate Equivalent Hourly Maintenance Cost (EHMC)

\[ EHMC = \frac{TMD}{ESH} \]

Where:

- **TMD** = Total maintenance dollars as approved by ERCOT
- **ESH** = Equivalent service hours
- **EHMC** is in terms of $/hour
Applying Equivalent Hours Maintenance Costs to Calculate Maintenance Rates

Starting Maintenance Cost ($/Start) = A * EHMC

Where:

A = Cyclic starting factor as defined above

EHMC = Hourly Maintenance Cost ($/Hour)

This hourly value is assigned as a capacity cost and is independent of unit loading.

Comments:

1. The above formulations are applicable for determination of Maintenance Cost Adder for both aircraft and industrial type combustion turbines.

2. CT incremental costs may only be developed and applied on a unit-by-unit basis.
How to Calculate Maintenance Cost Rate (MCR) for Energy Produced

\[
MCR = \frac{(TMD - TSD)}{TMWH}
\]

Where:
- \( MCR \) = Maintenance Cost Rate, $/MWh
- \( TSD \) = Total Start maintenance Dollars over the historical period
  \[= NS \times A \times EHMC\]
- \( TMWH \) = Total energy generation over the historical period, MWh

Note: The MCR value applies to operation over all output levels including operations at LSL and the entire range from LSL to HSL.
Long Term Service Agreements (LTSA) O&M costs

• A QSE or Resource Entity may include Verifiable O&M costs from a currently effective LTSA agreements if:
  ✓ Maintenance costs are incremental and consistent with ERCOT Verifiable Cost definitions and uses
    ◦ The LTSA specifically sets a dollar value for each component of the variable maintenance costs;
    ◦ ERCOT can verify the LTSA incremental or variable maintenance costs ($/MWh or $/start)
    ◦ Cost curves specifying O&M values vs. time are submitted

If submitted, LTSAs are considered CONFIDENTIAL information by ERCOT and will be returned to the QSE upon request
Incremental Operation and Maintenance Costs

Emission Costs

• May be included in Incremental O&M costs for Startup or for operation at and above LSL
  ✓ SO$_2$
  ✓ NO$_x$
  ✓ Other
  ✓ Cross-State Air Pollution Rule (CSAPR)

• Emission credits to meet environmental regulations
• Emission discharge rates submitted in Verifiable Cost Data
  ✓ Measured in lbs/MMBtu
  ✓ ERCOT uses emission cost indices
O&M Cost as a Function of Annual Startups

Source: Power Generation Asset Optimization:
Optimal Generating Strategies in Volatile Markets (Case Study)
Power Costs, Inc.; POWER-GEN 2001
Typical Costs

### Typical Costs

<table>
<thead>
<tr>
<th>In-Service Year = 2007</th>
<th>Size MW</th>
<th>$/MWh (Nominal 2007$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Capital &amp; Financing</td>
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<tr>
<td>Conventional Combined Cycle (CC)</td>
<td>500</td>
<td>22.71</td>
</tr>
<tr>
<td>Conventional CC - Duct Fired</td>
<td>550</td>
<td>23.27</td>
</tr>
<tr>
<td>Advanced Combined Cycle</td>
<td>800</td>
<td>22.33</td>
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<tr>
<td>Conventional Simple Cycle</td>
<td>100</td>
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<tr>
<td>Small Simple Cycle</td>
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<tr>
<td>Advanced Simple Cycle</td>
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<td>Integrated Gasification Combined Cycle (IGCC)</td>
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<td>Biomass Combustion - Stoker Boiler</td>
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<td>Biomass - WWTP</td>
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<tr>
<td>Fuel Cell - Proton Exchange</td>
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<tr>
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<td>Hydro - Small Scale</td>
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<td>Ocean - Wave</td>
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</table>

## O&M Costs Escalation Factors

### Cost Escalation Factors

<table>
<thead>
<tr>
<th>Year</th>
<th>Escalation Factors (1)</th>
<th>$ spent on Maintenance (before escalation factor applied)</th>
<th>Escalated Maintenance Amounts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>1.611</td>
<td>$0</td>
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</tr>
<tr>
<td>2014</td>
<td>1</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

(1) Calculated by ERCOT and effective as of December 1, 2014
QSEs submitting Power Purchase or Tolling Agreements (PPAs) as Resource–specific verifiable costs documentation are subject to the guidelines detailed below and in the Verifiable Cost Manual.

- Only QSEs offering Three-Part Supply Offers for a specific Resource may submit a PPA as verifiable costs documentation.
- A QSE submitting a PPA as verifiable costs documentation must represent 100% of the Resource’s capacity.
- Only PPAs:
  1. signed prior to July 16, 2008; and
  2. not between Affiliates, subsidiaries or partners will be accepted as verifiable cost documentation.
Fuel

- Captures the fuel costs of a Resource:
  - Startup to LSL
  - Operating at LSL

- Calculated from:
  - Fuel consumption rate (either MMBtu/start or MMBtu/hr); and
  - Fuel price ($/MMBtu)

ERCOT calculates fuel cost by using the Fuel Index Price ("FIP"), Fuel Oil Price ("FOP") or a Protocol-defined fixed amount of $1.50/MMBtu for solid fuel.
Verifiable Startup Fuel Cost

- QSE or Resource Entity must provide:
  - Fuel consumption
    - In the interval from first fire to LSL (MMBtu)
    - For each startup type
  - Fuel percentages for each startup type
- ERCOT calculates verifiable startup fuel costs by:
  - Weighting the fuel percentage by the relevant price index for each fuel type;
  - Multiplying by the fuel consumption rate; and
  - Multiplying by the Value of X for the Resource

Verifiable Startup Fuel Cost = Fuel Consumed at Startup * (1+VOXR) * Calculated fuel price
Calculating Verifiable Fuel Cost at LSL

Verifiable Fuel Cost at LSL ($/MWh)

- QSE or Resource Entity must provide:
  - Fuel consumption rate at LSL (MMBtu/Hr)
  - LSL (MW)
  - Fuel percentages for each fuel type

- ERCOT calculates the Verifiable Fuel Cost at LSL by:
  - Weighting the fuel percentages at LSL by the relevant fuel price index;
  - Multiplying by fuel consumption rate divided by the MW at LSL; and
  - Multiplying by the Value of X for the Resource

Verifiable Fuel Cost at LSL = (Fuel Consumption Rate / LSL) * (1+VOXR) * Calculated fuel price
Heat Rate Curve and Supporting Equation (I/O)

- Input/Output Curve equation
- Average Heat Rate Curve
- Incremental Heat Rate Curve
Preparing Heat Rate Data

Create Heat Rate Curves

• ERCOT will only approve heat rate data when Resource-specific I/O curves are submitted
  ✓ I/O Curve specified by third order polynomial equation with four non-zero coefficients
  ✓ Heat Rate data based on actual test results, operating data or manufacturer suggested values
Source of Input-Output Curve Data

• Resource total heat (or fuel) I/O curves
  ✓ Based on data from comparable units
  ✓ Modified by available actual unit test data
    ◦ must include minimum and maximum load points and at least two intermediate load points

• I/O curves are to be fitted from data using either manual or computer techniques
Defining Input-Output Curves

- Defined by the third-order equation:

\[ y = A + Bx + Cx^2 + Dx^3 \]

- All values (y, x, A, B, C, D) must be provided to ERCOT
  - Coefficients B, C, and D must be nonzero
  - Coefficient A must be greater than zero
Resource-Specific Heat Rate Curves

• Average Heat Rate ("AHR") Curve
  ✓ Determined by dividing fuel input by the power it generates for various levels of generation
  ✓ Average amount of energy used by a Resource to provide each unit of power output
Preparing Heat Rate Data

Average Heat Rate Curve

• All submitted AHR Curve data must be:
  ✓ Determined mathematically or graphically directly from the relevant Resource’s I/O Curve
  ✓ Submitted in terms of:
    ◦ Input (MMBTU / MWh)
    ◦ Output (MW)
Preparing Heat Rate Data

Average Heat Rate Curve

- All submitted AHR Curve data must be defined as the I/O Curve divided by the output \( x \):

\[
AHR = \frac{y}{x} = \frac{A + Bx + Cx^2 + Dx^3}{x}
\]

- \( x = \text{Output in MW}; \)
- \( AHR = \frac{y}{x} = \text{Input in MMBtu/MWh}; \) and
- \( A-D = \text{coefficients that define the equation} \)
Resource-Specific Heat Rate Curves

- Incremental Heat Rate ("IHR") Curve
  - First derivative of the I/O Curve
  - Amount of thermal energy used by a Resource to achieve an incremental change in electrical energy output
Preparing Heat Rate Data

Incremental Heat Rate Curve

• All submitted IHR Curve data must:
  ✓ Be determined mathematically or directly from the relevant Resource’s I/O Curve;
  ✓ Provide a monotonic, non-decreasing function;
  ✓ Be submitted in terms of MMBtu/MWh;
  ✓ Consist of at least 2, but no more than 10, pairs of IHR (MMBtu/MWh) and Output (MW) points
Preparing Heat Rate Data

Incremental Heat Rate Curve

- All submitted IHR Curve data must be defined as the I/O Curve’s first derivative:

\[ IHR = \frac{dy}{dx} = B + 2Cx + 3Dx^2 \]

- \( x \) = Output in MW;
- \( \frac{dy}{dx} \) = Input in MMBtu/MWh; and
- \( B-D \) = coefficients that define the equation
Preparing Heat Rate Data

Updates to Heat Rate Curve Data

• If the physical characteristics of a generator have changed and previously submitted Heat Rate Curves overstate fuel consumption or understate efficiency:
  ✓ Notify ERCOT, and
  ✓ Submit updated Heat Rate data

All references to Heat Rate Curves and Heat Rate data refer to **Net Output.**
Submitting Data for Mitigated Offers

- Verifiable Cost data used for Mitigated Offer Caps:
  - Variable O&M data (OM), and
  - Verifiable Incremental Heat Rate (IHR) data
  - Fuel Adder (FA)

- If OM is submitted, IHR must also be submitted

- OM must be submitted as a single average value along the IHR curve
Submission of Heat Rate Curve Data

• Two options for submitting Heat Rate Curves and data:

  ✓ Results of tests performed on the generating unit

  ✓ Manufacturer suggested Heat Rate values

All references to Heat Rate Curves and Heat Rate data refer to Net Output.
Fuel Costs
Fuel Prices – Fuel Adder

Generic Fuel Cost Adder
• $0.50/MMBtu

Actual Fuel Cost Adder
• May Include cost of:
  ✓ Spot fuel
  ✓ Transportation
  ✓ Commodity
  ✓ Storage
  ✓ Imbalance
  ✓ etc.
Fuel Prices – Fuel Adder

Calculation

- Based on a rolling 12-month period.
- Difference between actual average fuel price paid, including all fees, and the fuel average price used by ERCOT.

Submission Timeline

<table>
<thead>
<tr>
<th>Submission Months</th>
<th>Submission Period</th>
<th>Approval Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>September - February</td>
<td>April</td>
<td>May-June</td>
</tr>
<tr>
<td>March – August</td>
<td>October</td>
<td>November-December</td>
</tr>
</tbody>
</table>
Quick Start Generating Resources (QSGR)
Variable O&M - QSGR

OM ($/MWh) = ROM + ROMQ + Emissions Costs

ROMQ = \frac{\text{(Startup Fuel Costs + Startup OM Costs)}}{G}

Where:

- Startup Fuel Costs = RAFCRS_c \times 0.90 \times (AVGFIP + FA)
- Startup OM Costs = RVOMS_c
- G = 0.75 \times HSL \times \text{Max (RARF Min up Time, AVG number of running hours in the period, 2)}
- Avg number of running hours in a period = 75\% of the average run time over the past 20 days for electrical and physically similar QSGRs at the same plant site.
Variable O&M - QSGR

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM</td>
<td>O&amp;M above LSL</td>
<td>$/MWh</td>
</tr>
<tr>
<td>ROM</td>
<td>Submitted &amp; Approved O&amp;M above LSL</td>
<td>$/MWh</td>
</tr>
<tr>
<td>ROMQ</td>
<td>Variable O&amp;M for QSGRs</td>
<td>$/MWh</td>
</tr>
<tr>
<td>G</td>
<td>Average generation during Min Up Time</td>
<td>MWh</td>
</tr>
<tr>
<td>HSL</td>
<td>Average of the Seasonal HSL in the RARF</td>
<td>MW</td>
</tr>
<tr>
<td>RAFCRS</td>
<td>Raw Fuel Consumption at a Cold Start</td>
<td>MMBtu/Start</td>
</tr>
<tr>
<td>AVGFIP</td>
<td>Average FIP for the first 15 days of the previous month</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>FA</td>
<td>Fuel Adder for the Resource</td>
<td>$/MMBtu</td>
</tr>
<tr>
<td>RVOMS</td>
<td>Variable O&amp;M at a Cold Start</td>
<td>$/Start</td>
</tr>
</tbody>
</table>
**Incremental Heat Rate (IHR) Adjustment - QSGR**

Adj IHR = IHR + MEC

MEC = AHR_m – IHR_m

Where:
- IHR (MMBtu/MWh) = Approved Incremental Heat Rate points file in the resource verifiable cost filing
- MEC (MMBtu/MWh) = Minimum Energy Component
- AHR_m (MMBtu/MWh) = Average Heat Rate at the Midpoint of the QSGR Dispatch Range
- IHR_m (MMBtu/MWh) = Incremental Heat Rate at the Midpoint of the QSGR Dispatch Range

And:
- Midpoint (MW) = HSL – (HSL-LSL) * .50
How are Verifiable Costs Submitted?
How Should Resources Submit Verifiable Cost Data?

Single Unit Single Owner Data Requirements

• QSE may submit costs, either:
  ✓ One value for all seasons, or
  ✓ One value for each season, if applicable

• QSE may submit:
  ✓ Fuel and O&M data for Startup to LSL and operation at LSL
  ✓ O&M data and incremental heat rate for operation above LSL
How Should Resources Submit Verifiable Cost Data?

Split Generation Resource Data Requirements

• Each Resource submits verifiable cost data:
  ✓ May use a Management QSE
  ✓ Each Resource may submit cost data
  ✓ ERCOT may require all Resources to submit cost data

• Resources may not register as Split Generation and Combined Cycle
How Should Resources Submit Verifiable Cost Data?

Combined Cycle Data Requirements

• Each configuration registered in the RARF must be submitted
  ✓ Fuel and Incremental O&M data for Startup to LSL and operation at LSL
  ✓ O&M data and incremental heat rate for operation above LSL
• Input-Output ("I/O") curves required for each configuration
• Each unit in the CCP configuration must have separate verifiable costs

Verifiable Costs are Resource Specific
Supporting Data Submittal

- QSE/Resource must attest for accuracy and authenticity of submitted data
  - Signed by a QSE officer representing the Resource
  - Signed by Resource Entity if submitting Verifiable Costs
  - Must represent actual costs
  - ERCOT must be able to validate the data
Supporting Data Submittal

- Electronic Format:
  - MIS
  - Email: nodalverifiablecost@ercot.com

- Hard Copy Format
Verifiable Cost Submittal Process

Verifiable Costs

- Submitting Verifiable Costs
Submittal of Data

- Verifiable Cost Template Introduction

a. Resources submitting Verifiable Costs must fill in the following sheets:
   1. Start-Up Costs: Sheets 1-6 (select the appropriate sheet for the resource type CCP, SCP or SGR)
   2. Minimum Energy Costs: Sheets 7-12 (select the appropriate sheet for the resource type CCP, SCP or SGR)
   3. Heat Rates: Sheet 13

b. Resources submitting costs above the Low Sustainable Limit (LSL) used for Real Time Mitigation must fill in sheets 14-17 (select the appropriate sheet)

c. Resources submitting Standard O&M Costs should insert the Resource-Specific Standard O&M Costs approved in the Nodal Protocol Section 5.6 into the appropriate fields in lieu of actual verifiable costs. Note that the Protocols do not provide for Standard O&M Costs above LSL.

CONTACT: If you have any questions, please contact your ERCOT Account Manager. You may also contact ERCOT’s Verifiable Cost Group via e-mail at: NodalVerifiableCost@ercot.com

Instructions: Signature 1-CCP-Start-Up Costs 2-CCP-Seasonal-Start-Up Costs 3-SCP-Start-Up Costs 4-SCP-Seasonal-Start-Up Costs 5-SGR-Start-Up Costs
Verifiable Input Types in the Verifiable Costs Template

Submittal of Data

• Signature Page

By signing below, the undersigned QSE affirms that, as of the date listed below and to the best of the undersigned's knowledge:
  a) this submission is complete, true, and correct; and
  b) all costs listed in this submission are accurate

QSE Authorized Representative

Signature:
Printed Name:
Title:
Date:

Primary Contact Regarding the Verifiable Cost Submittal

Signature:
Printed Name:
Title:
Phone Number:
E-mail Address:
Fax Number:

(*) Resource information must match data provided in the Asset Registration Form (RARF)
Verifiable Input Types in the Verifiable Costs Template

Submittal of Data

- Startup Cost

<table>
<thead>
<tr>
<th>Start Type</th>
<th>FUEL (MMBtu)</th>
<th>FUEL PERCENT (%)</th>
<th>O&amp;M(7)(S)</th>
<th>EMISSIONS (lbs/MMBtu)</th>
<th>START-UP DURATION (Hours)</th>
<th>GENERATION (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start - BC(3)</td>
<td>BC - LSL(4)</td>
<td>Shut-Down(5)</td>
<td>Total(6)</td>
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<td></td>
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<td>0</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Intermediate(6)</td>
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<td>0</td>
<td>0%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:
(1) If Start-Up Costs vary by Season, ignore this sheet and fill in "4-SCP-Seasonal-StartUp Costs" Sheet.
(2) If Intermediate fuel is not available use same value as a "hot" Start.
(3) BC = Breaker Close.
(4) Total fuel consumed while ramping from Breaker Close to LSL.
(5) Shut-Down Fuel = Fuel consumed from Breaker Open to Shutdown.
(6) This value will be used to calculate Total Start-Up Fuel and Emission costs.
(7) Select Standard or Actual. If Standard selected, enter the values according to Protocol Section 5.6.1. If Actual selected, enter the values according to your supporting data.
(8) Estimated net generation delivered to the grid between Breaker Close and LSL.
Verifiable Input Types in the Verifiable Costs Template

Submittal of Data

- Minimum Energy

| Nodal Verifiable Cost - Total Minimum Energy Costs @ LSL for SCP Resource Configuration (1) |
|---------------------------------|------|------------------------------|---|-----------------|----------------|-----------------|-----------------|
| Minimum Energy Fuel Rate        | LSL  | Minimum Energy Fuel Rate     | O&M | Emissions (SO₂) | Emissions (NOₓ) | Fuel Percent (%) |
| MMBtu/hr                        | MW   | MMBtu/MWh                    | $/MWh | lbs/MMBtu     | lbs/MMBtu         | Gas             | Oil             | Solid Fuel |
| #DIV/0!                          |      |                              |      |                |                 |                 |                 |               |

Note:
(1) If Minimum Energy Costs vary by Season, ignore this sheet and use tables under the "10-SCP-Seasonal-Min-Energy Cost" sheet.
Submittal of Data

- Real-Time Mitigated Offer Cap Input

\[ I/O = y = a + bx + cx^2 + dx^3 \]

Incremental Heat Rate Curve: \[ IHR = \frac{dy}{dx} = b + 2cx + 3dx^2 \]

Where: \( x = \) Resource Output Level in MW
\( y = \) Input in MMBtu/hr
\( a-d = \) The Coefficients that define the equation

<table>
<thead>
<tr>
<th>Points along the IHR Curve</th>
<th>Output Level(^{1})</th>
<th>IHR(^{2})</th>
<th>Emissions (SO(_2))</th>
<th>Emissions(^{4}) (NO(_x))</th>
<th>O&amp;M(^{0})</th>
<th>Fuel Percent (%)(^{4})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 1</td>
<td>MW Level Not Chosen</td>
<td></td>
<td></td>
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<tr>
<td>Point 2</td>
<td>MW Level Not Chosen</td>
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<tr>
<td>Point 3</td>
<td>MW Level Not Chosen</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Point 4</td>
<td>MW Level Not Chosen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point 5</td>
<td>MW Level Not Chosen</td>
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<td>Point 6</td>
<td>MW Level Not Chosen</td>
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<td>Point 7</td>
<td>MW Level Not Chosen</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Point 8</td>
<td>MW Level Not Chosen</td>
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<tr>
<td>Point 9</td>
<td>MW Level Not Chosen</td>
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<td>Point 10</td>
<td>MW Level Not Chosen</td>
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</table>
What is the Review and Approval Process?
QSE or Resource Entity Submits Verifiable Costs

ERCOT has 15 business days to reach a decision or request additional data.
Verifiable Costs Submittal Process

**ERCOT Initiates a Request for Additional Information**

- **Start**
  - QSE Submits Verifiable

- **Does ERCOT need additional data?**
  - **YES**
    - ERCOT notifies QSE
    - QSE submits additional data within 30 business days
      - ERCOT reviews additional documentation and has 10 business days to reach a decision or request further documentation

- **NO**
  - QSE submits additional data within 30 business days

 ERCOT has 15 days to reach a decision or request additional data.
Verifiable Costs Submittal Process

ERCOT Calculates Verifiable Costs

1. **Start**
   - QSE Submits Verifiable Costs

2. ERCOT has 15 business days to reach a decision or request additional data.
   - Does ERCOT need additional data?
     - Yes → ERCOT notifies QSE
     - No → QSE submits additional data within 30 business days
       - ERCOT reviews additional documentation and has 10 business days to reach a decision or request further documentation

3. ERCOT notifies QSE of final decision and approved amounts.
Verifiable Costs Submittal Process

QSE Accepts or Rejects Costs Calculated by ERCOT

- **Start**
  - QSE Submits Verifiable Costs
    - ERCOT has 15 business days to reach a decision or request additional data

- **Flow**
  - Does ERCOT need additional data?
    - **Yes:** ERCOT notifies QSE
      - QSE submits additional data within 30 business days
    - **No:** ERCOT reviews additional documentation and has 10 business days to reach a decision or request further documentation
  - QSE has 5 business days to reject
Verifiable Costs Submittal Process

QSE Rejects Costs Calculated by ERCOT

Start

QSE Submits Verifiable Costs

ERCOT has 15 business days to reach a decision or request additional data

Does ERCOT need additional data?

YES

ERCOT notifies QSE

QSE submits additional data within 30 business days

ERCOT reviews additional documentation and has 10 business days to reach a decision or request further documentation

NO

ERCOT notifies QSE of final decision and approved amounts

QSE Rejects?

YES

Generic values will be used

NO

Generic values will be used

YES
Verifiable Costs Submittal Process

QSE Does Not Accept or Reject Calculated Costs

Start

QSE Submits Verifiable Costs

ERCOT has 15 business days to reach a decision or request additional data

Does ERCOT need additional data?

YES

QSE Rejects?

NO

ERCOT notifies QSE of final decision and approved amounts

Approved VC amounts will take effect in 3 business days

END

QSE Rejects?

NO

Approved VC amounts will take effect in 3 business days

END

YES

Generic values will be used

QSE Rejects?
Verifiable Costs Submittal Process

QSE May Appeal Calculated Verifiable Costs

Start

QSE Submits Verifiable Costs

ERCOT has 15 business days to reach a decision or request additional data

Does ERCOT need additional data?

YES

ERCOT notifies QSE

QSE submits additional data within 30 business days

NO

ERCOT notifies QSE of final decision and approved amounts

QSE has 5 business days to reject

QSE Rejects?

YES

Generic values will be used

NO

Approved VC amounts will take effect in 3 business days

Appeals Process?

YES

QSE Appeals decision?

NO

END

END
Verifiable Costs Submittal Process

Verifiable Costs Approval

Start

QSE Submits Verifiable Costs

ERCOT has 15 business days to reach a decision or request additional data

Does ERCOT need additional data?

YES

ERCOT notifies QSE

QSE submits additional data within 30 business days

ERCOT reviews additional documentation and has 10 business days to reach a decision or request further documentation

NO

ERCOT notifies QSE of final decision and approved amounts

QSE has 5 business days to reject

QSE Rejects?

YES

Generic values will be used

NO

Approved VC amounts will take effect in 3 business days

END

Appeals Process

YES

QSE Appeals decision?

NO

END
Rescinding Approval

• ERCOT has authority to review and reject the Verifiable Costs it previously approved if the QSE or Resource Entity is provided with sufficient notice.
• Rescinded approval will only affect future Operating Days.

See Section 11 of the Verifiable Cost Manual: Timeline for Rescinding Approval of Verifiable Costs
Other Relevant Issues
Event Specific Verifiable O&M Costs

- Currently limited to:
  - Forced Outage of a RUC-Committed Resource during startup
  - Cancellation of RUC-Committed Resource
- Can not be allocated to incremental generation:
  - Anomalous and infrequent events only
  - Submitted through Nodal Protocol dispute process

  a. Before Breaker Close

See Nodal Protocols Section 9.14: Settlement and Billing Dispute Process for details
Where Verifiable Costs are Used

Event Specific Verifiable O&M Costs

Forced Outages

Payment limited to:

- Costs that qualify as normal startup expenses, including fuel and operation and maintenance expenses, incurred before the event that caused the Forced Outage; and

- The respective QSE’s Startup Offer in the RUC.

See Nodal Protocols Section 9.14: Settlement and Billing Dispute Process for details
Event Specific Verifiable O&M Costs

RUC Cancellation

• Payment limited to:

  ✓ Normal Start Costs and fuel and operation and maintenance expenses.

See Nodal Protocols Section 9.14: Settlement and Billing Dispute Process for details
**Summary of Allowed Activities – Settlement Points**

<table>
<thead>
<tr>
<th>Settlement Points</th>
<th>3PO</th>
<th>AS Offer</th>
<th>DAM Energy Only Offers</th>
<th>DAM Energy Bid</th>
<th>CRR Offers and Bids</th>
<th>QSE to QSE Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Node</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCU Resource Node</td>
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<td>PUN Resource Node</td>
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<tr>
<td>CCP Logical Resource Node</td>
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</tbody>
</table>

**Note that Resource Specific offers (3PO and AS offers) are made for the Resource and the submittal does NOT specify a Resource Node but will be settled with the above designated SPP.**
Pending Protocol Changes

- NPRR 700 – Utilizing Actual Fuel Costs in Startup Offer Caps
  ✓ Sets actual costs for determining Offer Caps

- NPRR 714 – Real-Time Make-Whole Payment for Exceptional Fuel Cost
  ✓ Allows for Recovery of exceptional fuel costs

- NPRR 732 – Adjustments to Verifiable Costs for Required Resubmissions and Clarification of RUC Forced Outage and Cancellation Procedures
  ✓ Sets Resource cost to generic if adjustments are not filed timely (30d)
How are Verifiable Cost Rules Revised?
Verifiable Cost rules exist in:

- ERCOT Protocols
- Verifiable Cost Manual
- Verifiable Cost Template
Revisions to the ERCOT Protocols are posted to the ERCOT website and effective on the 1st of the month after ERCOT Board approval, unless otherwise directed.
Revisions to the Verifiable Cost Manual

Revisions to the ERCOT Protocols are posted to the ERCOT website and effective on the 1st of the month after TAC/ERCOT Board approval, unless otherwise directed.
Any Questions?