Cost Offer Development

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Why do we have cost-based offers?

• Market Power Mitigation
  – Structural market power is the ability of seller, or a group of sellers, to alter the market price of a good or service for a sustained period.
  – To mitigate the potential exercise of market power, market rules can offer cap units in various markets.
  – The Three Pivotal Supplier (TPS) test is used to determine if structural market power exists in a given market.
    • If structural market power is found to exist, some Market Sellers may be mitigated to cost-based offers to prevent any exercise of that market power.
Components of a Cost Offer

- Start-Up $/Start
- No Load $/Hr
- Incremental Energy $/MWh
Total Fuel Related Costs = Fuel Costs + SO\textsubscript{2} Allowance Cost + CO\textsubscript{2} Allowance Cost + NO\textsubscript{x} Allowance Cost + Maintenance Adder + Operating Costs
• Basic Fuel Cost – The cost of commodity calculated as stated in the Market Sellers’ Fuel Cost Policy (excluding fixed lease expenses)
• Fuel costs are a function of commodity cost, heat input, and performance factor
• Fuel costs are included in the calculations of start-up, no load, and the incremental energy offers
• Separate cost offers for each available fuel type must be created
Heat Input vs Heat Rates

• **Heat Input** equals a point on the heat input curve (MMbtu/hr) describing the resource’s operational characteristics for converting the applicable fuel input (MMBtu) into energy (MWh).
  – Typically obtained via plant performance testing or from the original equipment manufacturer
  – Also referred to as the input-output function

• **Heat Rate** equals the MMBtu content of the heat input divided by the MWh of power output.
  – Typically a measure of efficiency

• **Incremental heat rate** is the relationship between an additional MW of output and the heat input necessary to produce it.
  – Typically used to create incremental energy offers
  – Slope of the input/output curve (Heat Input curve)
Heat Input Example

Heat Input:
\[ y = Ax^2 + Bx + C \]
\[ y = 0.001564x^2 + 9.6894x + 306.744 \]

Incremental Heat Rate:
\[ y = 2Ax + B \]
\[ y = 0.003128x + 9.6894 \]

Heat Rate:
\[ y = \frac{\text{Heat Input}}{MW} \]

- Heat Input equation incorporates no load in the curve (Point “C”)
- Inc. HR does not capture no load and must be accounted for separately
- Heat Rate is a measure of efficiency
COA module in MIRA

• User to enter into MIRA:
  – a heat input curve by supplying a set of input and output data points
  – Or, the user can supply the coefficients to a polynomial that defines the incr. heat rate curve
• Market Seller is responsible for keeping up to date
• Updated as stated in Fuel Cost Policy (At least annually)

*Note: Cost offers >$1,000 are screened using most current COA data
• Performance Factor is the calculated ratio of actual fuel burn to either theoretical fuel burn (design heat input) or other current tested heat input

\[
\text{Performance Factor} = \frac{\text{Total Actual Fuel Consumed}}{\text{Total Theoretical Fuel Consumed}}
\]

• Factors may change actual fuel consumed such as
  – Unit age or modification
  – Changes in fuel properties
  – Seasonal ambient conditions
• Annual update required by Fuel Cost Policy entered into COA

*Note: Cost offers >$1,000 are screened using most current COA data
• Fuel Cost Policy contains the methodology of determining the cost of SO$_2$/CO$_2$/NO$_x$ EAs
• Market Participants are to submit Emissions via COA to PJM and MMU Annually for PJM review and approve
  – Expires December 31 of each year
• Must be approved by PJM before it may be used

*Note: Dual fuel units should use different EA factors based on the SO$_2$/CO$_2$/NO$_x$ emitted for each particular fuel or fuel mix
A VOM Template is submitted by the Market Participant via SharePoint to PJM and MMU Annually for PJM review and approve
- Separate process from Fuel Cost Policy Review
- Expires December 31 of each year

PJM’s VOM Template includes separate sheets for operating costs and maintenance costs

Must be approved by PJM before used in cost-based offers
• Maintenance Adders may be specified as:
  – $/Start, $/Hour, $/MMBtu, or $/MWh

• VOM value used in cost offers cannot exceed approved value

<table>
<thead>
<tr>
<th>Offer</th>
<th>$/MMBtu</th>
<th>$/Hr</th>
<th>$/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Cost</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No Load Cost</td>
<td>Yes</td>
<td>Yes; either No load OR Incremental</td>
<td>No</td>
</tr>
<tr>
<td>Incremental Energy</td>
<td>Yes</td>
<td>Yes; either No load OR Incremental</td>
<td>Yes</td>
</tr>
</tbody>
</table>
• Maintenance Tab
• 10/20 year history
  • Previous years escalated based on the Handy-Whitman index
• Immature units:
  • Units with neither 10 years history or 50,000 operating hours
  • To only include # of operating years < 10 (Section 1.8 request)
Operating Costs Template Example

- Operating Costs Tab
- 1-5 year history
  - For units using >1 year of history, the previous years are escalated using the Handy-Whitman index

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual $</th>
<th>Annual MWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>781</td>
<td>1,000</td>
</tr>
<tr>
<td>2019</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Operating Cost History</th>
<th>Operating History</th>
<th>Year Index Escalation Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>760</td>
<td>1.038</td>
<td>2019</td>
</tr>
<tr>
<td>2018</td>
<td>745</td>
<td>1.048</td>
<td>2018</td>
</tr>
<tr>
<td>2017</td>
<td>711</td>
<td>1.098</td>
<td>2017</td>
</tr>
<tr>
<td>2016</td>
<td>714</td>
<td>1.094</td>
<td>2016</td>
</tr>
<tr>
<td>2015</td>
<td>701</td>
<td>1.119</td>
<td>2015</td>
</tr>
</tbody>
</table>

Total Historical Operating Cost: $0.00
Total Annual MWH: -
Per Unit Operating Cost: #DIV/0! /MWh

2020 Market Seller Requested Operating Cost Adder

Operating Cost Adder: #DIV/0! /MWh
Operating Costs include but are not limited to:

- Water
- Chemicals
- Consumables
- Transportation
- Non-Fuel Pipeline Charges
Components of Cost Offers

• Start-up Costs
  – the unit costs to bring the boiler, turbine and generator from shutdown conditions to the point after breaker closure
  – determined based on the cost of start fuel, total fuel-related cost, performance factor, electrical costs (station service), start maintenance adder, and additional labor cost if required above normal station manning
  – can vary and be categorized in three unit temperature conditions: hot, intermediate, and cold
  – incurred once each time the unit operates regardless of the period of operation
Start-up cost ($/Start) = [Start Fuel (MMBtu/Start) * TFRC ($/MMBtu) * Performance Factor] 

+ [Station Service (MWh) * Station Service Rate ($/MWh)]

+ Start Maintenance Adder ($/Start) + Start Additional Labor Cost ($/Start)
• Start Fuel - Fuel consumed from first fire of start process (initial reactor criticality for nuclear units) to breaker closing (including auxiliary boiler fuel) plus fuel expended from breaker opening of the previous shutdown to initialization of the (hot) unit start-up, excluding normal plant heating/auxiliary equipment fuel requirements.

• Station Service Rate - A $/MWh value based on the 12-month rolling average off-peak energy prices updated quarterly by the Office of the Interconnection.

• Start Additional Labor Cost – Additional labor costs for startup required above normal station manning levels.
Components of Cost Offers

- **No Load Fuel**
  - (MMBtu/hour) is the total fuel to sustain zero net output MW at synchronous generator speed
- **No Load Cost**
  - ($/hour) – The hourly cost required to create the starting point of a monotonically increasing incremental offer curve for a generating unit.
    - Can be calculated using No Load fuel
    - The calculated No Load Cost may have to be adjusted to ensure that the slope of the Generator Offer Curve is monotonically increasing.
A regression analysis was performed on the data collected to obtain the unit’s Heat Input curve as a function of unit’s output with oil as a fuel:

\[
\text{Heat Input (MMBtu/HR)} = 0.00156391 \times MW^2 + 9.6894 \times MW + 306.744
\]

Then at zero output is No load Fuel = 306.744 MMBtu/hr

The initial estimate of a unit’s No Load Cost ($/Hr) is:

\[
\text{No Load Cost ($/Hr)} = (\text{No Load Fuel} \times \text{PF} \times \text{TFRC}) = 306.744 \text{MMBtu/hr} \times 1.02 \times 14.00/\text{MMBtu} = $4,380/hr
\]

The unit’s Cost Curve must be developed to determine if adjustments are needed for the unit’s No-Load Cost.

Total Operating Cost is calculated by:

\[
\text{Total Operating Cost ($/hr)} = \text{Heat Input} \times \text{PF} \times (\text{TFRC} + \text{VOM})
\]

The unit’s Incremental Cost ($/MWh) at various outputs can be determined by the following equation:

\[
\text{Incremental Cost ($/MWh)} = \frac{\text{Total Operating Cost MW2} – \text{Total Operating Cost MW1}}{MW2 – MW1}
\]

When calculating the first increment, MW1 is zero and the Total Operating Cost MW1 is the No-Load Cost. Since the Incremental Costs are monotonically increasing, no adjustment to the No-Load Cost is required.

\[
\text{Incremental Cost} = \frac{11,476 – 4,380}{50 – 0} = $141.91/MWh
\]
No Load Example – Steam Unit

- The unit’s Incremental Cost ($/MWh) at various output levels can also be determined by using the incremental heat rate curve

\[
\text{Incremental Cost} \left( \frac{\$}{\text{MWh}} \right) = (2 \times 0.00156391 \times \text{MW} + 9.6894) \times \text{PF} \times (\text{TFRC} + \text{VOM})
\]

- The No Load Cost is calculated by subtracting the incremental cost at the unit’s economic minimum point from the total cost (from the heat input at economic minimum value) at the unit’s economic minimum point.

\[
\text{No Load Cost} \left( \frac{\$}{\text{Hr}} \right) = \left( \text{Eco Min Heat Input} \times \text{PF} \times (\text{TFRC} + \text{VOM}) \right) - \left( \text{Eco Min Incr. Cost} \times \text{Eco Min MW} \right)
\]

\[
= \left( 795.12 \times \frac{\text{MMBtu}}{\text{Hr}} \times 1.02 \times \left( \frac{\$14}{\text{MMBtu}} + \frac{0.015}{\text{MMBtu}} \right) \right) - \left( \frac{\$142.10}{\text{MWh}} \times 50 \text{ MW} \right) = 4,370.97/\text{Hr}
\]

- Differences in the calculated No Load Cost between the two methods are due to the differences in using a block average cost offer method versus a sloped derivative cost offer.
- When using the incremental heat rate method, user must select “Use Bid Slope” when entering cost information into Markets Gateway.
Slope Curve vs. Block Schedule

- **Slope Offer Curve**
  - "Use Bid Slope" in Markets Gateway
  - Must select in Day-Ahead offer
  - No 0 MW point defined
  - The first point describing the Economic Minimum Limit of the unit is extended to Y-axis

- **Block Offer**
  - Step function

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• Incremental energy cost
  – ($/MWH) the cost per MWh to produce all of the energy segments above the Economic Minimum level
  – Calculated by summing the cost of each segment of energy in the unit’s incremental cost curve up to the generation level
  – No-Load Costs are not included in the incremental costs
  – Must be monotonically increasing
**Total Production Cost**
Start-Up Cost + Run Hours * Operating Cost
- Represents the cost of starting a unit & operating it over a period of time

**Operating Cost**
No Load Offer + Incremental Offer Curve
- Represents the hourly production cost

**Incremental Cost**
Incremental Offer Curve
- Represents the cost to generate the next MW
Specific details for unit types can be found in the following sections:

- Section 3 – Nuclear
- Section 4 – Fossil/Steam
- Section 5 – Combined Cycle (CC)
- Section 6 – Combustion Turbine (CT) and Diesel
- Section 7 – Hydro
- Section 9 – Wind Units
- Section 10 – Solar Units
- Section 11 – Energy Storage Units
- Attachment B: No Load Calculation Examples by Technology
Section 1.8

• Cost Methodology and Approval Process
  – A Market Seller which seeks to obtain an exemption, exception or change to any time frame, process, methodology, calculation or policy set forth in this Manual, or the approval of any cost or methodology that is not specifically permitted by this Manual not related to the Fuel Cost Policy, shall submit a request to PJM and MMU for consideration and determination along with documentation supporting the request.
  – After receipt of such a request, PJM and MMU will review the request and PJM will notify the Market Seller and MMU whether the request is approved no later than thirty (30) calendar days after submission of the request.
• VOM Template:

• Fuel Cost Policy Templates
  http://www.monitoringanalytics.com/tools/tools.shtml
Cost Offer Tools User Guides

- Markets Gateway User Guide
  https://www.pjm.com/~/media/etools/markets-gateway/markets-gateway-user-guide.ashx

- MIRA User Guide

- COA Module User guide