Modification of Incremental Heat Rate Calculation

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**Cost-based DEB Calculation**

- Generator provides the average heat rates (AHR) in BTU/KWh.
- CAISO calculates DEB using monotonically incremental heat rate (MIHR) between various operating points
  - \((\text{MIHR} \times \text{fuel price}) + \text{O&M}\)
- True incremental heat rates (IHR) for segments between operating points are not always monotonically increasing.
- Current method adjusts IHR segments (if necessary) to get monotonic incremental heat rate (MIHR)
  - e.g. \(\text{MIHR}_2 = \max(\text{MIHR}_1, \text{IHR}_2)\)
Normal Incremental Heat Rate Curve

Generator 1 / GAS Combined Cycle

Heat Rate (BTU/KWh)

Average Heat Rate
Actual Incremental
Current Incremental

MW Output Level
Issue of Extremely High Incremental Heat Rate

- Spikes in IHR combined with monotonic adjustment can cause DEB to significantly exceed a unit’s actual marginal cost
Anomalous Incremental Heat Rate

Generator 2 / GAS Turbine

Heat Rate (BTU/KWh)

MW Output Level

- Average Heat Rate
- Actual Incremental
- Current Incremental
Potential Modification Options

- Option 1: Cap at Gen Technology-based Cap
- Option 2: Cap at Average Heat Rate
- Option 3: Segment Replacement
Option 1: Cap at Gen Technology-based CAP

- **Generator Technology-based CAPs**
  - Combined Cycle 12,600 BTU/kWh
  - Gas Turbine 17,000 BTU/kWh
  - Steam Turbine 10,600 BTU/kWh

- **CAP is not applied to segments >= 80% of Pmax.**

- **Steps**
  1. Calculate the actual incremental heat rate
  2. Apply the CAP to each incremental heat rate segment.
  3. Use the same left-to-right adjustment to ensure monotonicity (increasing).
Option 1. Tech-based CAP Example

Generator 2 / GAS Turbine

![Diagram showing heat rate vs. MW output level for Generator 2/GAS Turbine, with lines and markers representing average heat rate, actual incremental, current incremental, and Option 1 technology CAP.]
Option 2: Cap at Average Heat Rate

- Use the Average Heat Rates at various operating levels submitted by generators as the CAP.

- CAP is not applied to segments $\geq 80\%$ of $P_{\text{max}}$.
- CAP = Average HR at lower operating level of each segment.

**Steps**

1. Calculate the actual incremental heat rate
2. Apply the CAP to each incremental heat rate segment.
3. Use the same left-to-right adjustment to ensure monotonicity (increasing).
Option 2: Cap at Average Heat Rate Example

Generator 2 / GAS Turbine

- **Average Heat Rate**
- **Actual Incremental**
- **Current Incremental**
- **Option2 - CAP at Average**

Heat Rate (BTU/KWh) vs. MW Output Level
Option 3: Segment Replacement

- Identify an anomalous or spike segment and replace it with the previous or next segment

- Replacement rule is not applied to segments >= 80% of Pmax.

- Steps
  1. Calculate the actual incremental heat rate
  2. Identify an anomalous or spike segment
     - Anomalous: greater than technology-based CAP
     - Spike: the right segment is lower than the current one
  3. Segment Replacement
     - Replace the current anomalous segment with the one immediately to the right. Note the segment to the right is subject to the same criteria in Step#2.
     - Otherwise, replace the current segment with the one to the left.
  4. Use the same left-to-right adjustment to ensure monotonicity (increasing).
Option 3: Segment Replacement Example

Generator 3 / GAS Turbine

- Heat Rate (BTU/KWh)
- MW Output Level

Legend:
- Blue squares: Average Heat Rate
- Pink squares: Actual Incremental
- Red crosses: Current Incremental
- Yellow squares: Option3- Segment Replacement
Aggregation Incremental Heat Rate – CC Units

Aggregate Incremental Heat Rate_Combined Cycle Units

- Actual Incremental
- Current Incremental

Cumulative MW %

Incremental Heat Rate

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

0 5000 10000 15000 20000 25000 30000
Aggregation Incremental Heat Rate – CC Units (Option 1)

Aggregate Incremental Heat Rate_Combined Cycle Units

- Actual Incremental
- Current Incremental
- Option 1: Technology CAP

Cumulative MW %

Incremental Heat Rate
Aggregation Incremental Heat Rate – CC Units (Option 2)
Aggregation Incremental Heat Rate – CC Units (Option 3)

![Chart showing incremental heat rate comparison for combined cycle units with lines representing actual incremental, current incremental, and option 3: segment replacement.](chart.png)
Aggregation Incremental Heat Rate – GT Units

- Actual Incremental
- Current Incremental
- Option 1: Technology CAP
- Option 2: CAP at Average Heat Rate
- Option 3: Segment Replacement
Aggregation Incremental Heat Rate – ST Units

![Chart showing incremental heat rate for steam turbine units with different options.](chart)

- **Actual Incremental**
- **Current Incremental**
- **Option 1: Technology CAP**
- **Option 2: CAP at Average Heat Rate**
- **Option 3: Segment Replacement**
Initial DMM Recommendation

- **Option 2, Cap Incremental Heat Rate at Average Heat Rate**

- **Criteria**
  - “Fixing” unreasonably high incremental heat rates of specific units
  - Not creating any unreasonably low incremental heat rates for any specific units, and
  - Resulting in the best overall “fit” between the monotonically non-decreasing heat rates and actual incremental heat rates of all units
  - Simplicity (in comparison with Option 3)
Discussion and Next Steps

- Input from MSC
- Finalize initial white paper for comment (February)
- Stakeholder comments/discussion (March-April)
- Possible inclusion in MRTU filing (May)
Generator 1 Example - all options

Generator 1 / GAS Combined Cycle

- Average Heat Rate
- Actual Incremental
- Current Incremental
- Option1- Technology CAP
- Option2- CAP at Average
- Option3- Segment Replacement

Heat Rate (BTU/KWh)

MW Output Level
Generator 2 Example - all options

Generator 2 / GAS Turbine

- Average Heat Rate
- Actual Incremental
- Current Incremental
- Option1 - Technology CAP
- Option2 - CAP at Average
- Option3 - Segment Replacement

MW Output Level vs Heat Rate (BTU/KWh)
Generator 3 Example - all options

![Generator 3 / GAS GT](chart)

- **Heat Rate (BTU/KWh)**
  - **Average Heat Rate**
  - **Actual Incremental**
  - **Current Incremental**
  - **Option1 - Technology CAP**
  - **Option2 - CAP at Average**
  - **Option3 - Segment Replacement**

**MW Output Level**
Aggregation Incremental Heat Rate (all options)—CC Units

Aggregate Incremental Heat Rate_Combined Cycle Units

- Actual Incremental
- Current Incremental
- Option 1: Technology CAP
- Option 2: CAP at Average Heat Rate
- Option 3: Segment Replacement

Cumulative MW %

Incremental Heat Rate

0 5000 10000 15000 20000 25000 30000

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%