Modification of Incremental Heat Rate Calculation

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Market Surveillance Committee Meeting
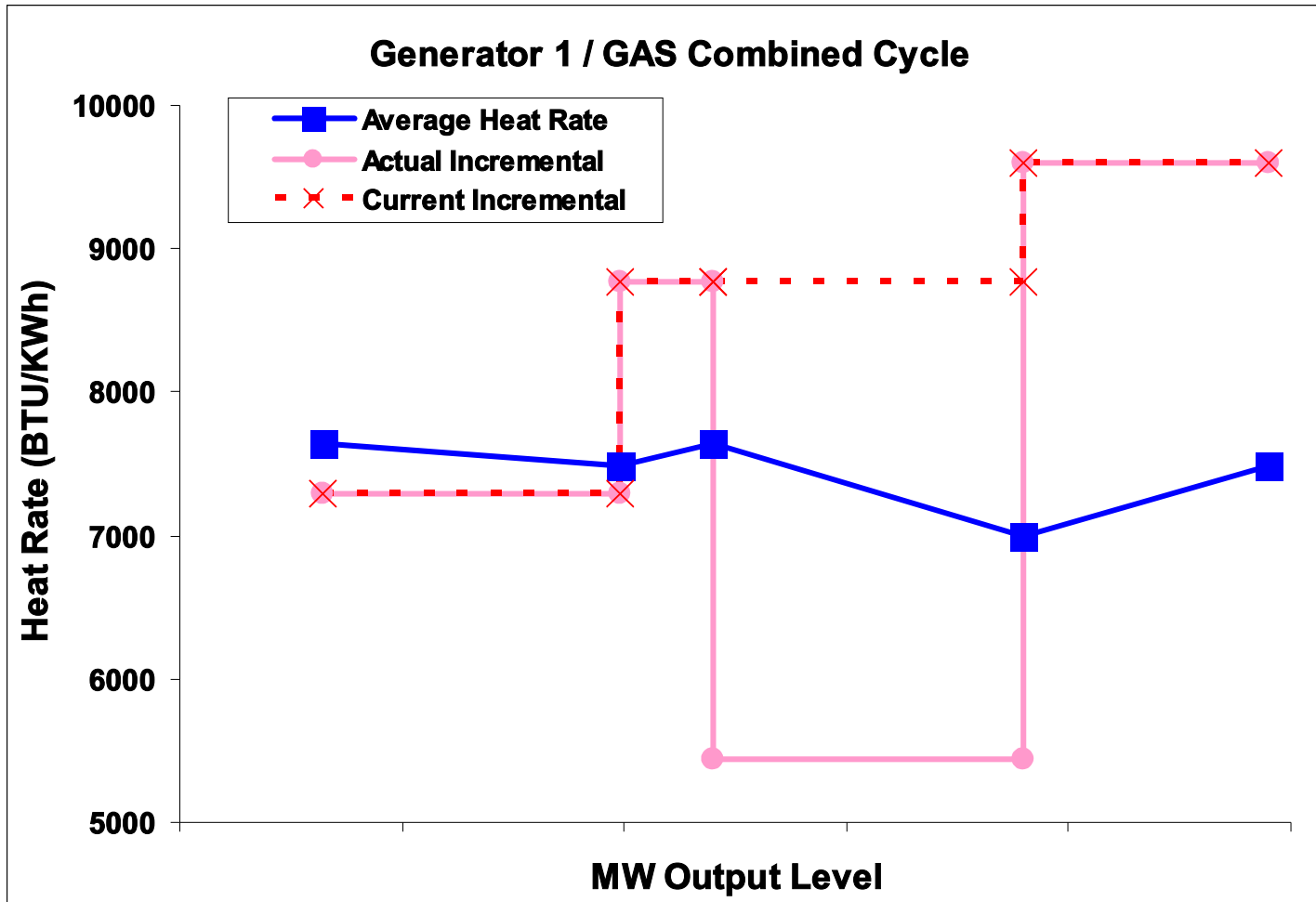## February 13, 2007

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**

  - (MIHR x fuel price) + 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. $MIHR_2 = \max(MIHR_1, IHR_2)$

Normal Incremental Heat Rate Curve

Generator 1 / GAS Combined Cycle

Legend:
- Average Heat Rate
- Actual Incremental
- Current Incremental

Y-axis: Heat Rate (BTU/KWh) — 5000, 6000, 7000, 8000, 9000, 10000
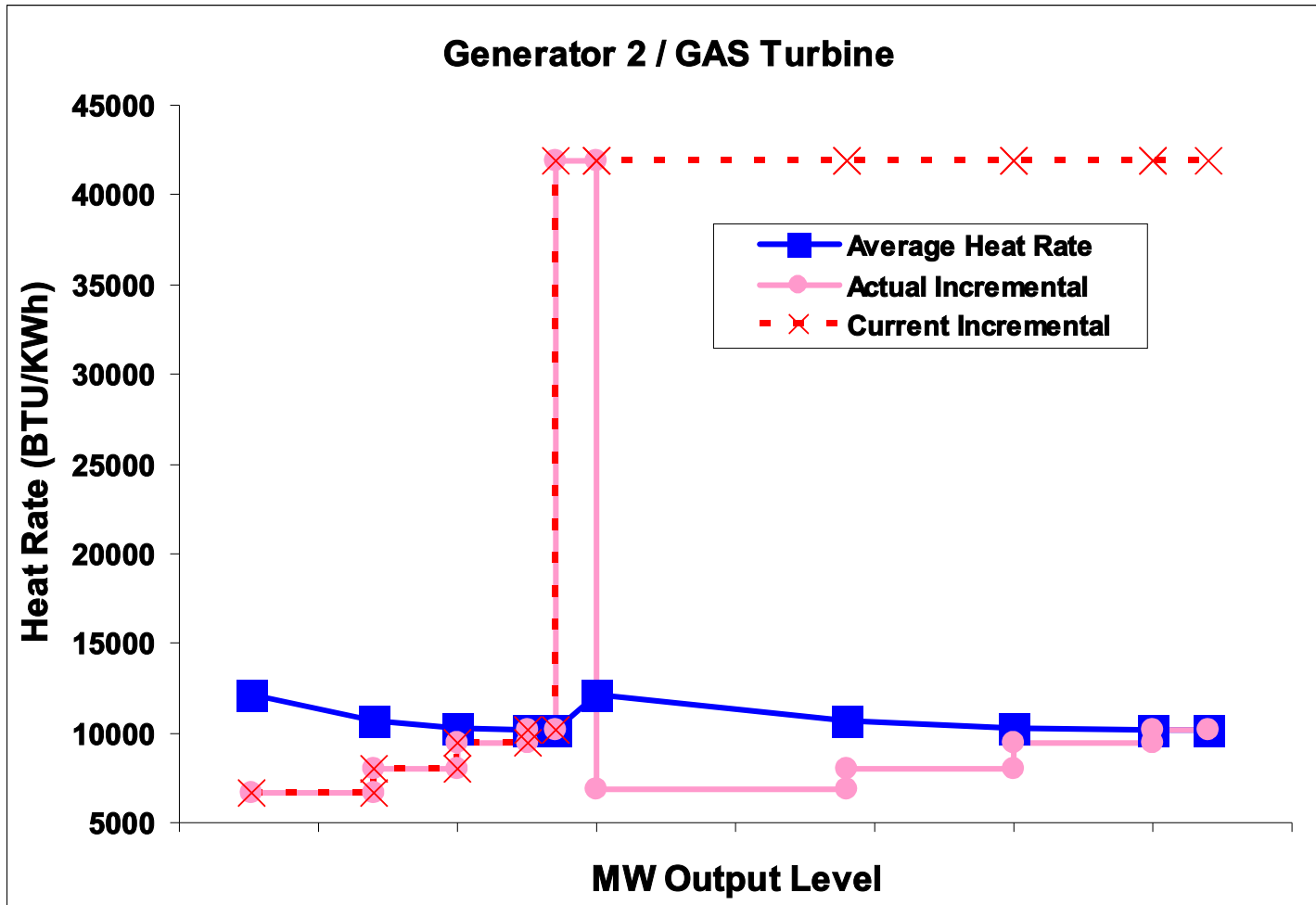
X-axis: MW Output Level

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

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).
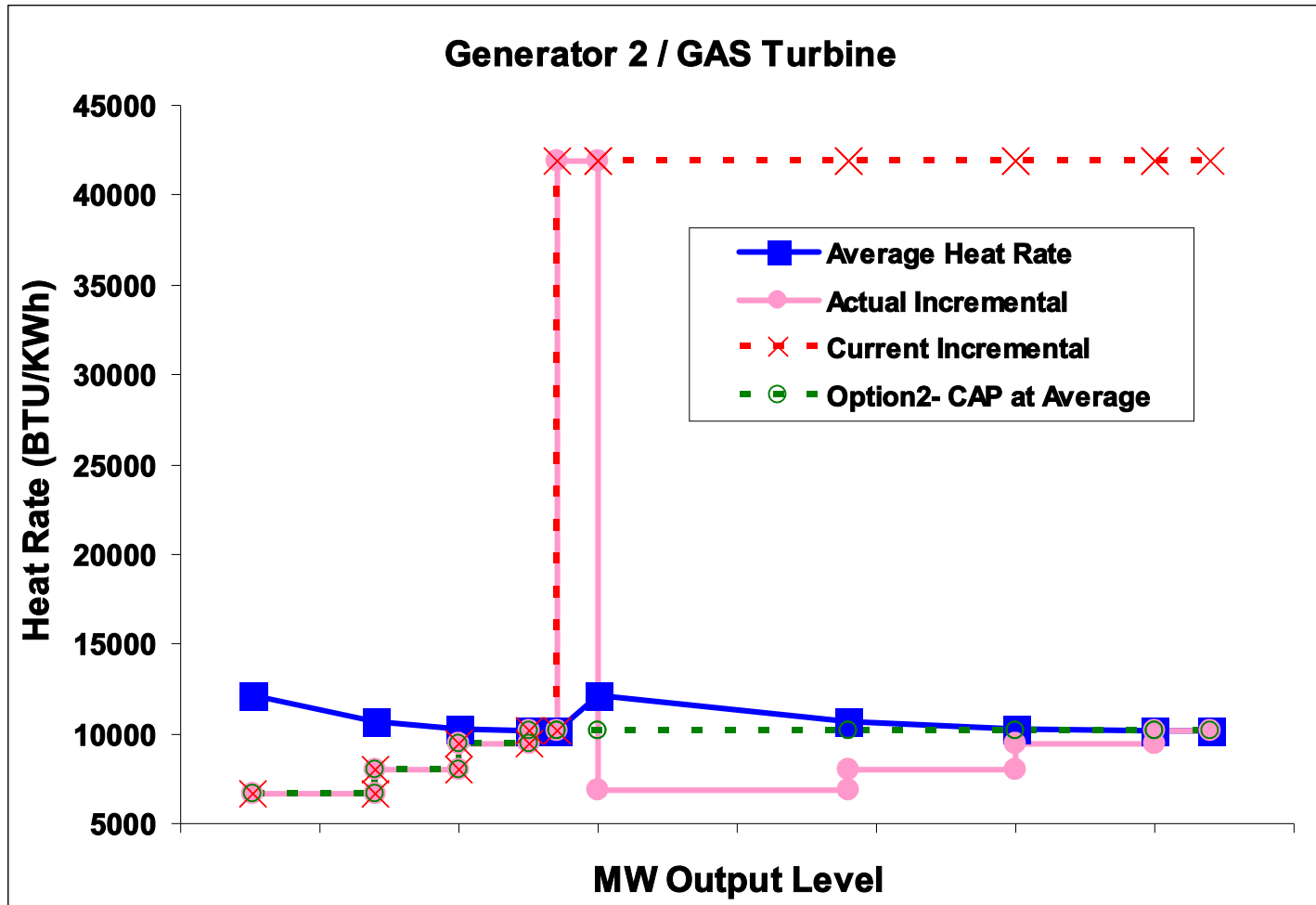
Option 1. Tech-based CAP Example
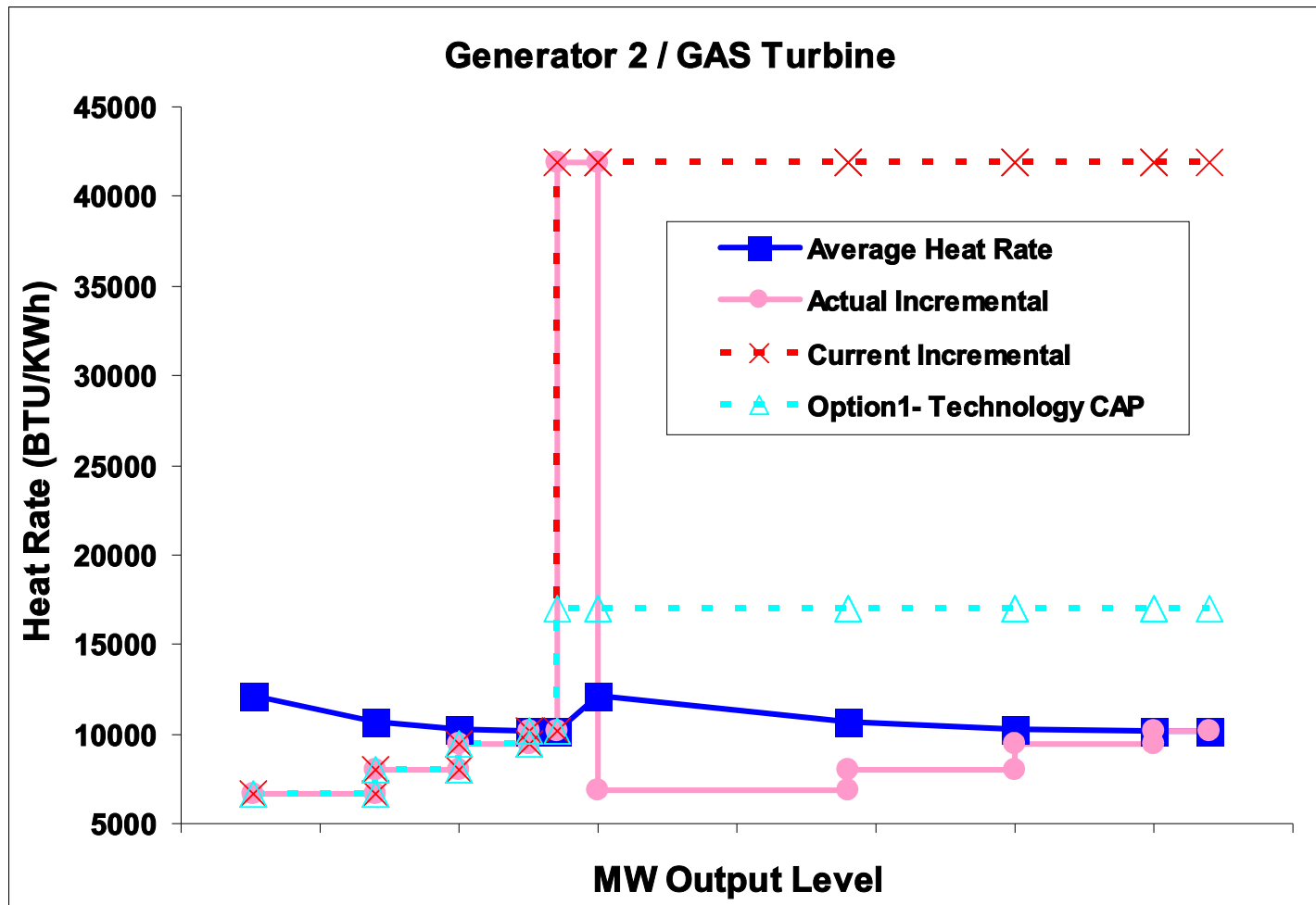
Option 2: Cap at Average Heat Rate

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

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

- 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).

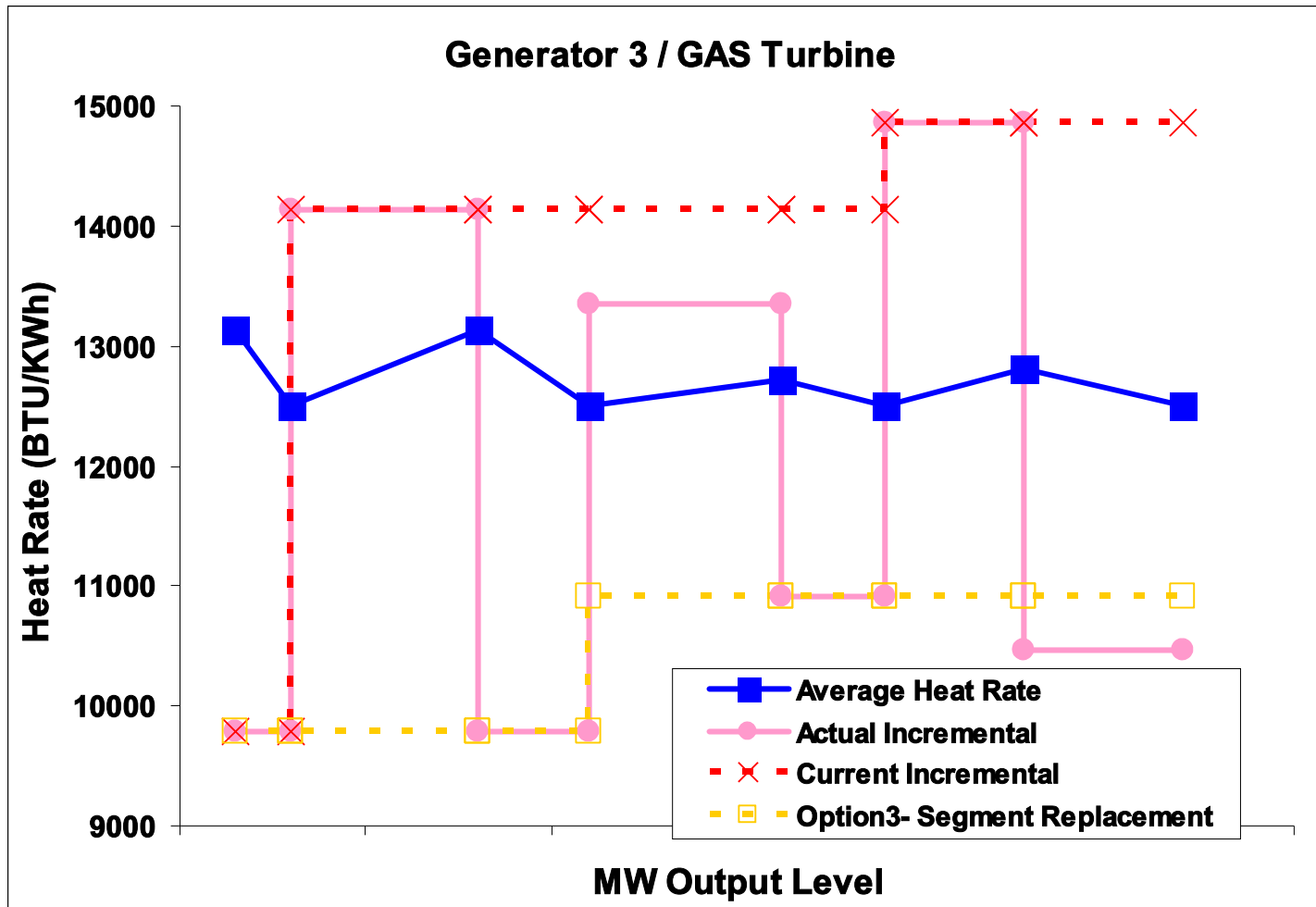# Option 2: Cap at Average Heat Rate Example

Generator 2 / GAS Turbine

Legend:
- Average Heat Rate
- Actual Incremental
- Current Incremental
- Option2- CAP at Average

Y-axis: Heat Rate (BTU/KWh)
X-axis: 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

- ■ Average Heat Rate
- ● Actual Incremental
- ✕ Current Incremental
- □ Option3- Segment Replacement

Aggregation Incremental Heat Rate – CC Units

Aggregate Incremental Heat Rate_Combined Cycle Units
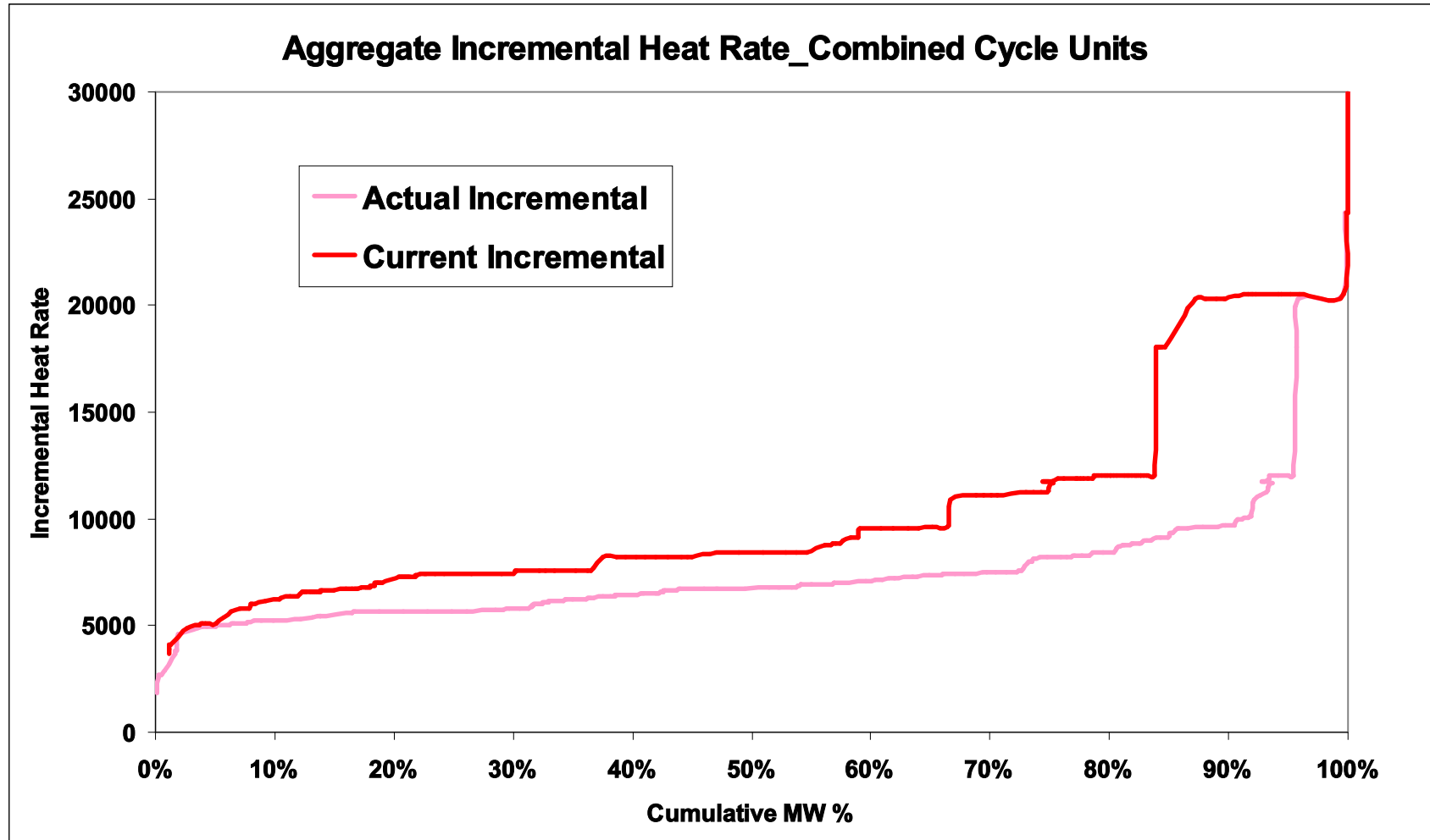
Aggregation Incremental Heat Rate – CC Units (Option 1)

Aggregate Incremental Heat Rate_Combined Cycle Units

MSC Meeting

Aggregation Incremental Heat Rate – CC Units (Option 2)

Aggregate Incremental Heat Rate_Combined Cycle Units

Legend:
- Actual Incremental
- Current Incremental
- Option 2: CAP at Average Heat Rate

Y-axis: Incremental Heat Rate (0 to 30000)
X-axis: Cumulative MW % (0% to 100%)

California Independent
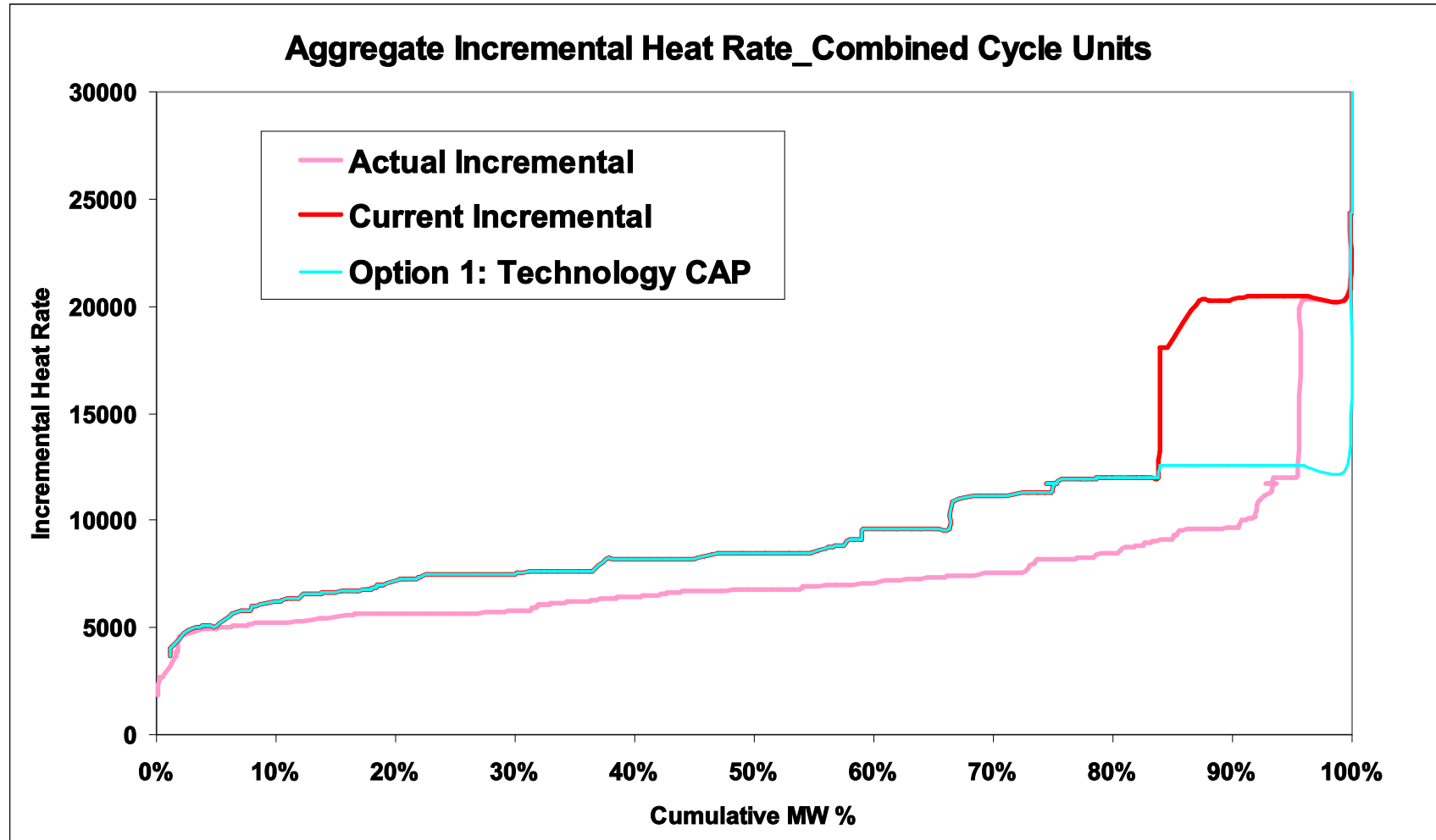System Operator Corporation

California ISO
Your Link to Power
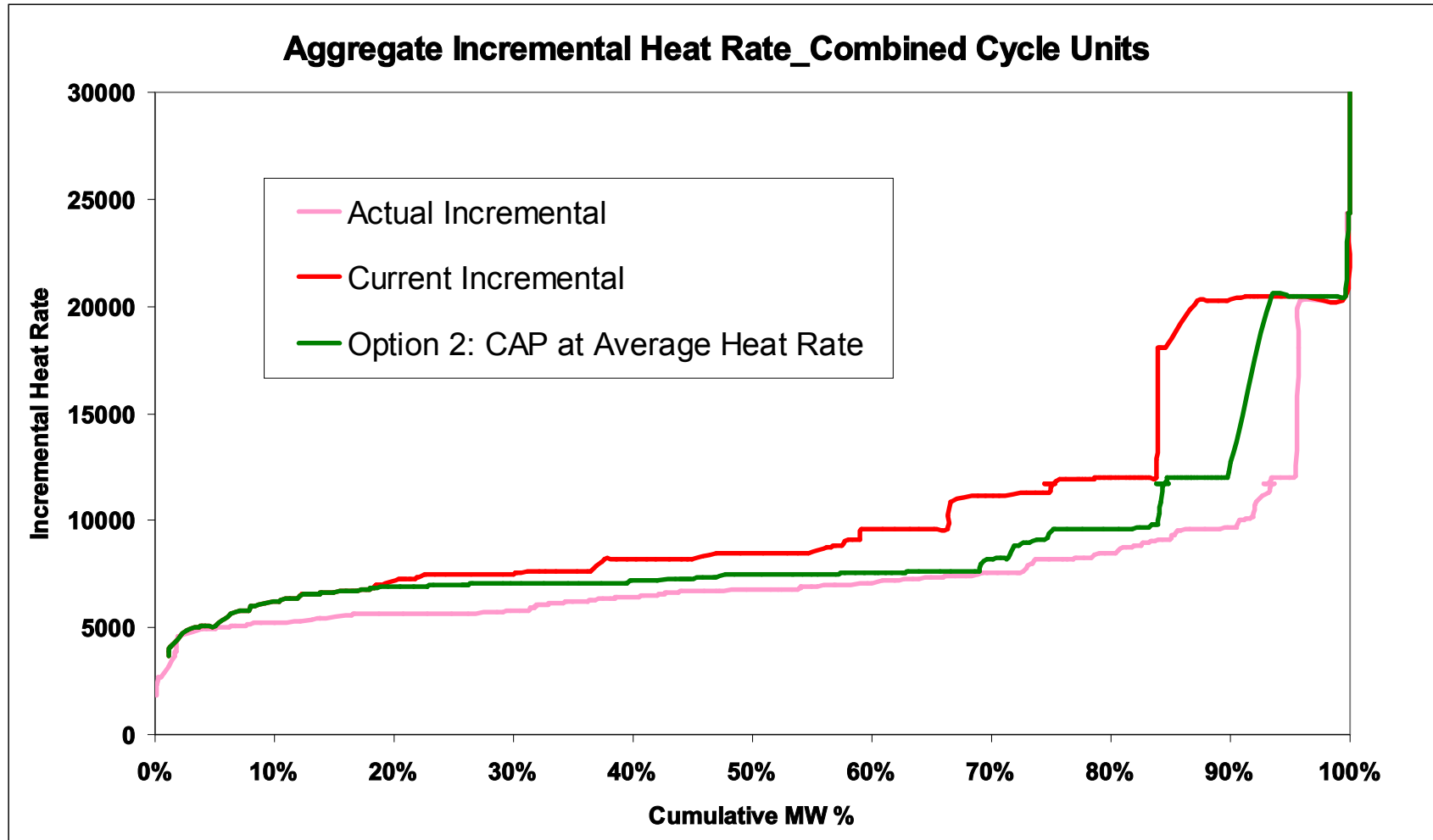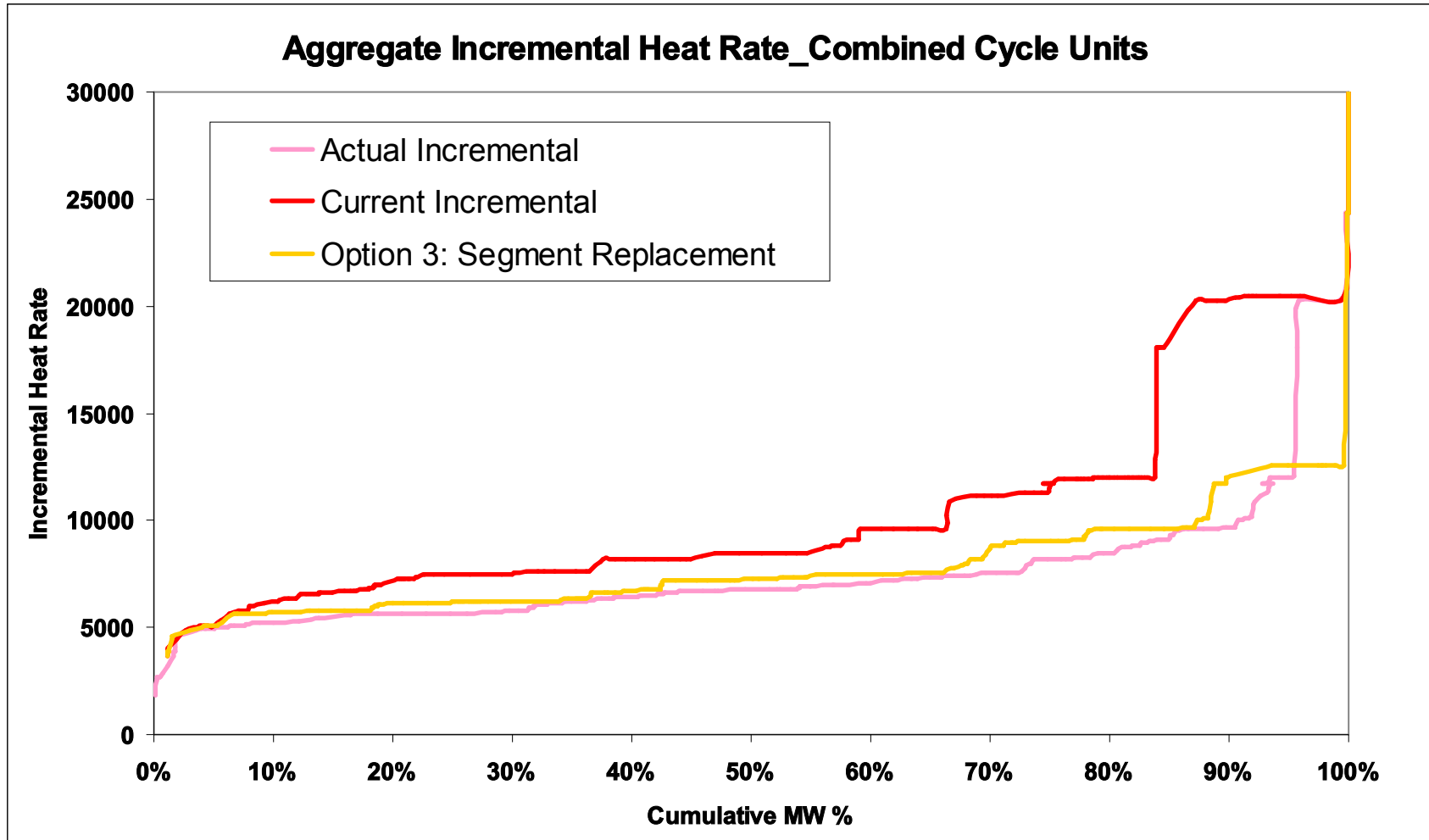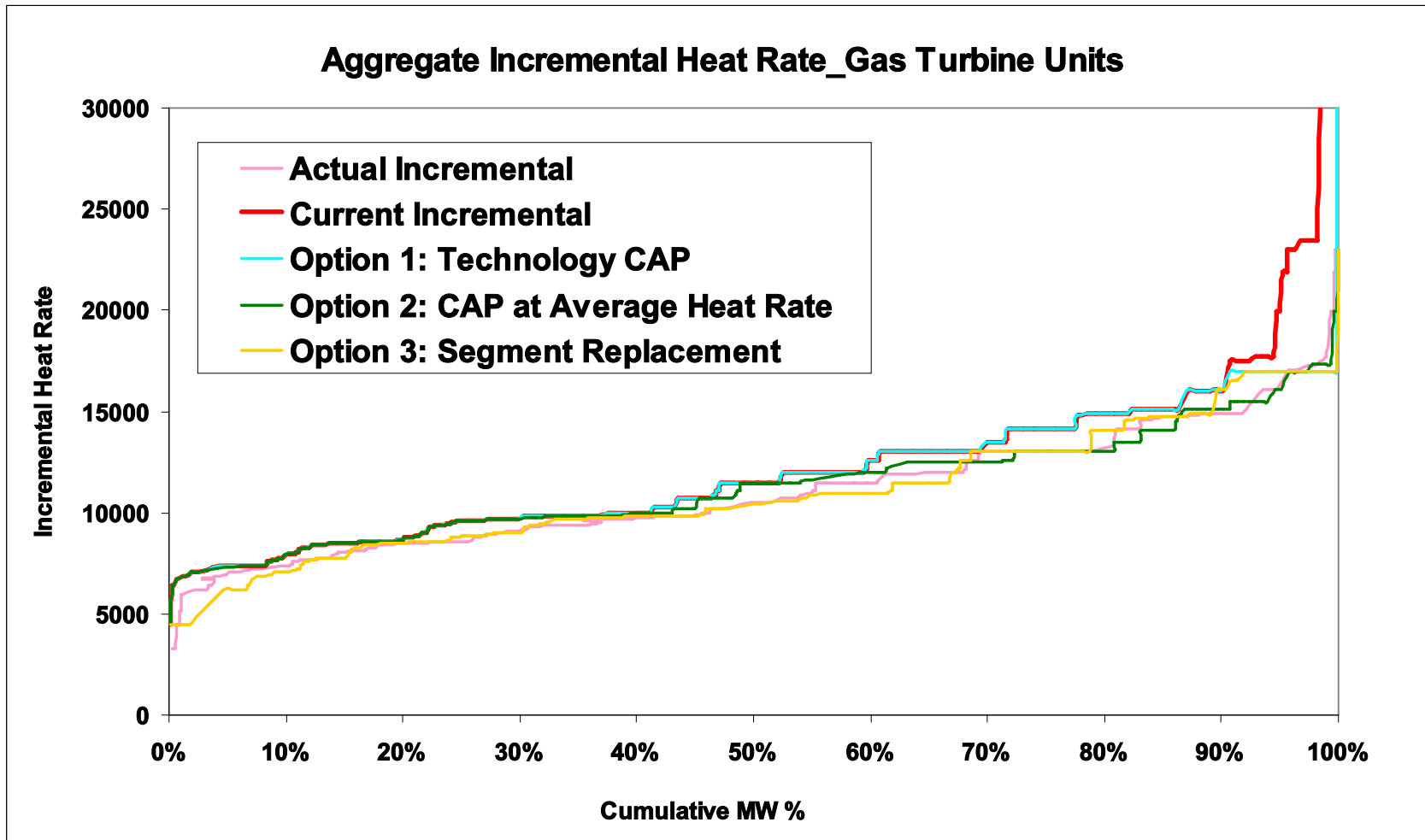
Aggregation Incremental Heat Rate – CC Units (Option 3)

Aggregation Incremental Heat Rate – GT Units

Aggregate Incremental Heat Rate_Gas Turbine Units

Legend:
- 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

Aggregate Incremental Heat Rate_Steam Turbine Units

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

Y-axis: Incremental Heat Rate (6000 to 15000)
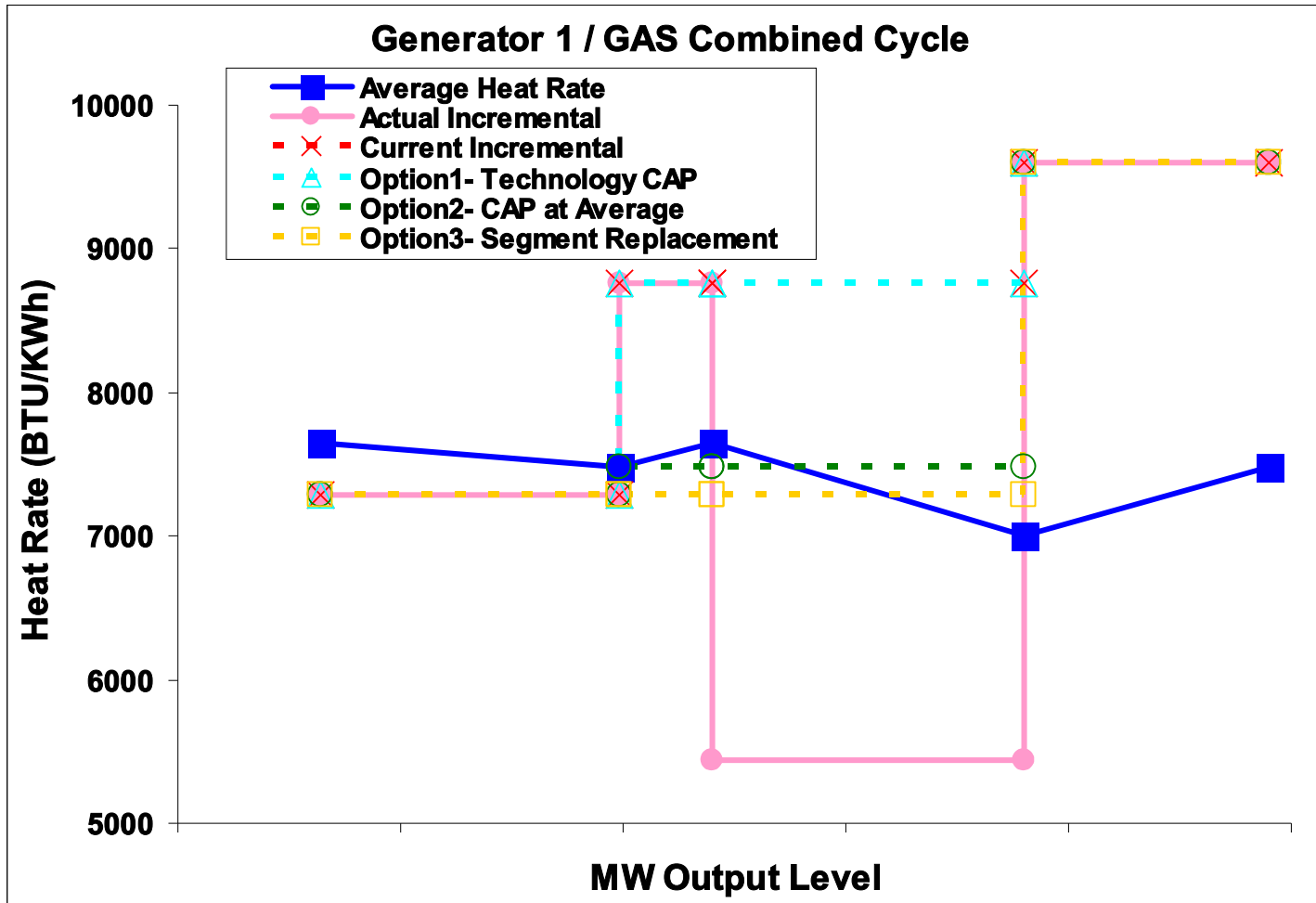X-axis: Cumulative MW % (0% to 100%)

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
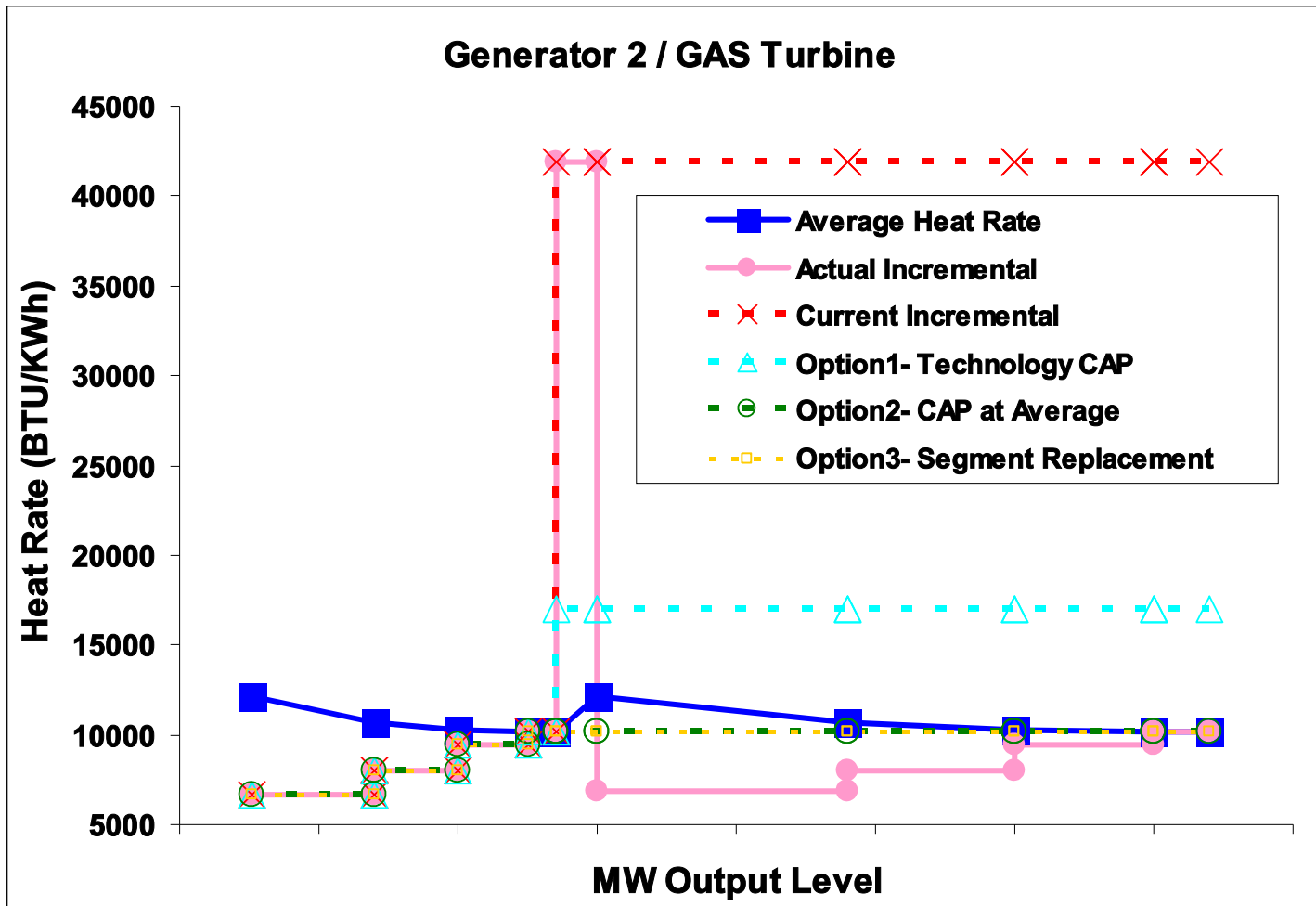
  - Simplicity (in comparison with Option 3)

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

California Independent System Operator Corporation

Generator 1 / GAS Combined Cycle

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

Y-axis: Heat Rate (BTU/KWh) — 5000, 6000, 7000, 8000, 9000, 10000

X-axis: MW Output Level

Generator 2 Example - all options

Generator 2 / GAS Turbine

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

Y-axis: Heat Rate (BTU/KWh)
X-axis: MW Output Level
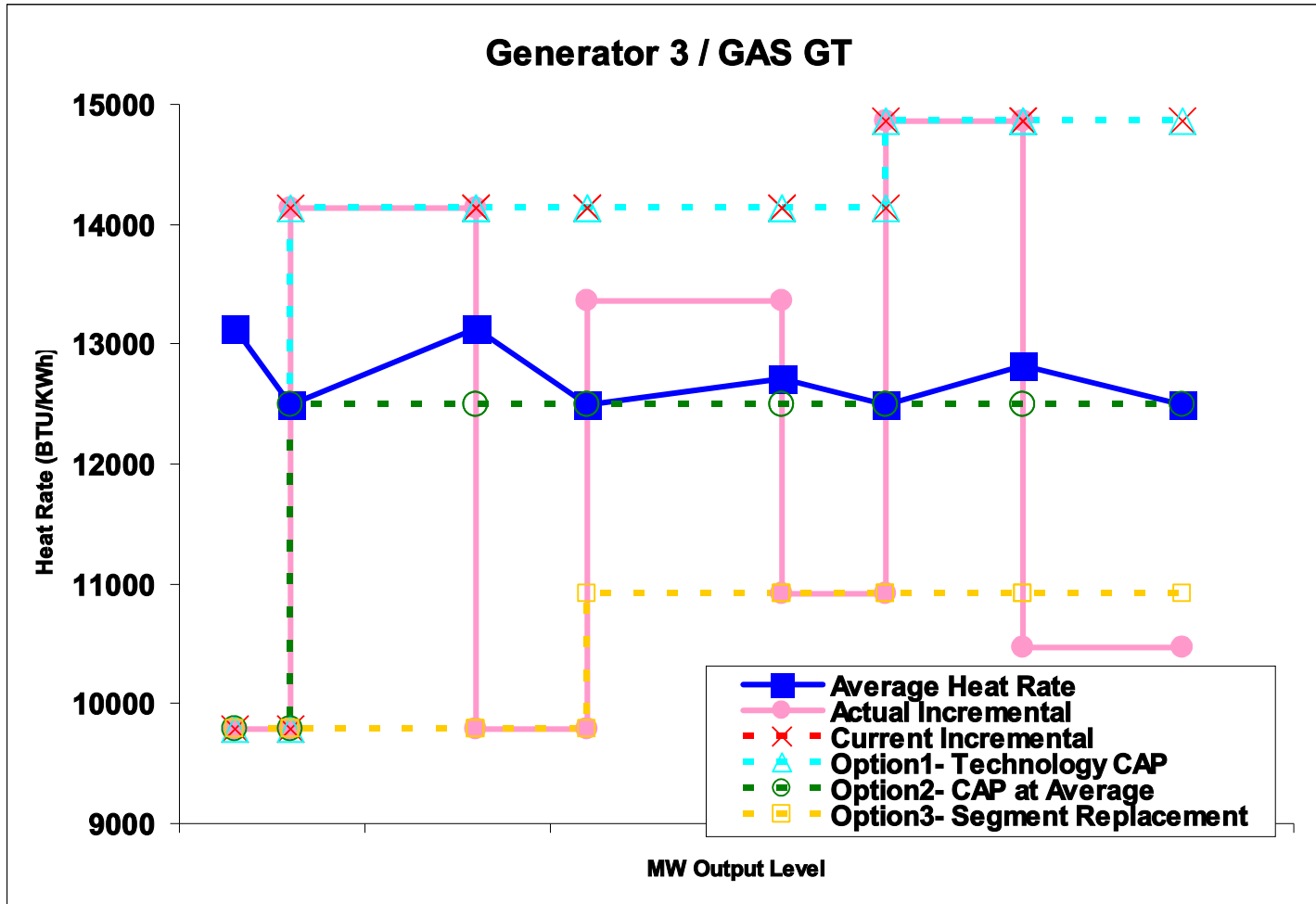
Generator 3 Example - all options

Aggregation Incremental Heat Rate (all options)– CC Units

Aggregate Incremental Heat Rate_Combined Cycle Units