Comparison of Average and Incremental Heat Rates from CRA and NREL

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For the GE MAPS model, CRA has released their methodology for modeling the heat rates of power plants at partial load. They multiply the full-load heat rate (FLHR) by an input ratio for different levels of partial load. For three of the main fossil technologies these are shown below.

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| --- | --- | --- | --- |
| **CRA Partial Load Heat Rate Fractions** |  |  |  |
| **Large Coal** | **Gas Combined Cycle (CC)** | **Gas Combustion Turbine (CT)** |
| **Load** | **Incremental HR** | **Load** | **Incremental HR** | **Load** | **Incremental HR** |
| 0-30% | 110% | 0%-50% | 113% | 0%-100% | 100% |
| 30%-50% | 93% | 50%-67% | 75% |  |  |
| 50%-75% | 95% | 67%-83% | 86% |  |  |
| 75%-100% | 100% | 83%-100% | 100% |  |  |

Separately, in Table 7 of their NEEM model documentation they publish the FLHR for a number of different technologies, three of which are shown below. Although it is not clear from the table, I believe that existing plants use the 2010 Heat Rate while future plants would use the 2015+ heat rates. From the data we can calculate the average heat rate at different load levels. We will use the 2010 heat rates to represent the fleet of existing plants.

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| --- | --- | --- | --- |
| **Table 7 - New Build Costs and Characteristics** |  |  |  |
|   | **Capital Costs** | **Performance Data** |
| **Technology** | **2015 All-in Capital Cost (2010$/kW)** | **2025 All-in Capital Cost (2010$/kW)** | **Total FOM (2010$/ kW-yr)** | **Total VOM (2010$/ MWh)** | **2010 Heat Rate - HHV (Btu/kWh)** | **2015+ Heat Rate - HHV (Btu/kWh)** |
| Advanced Coal | 2,844 | 2,743 | 29.67 | 4.25 | 9,200 | 8,800 |
| CC H-Frame | 1,021 | 985 | 14.39 | 3.43 | 7,050 | 6,430 |
| CT | 702 | 678 | 6.70 | 9.87 | 9,750 | 9,750 |

Greg Brinkman of NREL presented a set of slides at the UWIG User Group meeting on Oct. 12, 2011. Included in his analysis was a chart showing the average heat rate of plants in WECC as a function of their loading or fraction of maximum generation. We converted these lines to data points in order to calculate the incremental heat rate for each block of load.

You can see relatively close agreement between the two groups’ average heat rate curves. The main difference is that CRA uses a single flat heat rate for combustion turbines, while NREL’s data shows a declining average rate. CRA’s FLHR for CC’s is lower than the WECC average value though they are the same at 50% of capacity.



The incremental curves CTs show the NREL data at high values at low power levels and low values above 50% of capacity while the CRA incremental is constant. The CRA CCs are more efficient between 50% and 100% of capacity. Small coal plant data from CRA was also examined; their curve lies essentially on the other coal curves from CRA and NREL.



It is unclear whether the NREL values are better than the CRA values. While their CT curves show more responsiveness to load (which is in keeping with turbine behavior) their incremental CC curve approaches the efficiency of their CT at higher load levels.