

Heat Rate Presentation

Utility Advisory Board Workshop
April 24, 2018

Heat Rate

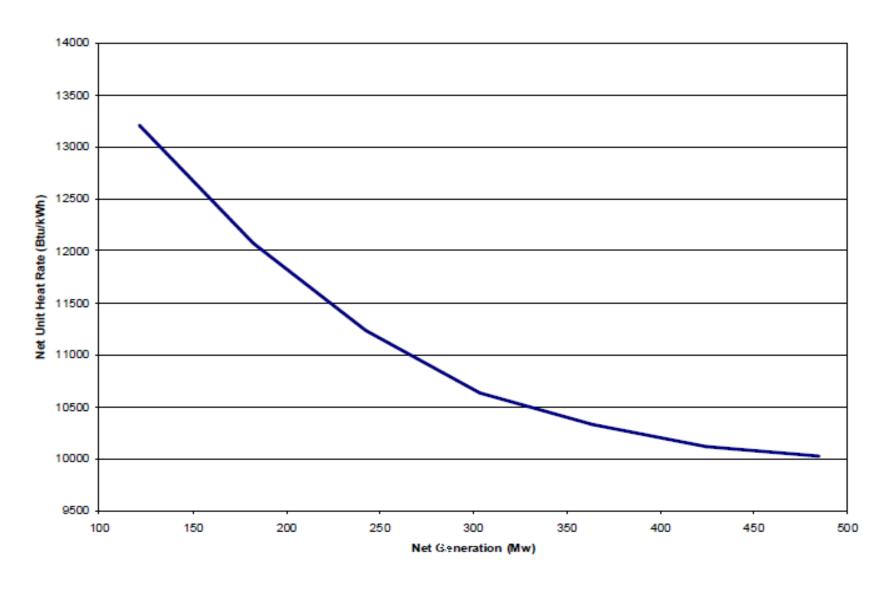
The common measure of system efficiency in a power plant.

$$HeatRate(Btu/kWh) = \frac{Energy\ Input(Btu/hr)}{Power\ Output(kW)}$$

- Increasing heat rate decreasing efficiency
- Decreasing heat rate increasing efficiency



Typical Heat Rate Curve



Heat Rate Determination

- Net Unit Heat Rate
 - Measure of the combined performance of the turbine cycle, boiler cycle, and any other associated auxiliaries
- Energy Input
 - Energy In Fuel = Fuel Flow(Ibm/hr)*FuelHeatingValue(Btu/Ibm)
- Net Unit Heat Rate:

$$Net \ Heat \ Rate(Btu \ | \ kWh) = \frac{Fuel \ Flow(lbm \ | \ hr) * Fuel \ Heating \ Value(Btu \ | \ lbm)}{Net \ Power \ Output(kW)}$$



Why is Heat Rate Important?

- 70 80 % of our overall production cost is our fuel
- Aging plants are more susceptible to efficiency losses over time
 - Plants are generally designed for 30 to 40 year life
- Directly impacts expenses
- The bottom line is the heat rate(efficiency)
 integrated with the actual commodity pricing are
 key factors in determining the optimal economic
 dispatch of GRU generating units.



Power Plant Efficiency Objectives

- Boiler Combustion Side
 - Maximize heat transferred to the working fluid
 - Minimize heat losses from the system
 - Flue gas
 - Unburned carbon complete combustion
 - Radiation
- Turbine Side / Balance of plant
 - Maximize thermal energy utilization
 - Minimize aux power usage
 - Minimize losses



Boiler Efficiency

$$Boiler \, Efficiency = \frac{Btus \, Transferred \, To Working \, Fluid \, (water \, or \, steam)}{Btus \, Input \, As \, Fuel}$$

Or

$$Efficiency = \frac{Useful\ Energy\ Output}{Energy\ Input}$$



Definition of Standards for Heat Rate

Actual Net Heat Rate Losses that have not been identified yet Unaccounted-For through routine or special performance Losses tests Best achievable heat rate increased for deviation of measured parameters from Accounted-For their expected values. Includes Losses controllable and uncontrollable losses which could require capital expenditures to eliminate. Best Achievable Net Heat Rate Design net heat rate adjusted for unrecoverable losses due to design expectations not being met. The Unrecoverable difference between actual and Losses theoretical Expected Design Net Heat Rate



Boiler Efficiency – Off Design Fuel

Fuel		Typical Energy Content (HHV)		Higher Heating Value (Btu/lb)		
No. 2 Fuel Oil		137,800	Btu/gal	18,596	Btu/lb	
No. 6 Fuel Oil		150,500	Btu/gal	20,421	Btu/lb	
Natural Gas		1,027	Btu/cu ft	22,810	Btu/lb	
Performance Coal		12,700	Btu/lb	12,700	Btu/lb	
Compliance Coal		12,500	Btu/lb	12,500	Btu/lb	
Biomass ¹		5,000	Btu/lb	5,000	Btu/lb	
1. Biomass HHV assumes that DHR is run at full load.						



Heat Rate Curves

- Deerhaven Renewable
- Deerhaven Unit 2



2017 DHR HR DATA

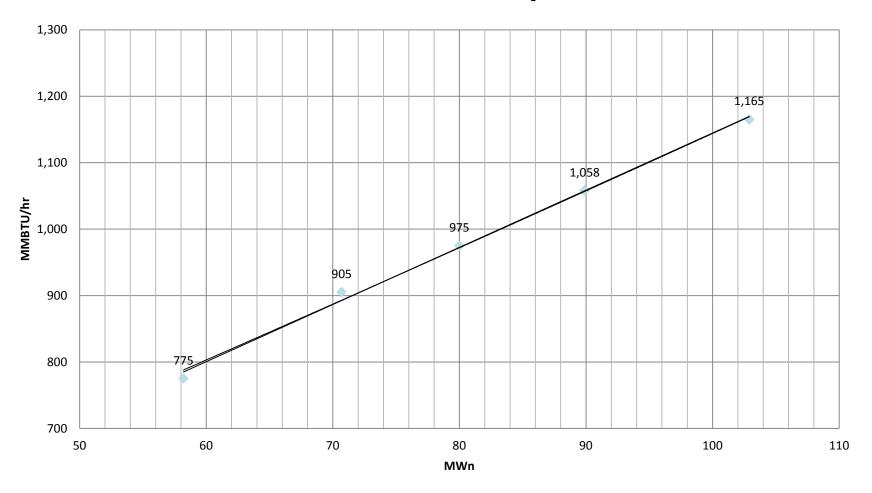
MWn	Fuel Feed	Heat Input	Average Heat Rate
	(lb/hr)	(MMBTU/hr)	(MMBTU/MWn-h)
58.2	155,044	775	13.30
70.7	181,144	905	12.80
80.0	195,184	975	12.18
89.9	211,767	1,058	11.76
102.9	233,106	1,165	11.31

^{*} Heating Value (BTU/lb) 4,996



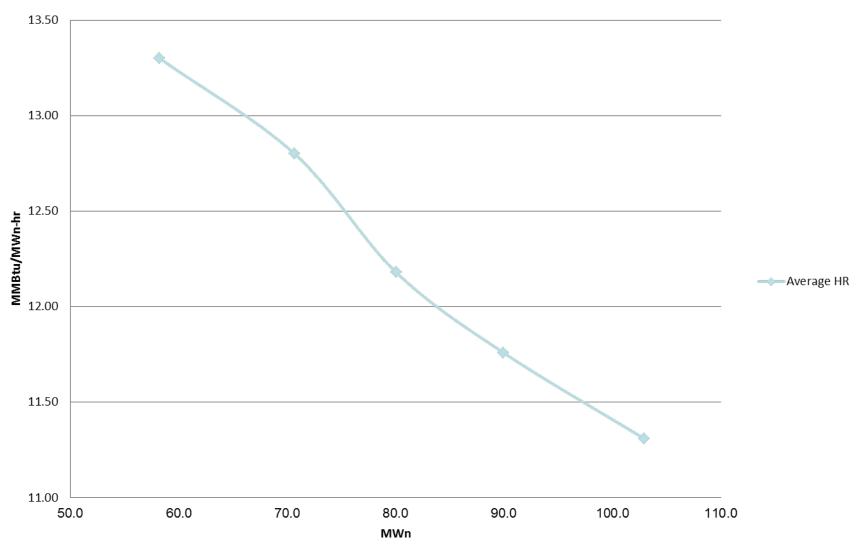
^{*} Density (lb/ft3) 23.15

2017 DHR Heat Input Curve





2017 DHR Average Heat Rate Curve





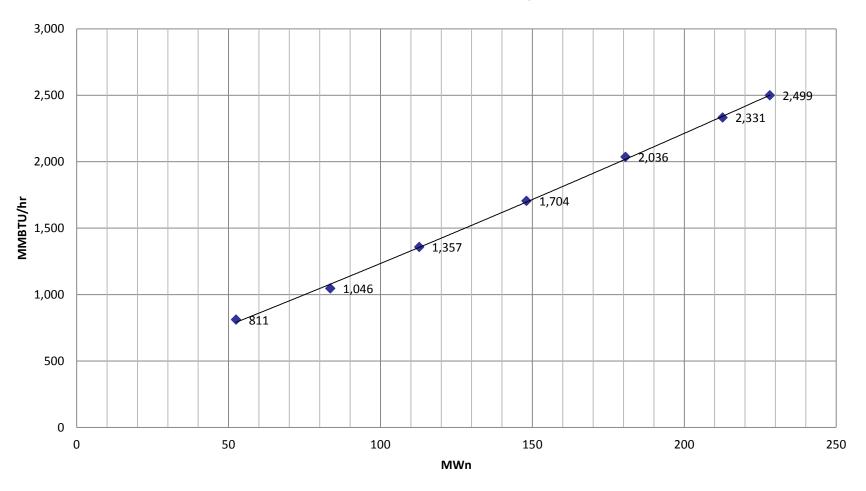
2017 DH2 HR DATA

MWn	Fuel Feed (lb/hr)	Heat Input (MMBTU/hr)	Average Heat Rate (MMBTU/MWn-h)
52.5	40,410	811	15.44
83.5	53,740	1,046	12.83
112.8	90,940	1,357	11.95
148.1	117,710	1,704	11.45
180.7	141,300	2,036	11.39
212.7	158,880	2,331	10.98
228.2	167,060	2,499	10.93

^{*} Heating Value (BTU/lb) 12,966

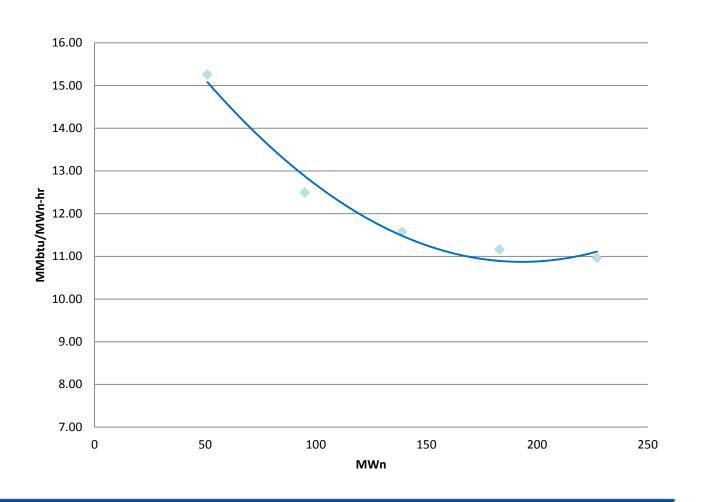


2017 DH2 Heat Input Curve





2017 DH2 Average Heat Rate Curve



 $y = 0.0002x^2 - 0.0805x + 18.643$ $R^2 = 0.9775$

Average HrPoly. (Average Hr)



Questions?

