Markets 201

Incremental Offer Curve and No-Load Cost

PJM State & Member Training Dept.

Objectives

Student will be able to:

- Identify how PJM dispatches resources
- Describe how to develop unit incremental offer curves
- Explain how to calculate startup and No-Load costs
- Describe where to input offer curves, startup and no load in Markets Gateway

Curve Definitions

Heat-Rate Curve

- Plots the heat energy required per MWh of generated electrical output for the generator as a function of the generator's MW output. It indicates the efficiency of the unit over its operating range.
  - Generally, units are least efficient at the minimum and maximum portions of their MW output capability and most efficient somewhere in the middle of their operating range. The vertical axis is plotted in MMBtu/MWh and the horizontal axis is plotted in MW. You may interpret the heat rate for a generator producing X MW as follows: the heat rate indicates the amount of heat input energy per MWh of generation required to produce X MW of power. The lower this number, the less input energy is required to produce each MWh of electricity.

Input-Output Curve

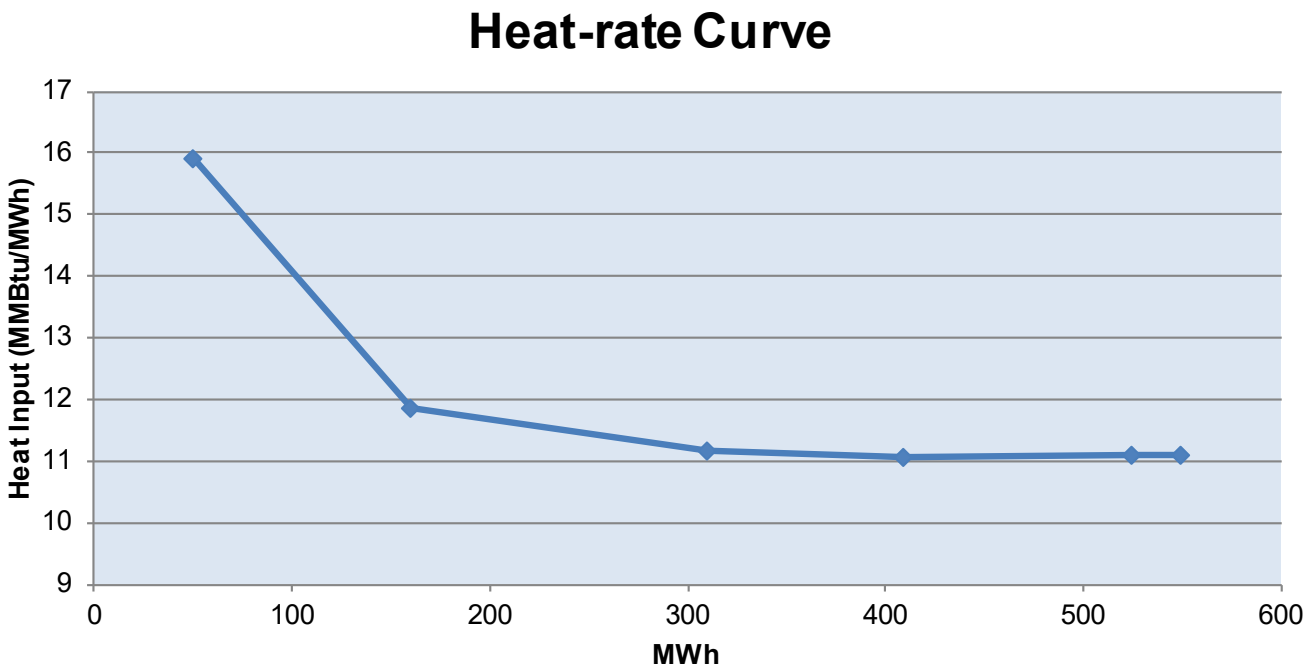
- Derived simply from the heat-rate curve by multiplying it by the MW output of the unit. This yields a curve showing the amount of heat input energy required per hour as a function of the generator's output.

Incremental Cost Curve

- Indicates the marginal cost of the unit: the cost of producing one more MW of power at that unit.
- Calculated by taking the derivative of the input-output curve and multiplying by the fuel + variable operation and maintenance costs

Heat Rate Curve Example

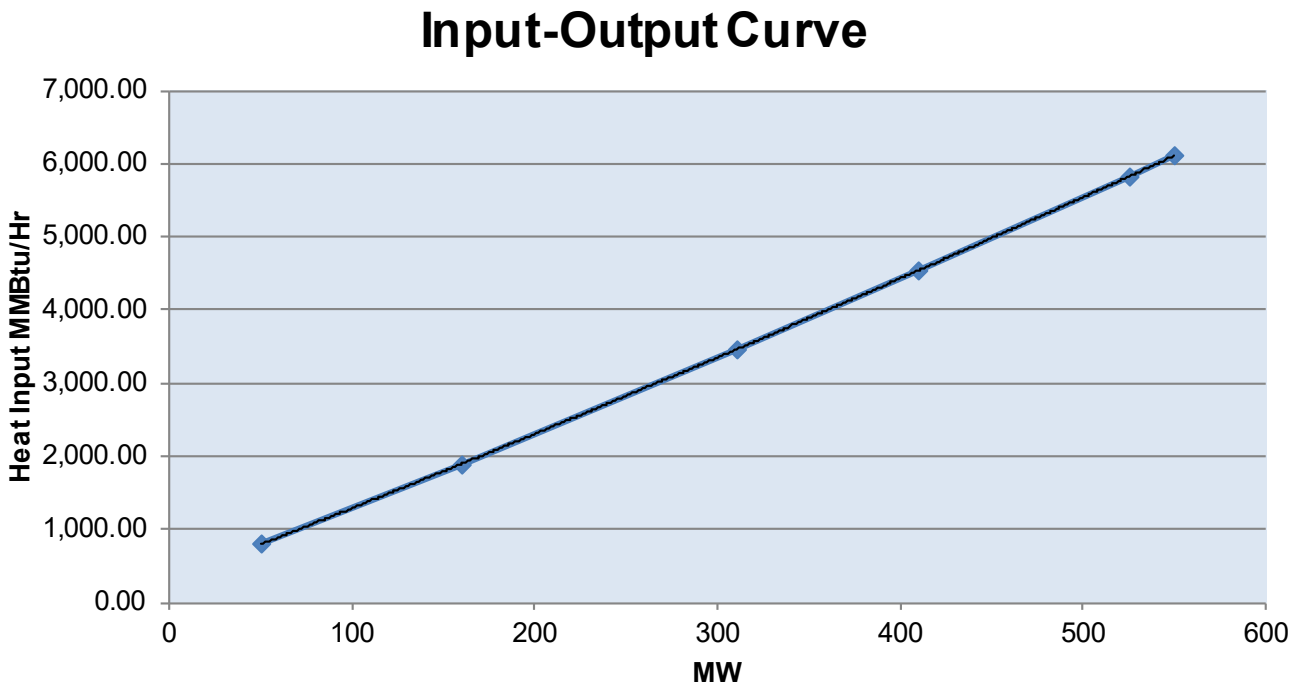
Net Gen MW	Heat Input MMBtu/MWh
50	15.9024
160	11.85675
310	11.16370968
410	11.0787561
525	11.09472381
550	11.10727273



- Heat Rate equals the MMBtu content of the heat input divided by the MWh of power output.
- Total Heat Rate = MMBtu/MWh = Heat Input/Net MW
- The heat rate curve indicates the efficiency of the unit over its operating range and the smaller the heat rate value the greater the efficiency.

Input-Output Curve Example

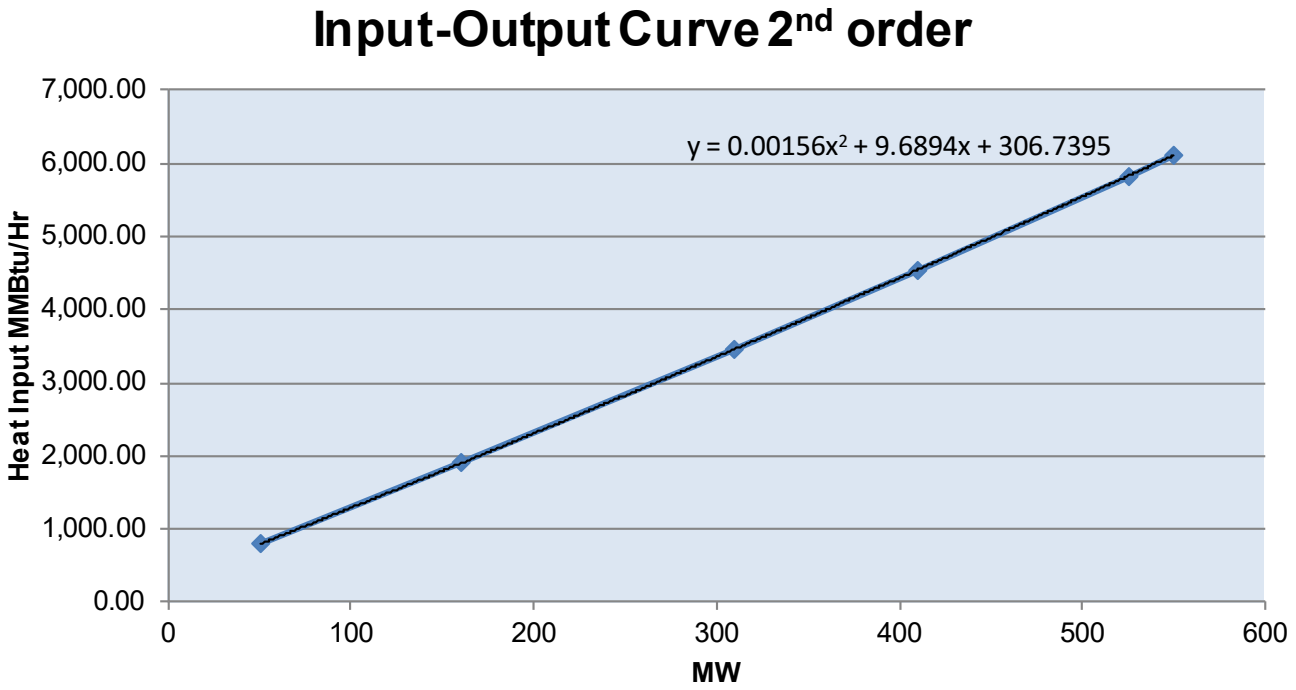
Net Gen MW	Heat Input MMBtu/Hr
50	795.12
160	1,897.08
310	3,460.75
410	4,542.29
525	5,824.73
550	6,109.00



- The input-output curve is derived from multiplying heat-rate curve by the MW output of the unit
- Can also be obtained by collecting heat input values as a function of unit's output and performing a regression analysis on the data

Equation for Input-Output Curve

Net Gen MW	Heat Input MMBtu/Hr
50	795.12
160	1,897.08
310	3,460.75
410	4,542.29
525	5,824.73
550	6,109.00

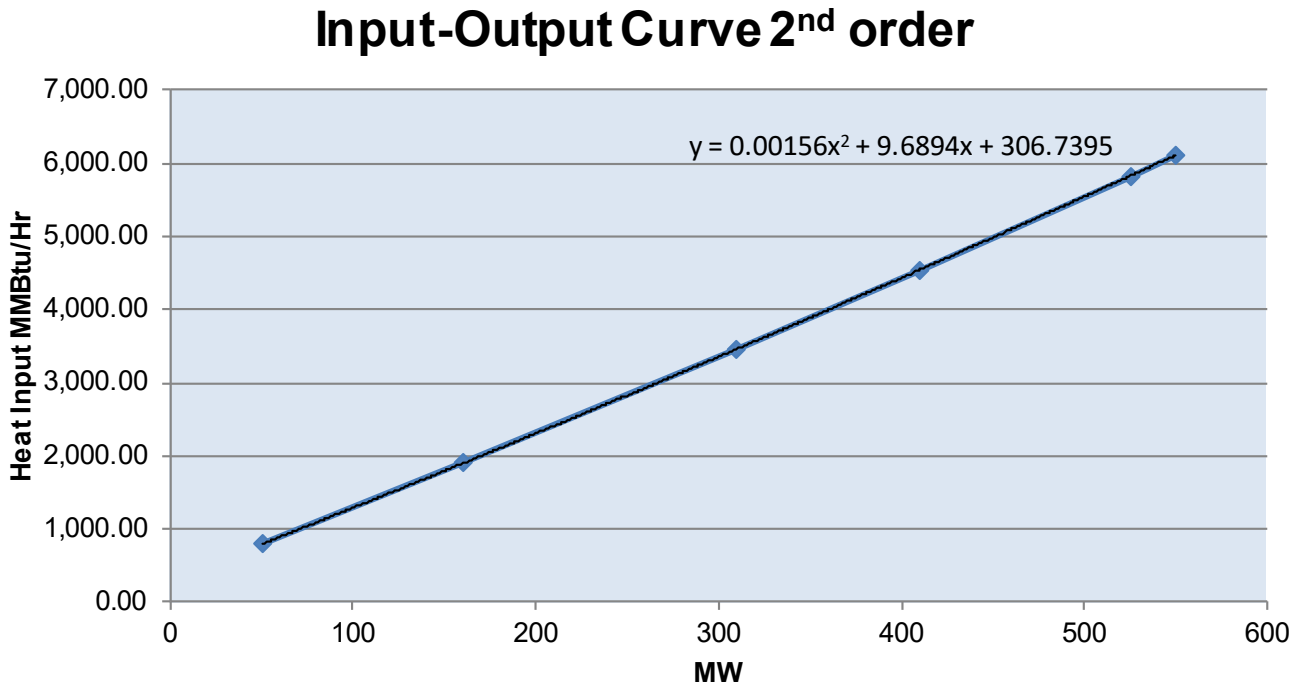


The equation for the Input-Output curve is needed to calculate the Incremental Heat Rate curve

- Using non-linear regression, the equation for heat input data:
  - $y = 0.00156x^2 + 9.6894x + 306.7395$

No-Load Fuel

Net Gen MW	Heat Input MMBtu/Hr
50	795.12
160	1,897.08
310	3,460.75
410	4,542.29
525	5,824.73
550	6,109.00



- No-Load Fuel (MMBtu/hr) is the total fuel to sustain zero net output MW at synchronous generator speed
- The y-intercept (where x = 0) of the Input-Output equation

  = 306.7395 MMBtu/hr

Incremental Heat Rate Curve

- The Incremental heat rate is the relationship between an additional MW of output and the heat input necessary to produce it.
- Graphically, the incremental heat rate can be determined from the ratio of the change in fuel input to the change in unit MW output; which is the slope of the input/output curve.
- Mathematically, the incremental heat rate curve can be expressed as the first derivative of the heat rate curve (input heat versus MW output).

Incremental Heat Rate Curve

- Take the first derivative of the Input-Output curve equation
  - The first derivative of heat input-output curve represents rate of change of generator output, or incremental offer curve
  - $y'(x) = 0.00312x + 9.6894$

Incremental Cost Curve

- Multiply equation of the Incremental Heat Rate Curve by (TRFC + VOM) * Performance Factor
  - Incremental Heat Rate Curve = 0.00312x + 9.6894

TFRC ($/MMBtu)	VOM ($/MMBtu)	Performance Factor
3.5	0.15	1.02

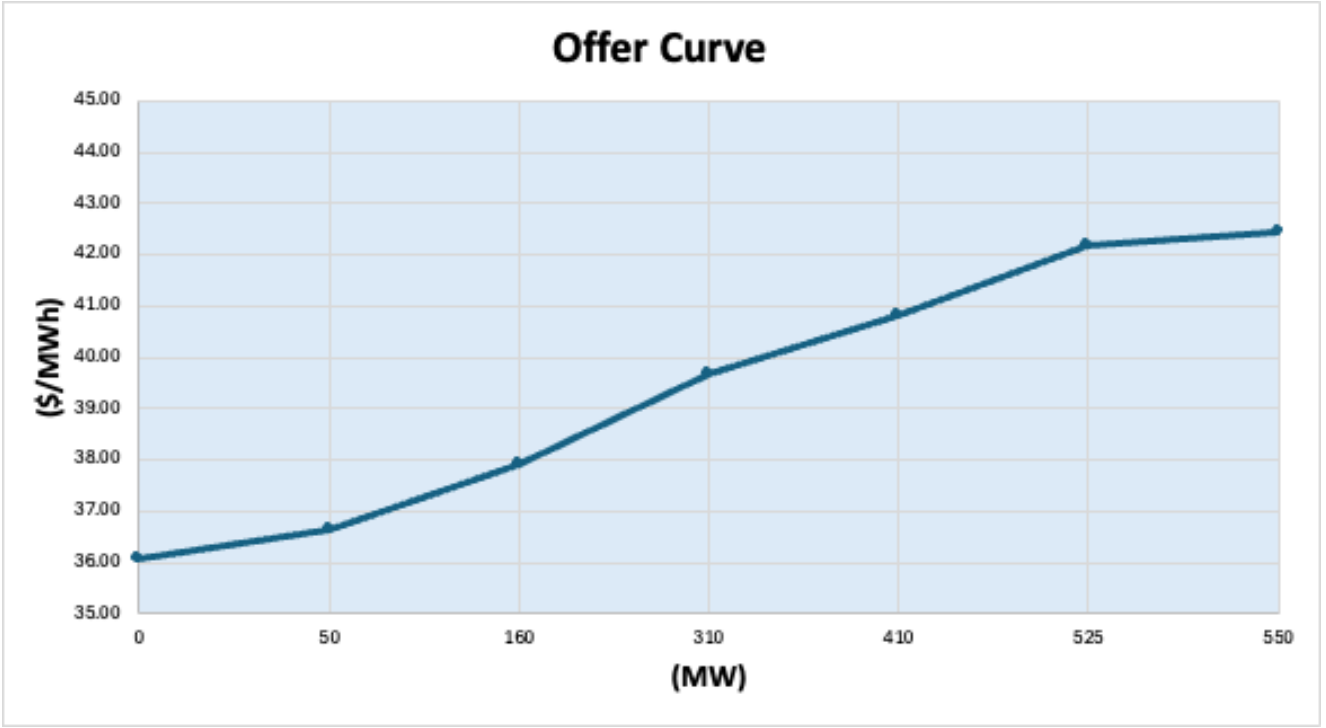
  - Total Fuel Related Cost (TFRC) = is the sum of fuel costs, emission allowance cost, maintenance cost, and operating cost.
  - Variable Operations and Maintenance Costs (VOM)
  - Performance Factor = total actual fuel consumed / total theoretical fuel consumed

Incremental Cost Curve

- Multiply equation of the Incremental Heat Rate Curve by (TRFC+ VOM) * Performance Factor
  - Incremental Cost Curve = (0.00312x + 9.6894) * ((3.5+0.15)*1.02)

- Units offered using a sloped function must select the “use offer slope” option in Markets Gateway. Generators offered using a sloped function must start their incremental offer curve with a zero MW segment.

MW	Offer
0	36.07
50	36.65
160	37.93
310	39.67
410	40.84
525	42.17
550	42.46



No-Load Cost

No-Load Cost ($/hour) - The hourly cost required to theoretically operate a synchronized unit at zero MW. It consists primarily of the cost of fuel, as determined by the unit's no load heat (adjusted by the performance factor) times the fuel cost. It also includes operating costs, Maintenance Adders, and emissions allowances.

NoLoadCost($/Hour) = (NoLoadFuel)*(Performance Factor*Total Fuel Related Cost) + Maintennce Adder $ $h$our + Operating Cost Adder ($ $h$our)

NoLoadCost($/Hour) = 306.7395 MMBtu/hr * (1.02 * $3.5/MMBtu) + $9.30 + $0 = $1,104.36

Start-up Cost

For units with soak process: Start Cost shall mean the net unit costs from PJM's notification to the level at which the unit can follow PJM's dispatch and from last breaker open to shutdown.

For units without soak process: Start Cost shall mean the unit costs from PJM's notification to first breaker close and from last breaker open to shutdown.

Start–Up Cost ($/Start) =

[StartFuel (MMBtu/(Start))*Total Fuel Related Cost ($/MMBtu)*Performance Factor] + [Station Service (MWh) * Station Service Rate ($/MW$h$)] + Start Maintenance Adder ($/Start)

Cold Start-up cost = $70,500.66

Intermediate Start-up cost = $52,900.42

Hot Start-up cost = $7,300.49

Example

Cost Offers and Parameters – COST01 Schedule

	MW	Offer
	0	36.07
	50	36.65
Eco Min	160	37.93
	310	39.67
	410	40.84
	525	42.17
Eco Max	550	42.46

No-Load Cost($/Hour) =$1,104.36
Cold Start-up cost = $70,500.66
Intermediate Start-up cost = $52,900.42
Hot Start-up cost = $7,300.49

Cost Offers and Parameters – PRICE99 and PRICE79 Schedule

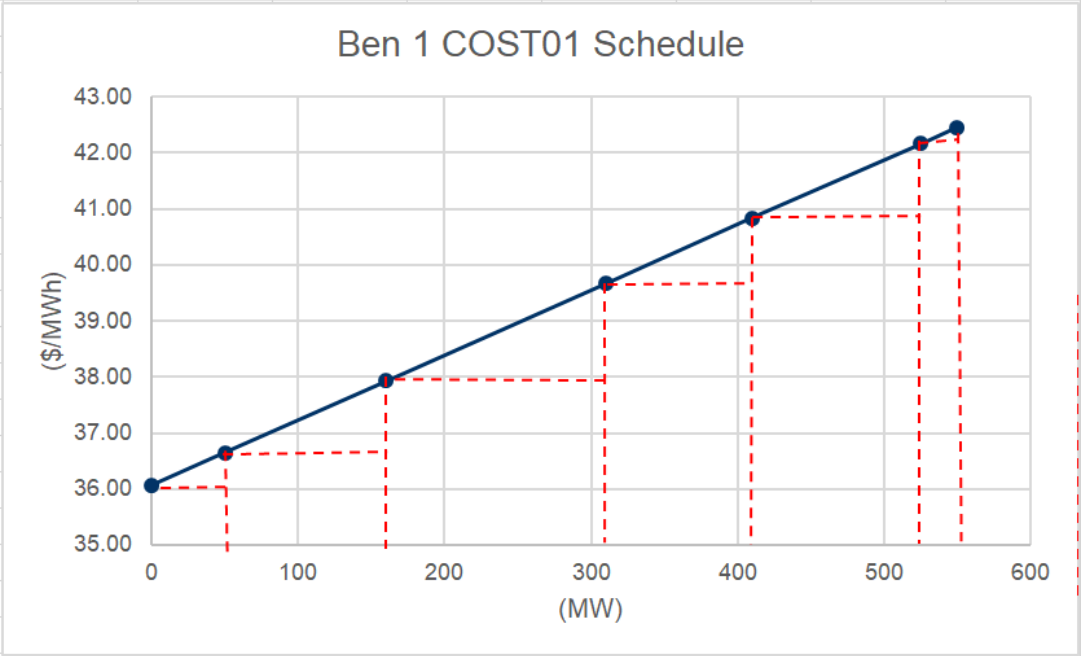
In this example, the PRICE99 and Price 79 schedules have been market up 20% from the COST01 schedule

	MW	Offer
	0	43.28
Eco Min	50	43.98
	160	45.52
	310	47.60
	410	49.01
	525	50.60
Eco Max	550	50.95

No-Load Cost($/Hour) =$1,104.36
Cold Start-up cost = $70,500.66
Intermediate Start-up cost = $52,900.42
Hot Start-up cost = $7,300.49

Production Cost – COST01 Schedule

	Ben 1		
Segment	MW	Price	
1	0	36.07	
2	50	36.65	
3	160	37.93	**Eco Min**
4	310	39.67	
5	410	40.84	
6	525	42.17	
7	550	42.46	**Eco Max**

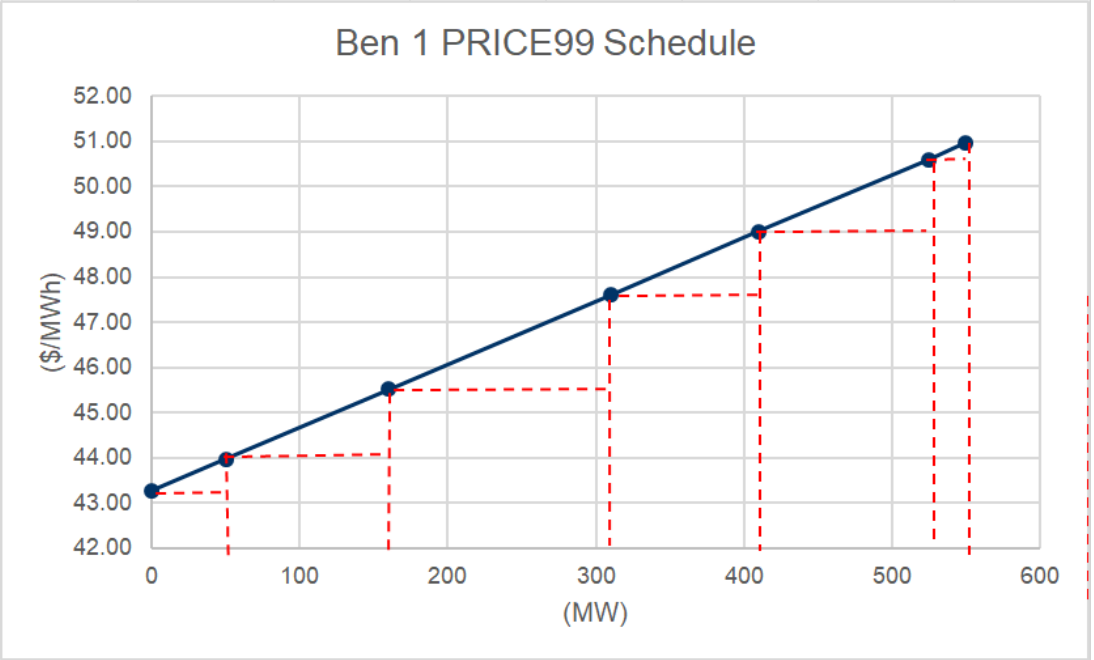


Cost Based Start-up and No-Load	
Cold Start Cost =	$70,500.66
No-Load Cost =	$1,104.36

Production Cost at Eco Min				
	Rectangle	Triangle	Total	
No-Load			$1,104.36	
Area 1	1803.5	14.5	1818	
Area 2	4031.5	70.4	4101.9	
Area 3	5689.5	130.5	5820	
Area 4	3967	58.5	4025.5	
Area 5	4696.6	76.475	4773.075	
Area 6	1054.25	3.625	1057.875	
Production Cost at eco max =			$22,700.71	
Total Production Cost at eco max =			**$93,201.37**	(Included Start-up)
Production Cost Rate at eco max =			**$41.27**	**$169.46**

Production Cost – PRICE99 Schedule

	Ben 1		
Segment	MW	Price	
1	0	43.28	
2	50	43.98	
3	160	45.52	**Eco Min**
4	310	47.60	
5	410	49.01	
6	525	50.60	
7	550	50.97	**Eco Max**



Cost Based Start-up and No-Load	
Cold Start Cost =	$70,500.66
No-Load Cost =	$1,104.36

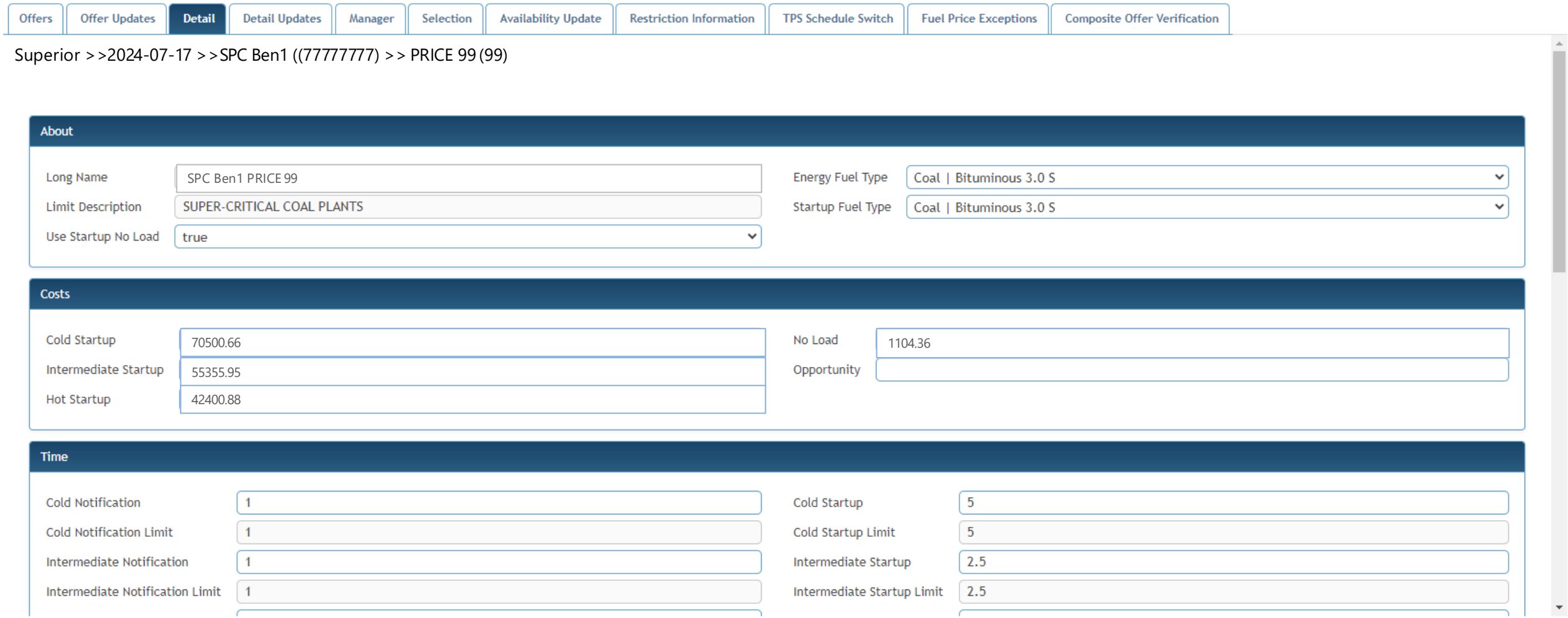
Production Cost at Eco Min				
	Rectangle	Triangle	Total	
No-Load			$1,104.36	
Area 1	2164	17.5	2181.5	
Area 2	4837.8	84.7	4922.5	
Area 3	6828	156	6984	
Area 4	4760	70.5	4830.5	
Area 5	5636.15	91.425	5727.575	
Area 6	1265	4.625	1269.625	
Production Cost at eco max =			$27,020.06	
Total Production Cost at eco max =			**$97,520.72**	(Included Start-up)
Production Cost Rate at eco max =			**$49.13**	**$177.31**

Markets Gateway – Schedules Offers

From Markets Gateway – Schedule Offers

MW	Price
0	43.28
50	43.98
160	45.52
310	47.60
410	49.01
525	50.60
550	50.97

Markets Gateway – Schedules Details



Questions?

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