Greater Than $1000/MWh Cost
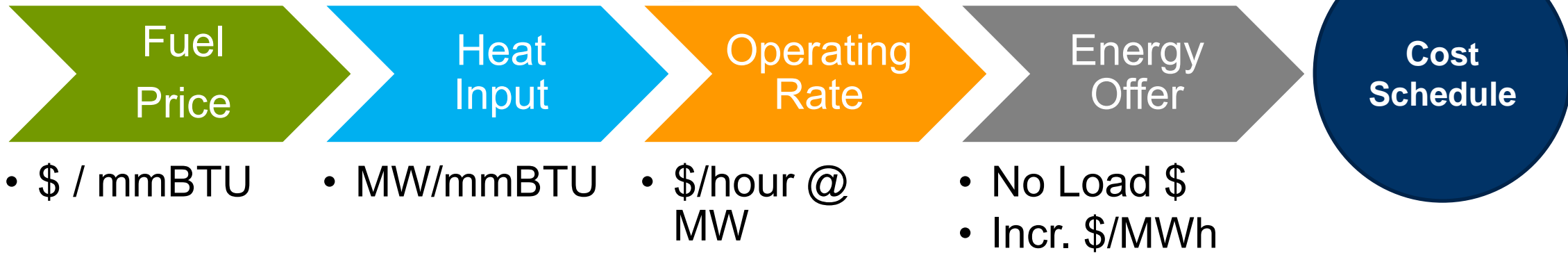# Offer Verification Proposal

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MIC Special Session Market Operations Price Transparency
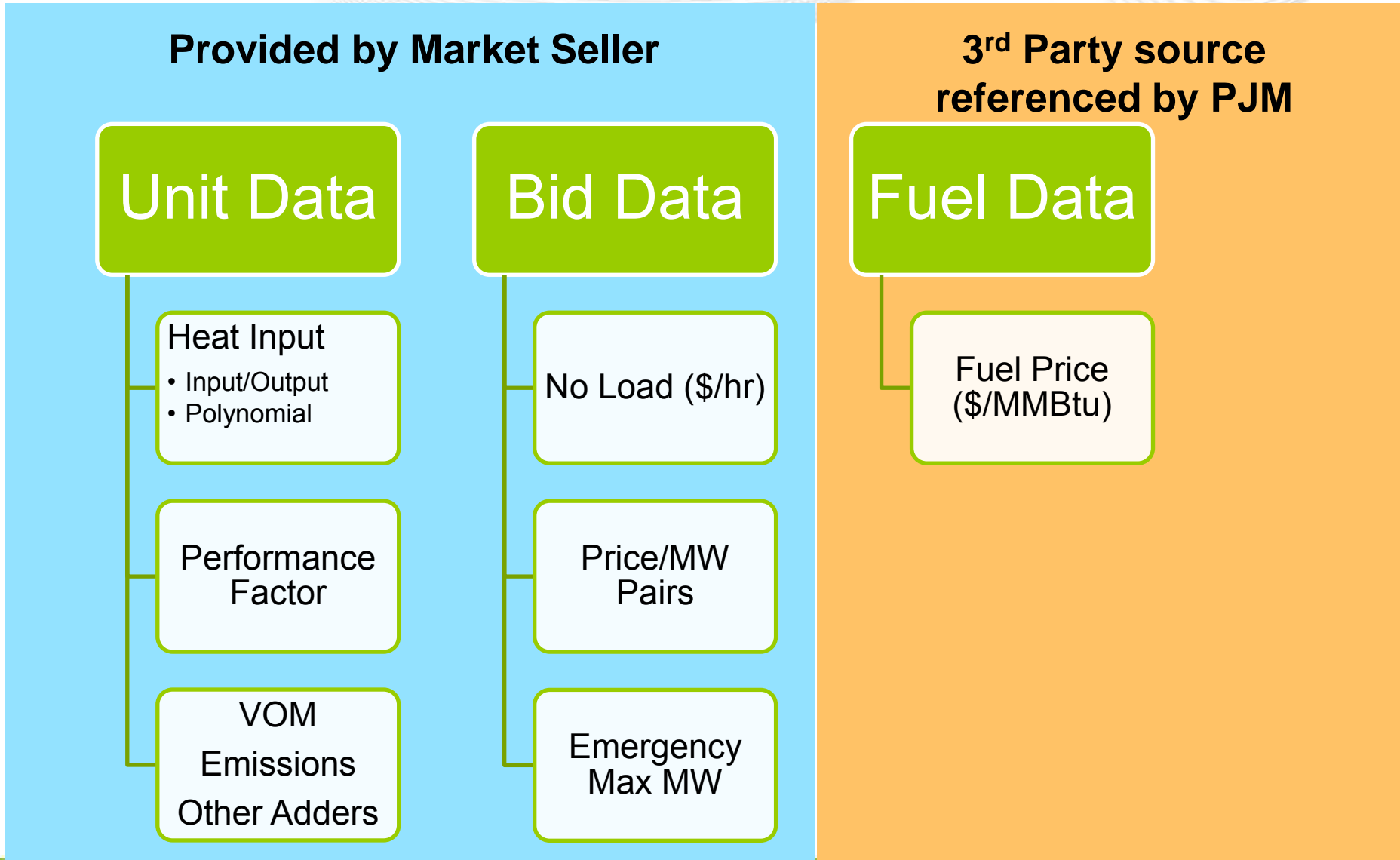
April 25, 2017

- FERC Order 831 "Offer Caps":
  - **Validation of cost of incremental energy offers** that exceed $1,000/MWh before the unit is allowed to set LMP
  - Maximum incremental cost allowed to set LMP at $2,000/MWh

"… ensure that a resource's cost-based incremental energy offer reasonably reflects that resource's actual or expected costs."

- *Ex ante* Validation implementation November 1st, 2017 with IDO

All thermal units burn fuel for electricity, generally as:

Fuel Price	Heat Input	Operating Rate	Energy Offer	Cost Schedule
• $ / mmBTU	• MW/mmBTU	• $/hour @ MW	• No Load $ • Incr. $/MWh	

- Details are specified in the Operating Agreement Schedule 2

Provided by Market Seller

3rd Party source referenced by PJM

Unit Data

- Heat Input
  - Input/Output
  - Polynomial

- Performance Factor

- VOM
  Emissions
  Other Adders

Bid Data

- No Load ($/hr)

- Price/MW Pairs

- Emergency Max MW

Fuel Data

- Fuel Price ($/MMBtu)

- PJM will use a third party vendor for forward and intra-day (near real-time) commodity price data

- Each gas unit may specify up to four trading hubs
  - Trading hubs are documented in Fuel Cost Policy
  - Units behind a citygate or on a non-traded hub may specify nearest applicable proxy hub
  - PJM will use the highest price among assigned hubs, with a **variance adder** allowing for uncertainty

- Examined historical natural gas, North NJ, Winter price ranges:

Statistic	Distribution Percentage	2014 2015	2015 2016	2016 2017	3-Year
Mean + 1 σ	68%	11.6%	11.8%	5.2%	10.1%
Mean + 2 σ	95%	18.1%	17.2%	7.4%	**15.2%**
Mean + 3 σ	99%	24.5%	22.6%	9.5%	20.4%

PERCENT = (HIGH TRADE – SETTLED PRICE) / SETTLED PRICE

- The **Heat Input Curve** describes the operational characteristics that convert fuel input to energy production
  - 1 mmBTU   = 1,000,000 BTUs = 10 therms = 1 dekatherm
  - 1 MW   =   1,000 kW
- The Heat Input can be represented as
  - Polynomial with MW ranges $mmBTU = a\, MW^2 + b\, MW + c$
  - Table of Input / Output pairs   mmBTU, MW
- A Performance Factor (PF) scales heat up for actual/theoretical
  - Value of 1.0 is normal for recently performance-tested units

- Block-loaded machinery (CTs, Diesels) generally have 1 output point

- Fossil (Steam, Combined Cycle) operate on a non-linear curve

  – Operational data to find fuel / MWh pairs

  – Regression modelling to find coefficients

Heat Input = $a + bx + cx^2$

MMBtu

Incremental Heat

No-load → Heat Input

MW1   MW2   MW3   Emergency Max
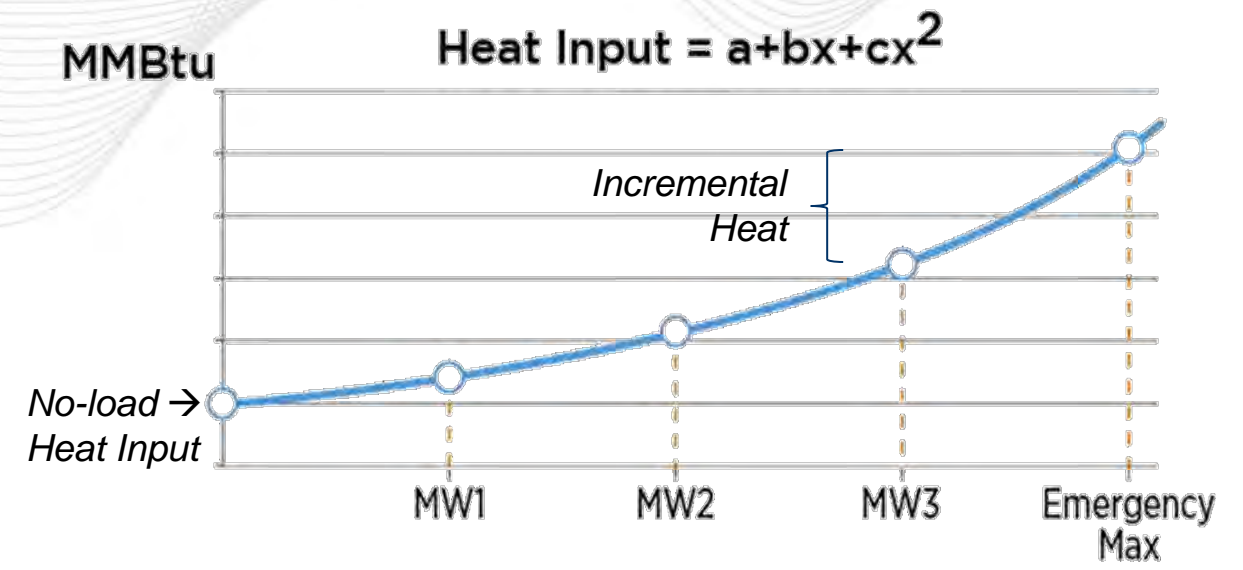
No Load = Heat req. to run at zero MW output

Heat Incremental = Addl. heat req. to increase output

Duct Burners = Supplementary burners that increase MW output w/ different operating characteristics, results in a second polynomial band

For each energy offer segment (price, MW pair), $i = 1 .. n$:

Maximum Allowable Operating Rate ($/hour @ MW) =

$\{$ [(Heat Input $_i$ @ MW$_i$) x (Performance Factor) x (Fuel Cost)] + A $\}$ x (1 + B)

Heat Input = Derived from coefficients or table

Performance Factor = 1.0 or greater

Fuel Cost = Estimated Fuel Cost plus Variance Adder

A = VOM, Emissions and Other Adders

B = Up to 10% Cost Adder

- Energy Offer data entered by Market Seller in Markets Gateway
  - Energy No Load Cost ($/hour)
  - Incremental Energy Offer segments (price $/MWh @ MW pairs)
- Operating Range (up to Emergency Maximum MW)
- Bid-Slope (yes/no) or block-loading
- If the last segment's MW < Emergency Max, extra segment is added at { Pr_{max}, Emergency Max }

$/MW   Price/MW Segment Pairs

Price 4

Price 3

Price 2

Price 1

No Load
$/hr

MW1   MW2   MW3   Emergency Max

For each energy offer segment (price, MW pair), $i = 1 .. n$:

Bid Production Cost ($/hour @ MW) =

(Energy No Load) +

$$\sum_{i=1}^{n}(MW_i - MW_{i-1})\, x\, (P_i) - \frac{1}{2}\, x\, UBS\, x\, (MW_i - MW_{i-1})\, x\, (P_i - P_{i-1})$$

Energy No Load = Submitted Cost of Operation at 0 MW, in $/hour

MW = Segment MW, in MW

P = Segment Price, in $/MWh

UBS = Uses Bid-Slope = 0 for Block-loaded, 1 for Sloped

Segment "zero" = P_1 at 0 MW, always block-loaded

For each energy offer segment (price, MW pair), $i = 1 .. n$:

Maximum Allowable Incremental Cost ($/MWh @ MW) =

[(Max. Allowable Oper. Rate$_i$) − (Bid Production Cost $_{i-1}$)] / (MW$_i$ − MW$_{i-1}$)

– At each offered MW (up to Emergency Max), calculate the estimated cost (incl. no load) to output at that level from the heat rate data

– The maximum incremental cost of each segment in the energy offer is set by the <u>remaining</u> difference from fuel costs

Segment "zero" bid production cost is the No Load Cost @ 0 MW

For each energy offer segment (price, MW pair), $i = 1 .. n$:

Maximum Allowable Incremental Cost ($/MWh @ MW) =

@ MW_1: { MaxRate(MW_1) – [No-Load] } / MW_1

@ MW_2: { MaxRate(MW_2) – [No-Load + (MW_1 x P_1)] } / (MW_2 – MW_1)

@ MW_3: { MaxRate(MW_3) – [No-Load + (MW_1 x P_1)

+ (MW_2 - MW_1) x P_1

+ ((MW_2 - MW_1) x (P_2 - P_1) x S)] } / (MW_3 – MW_2)

UBS = ½ or 1

@ MW_n: { MaxRate(MW_n) – [Bid Production Cost$_{n-1}$] } / (MW_n – MW_{n-1})
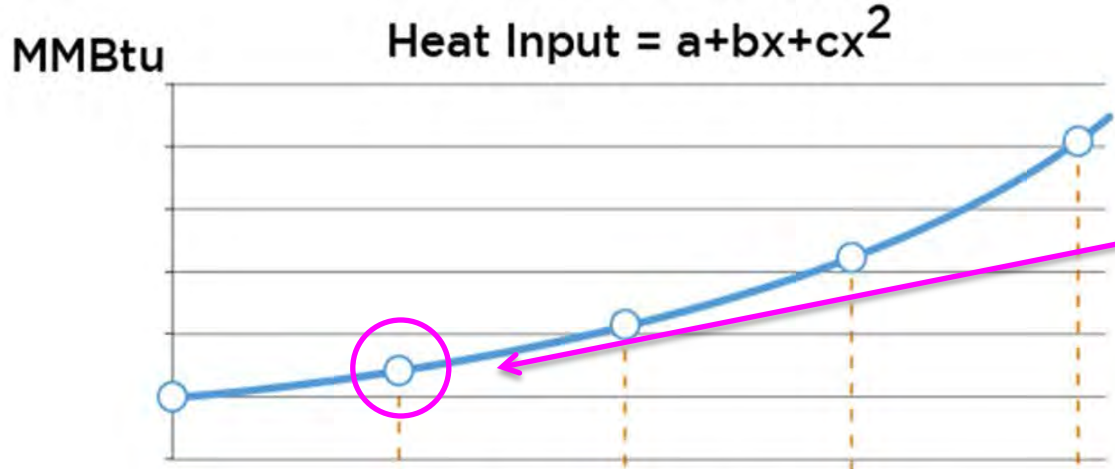
Segment 1 = $Price_1$ @ MW_1

Heat Input @ MW_1

Max Allow Op $Rate_1$ @ MW_1
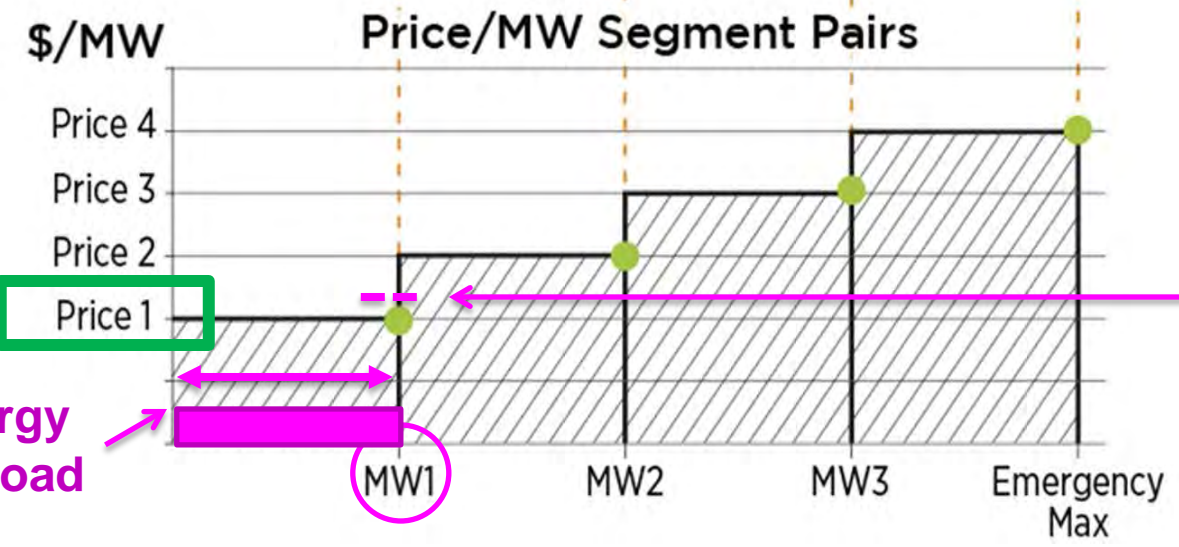
BPC_0 = Energy No Load

Price 1 verified if

$\leq (MaxRate_1 - NoLoad) / MW_1$

Heat Input = $a + bx + cx^2$

MMBtu

$/MW

Price/MW Segment Pairs

Price 4
Price 3
Price 2
Price 1

No Load
$/hr

MW1   MW2   MW3   Emergency Max
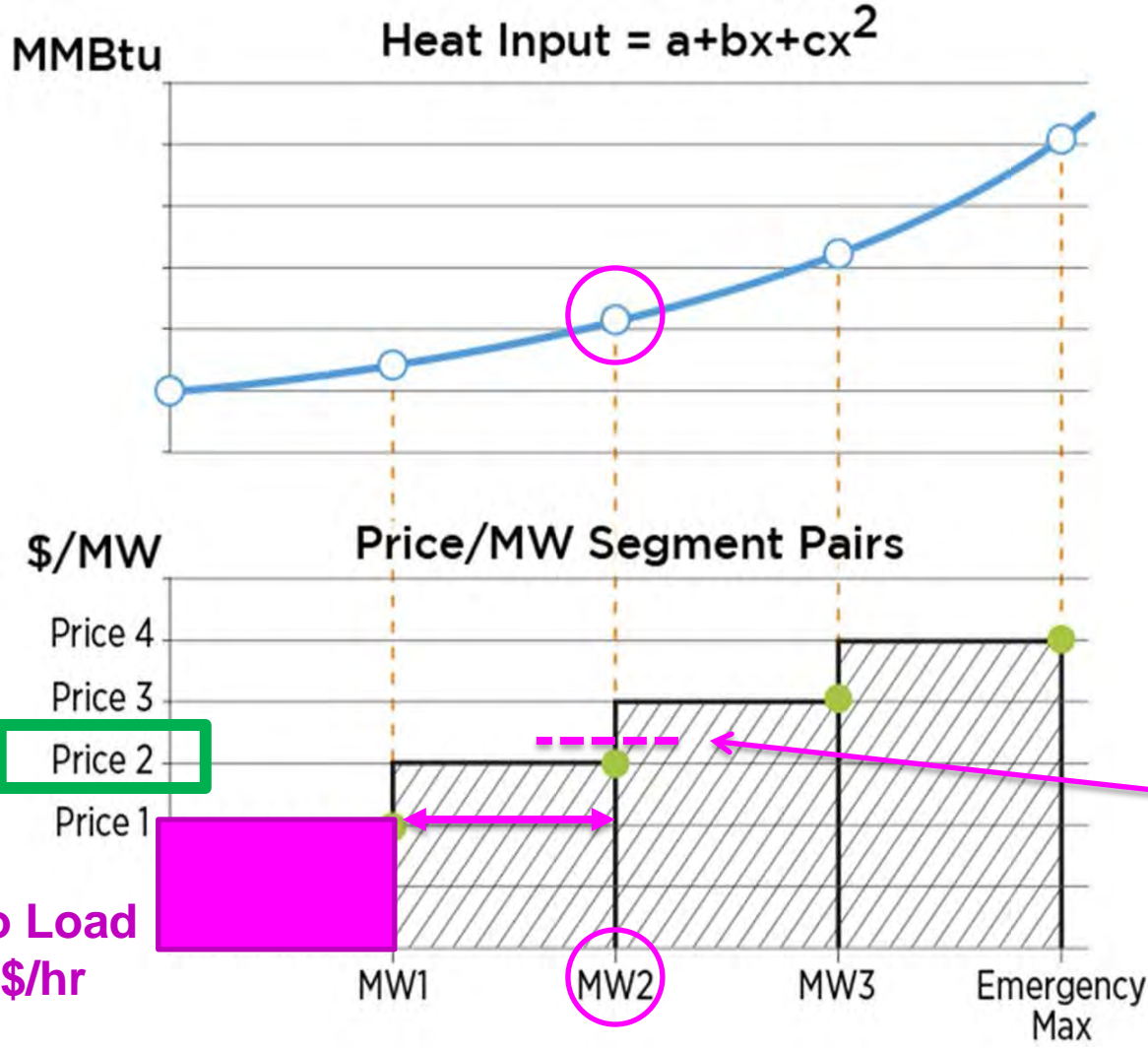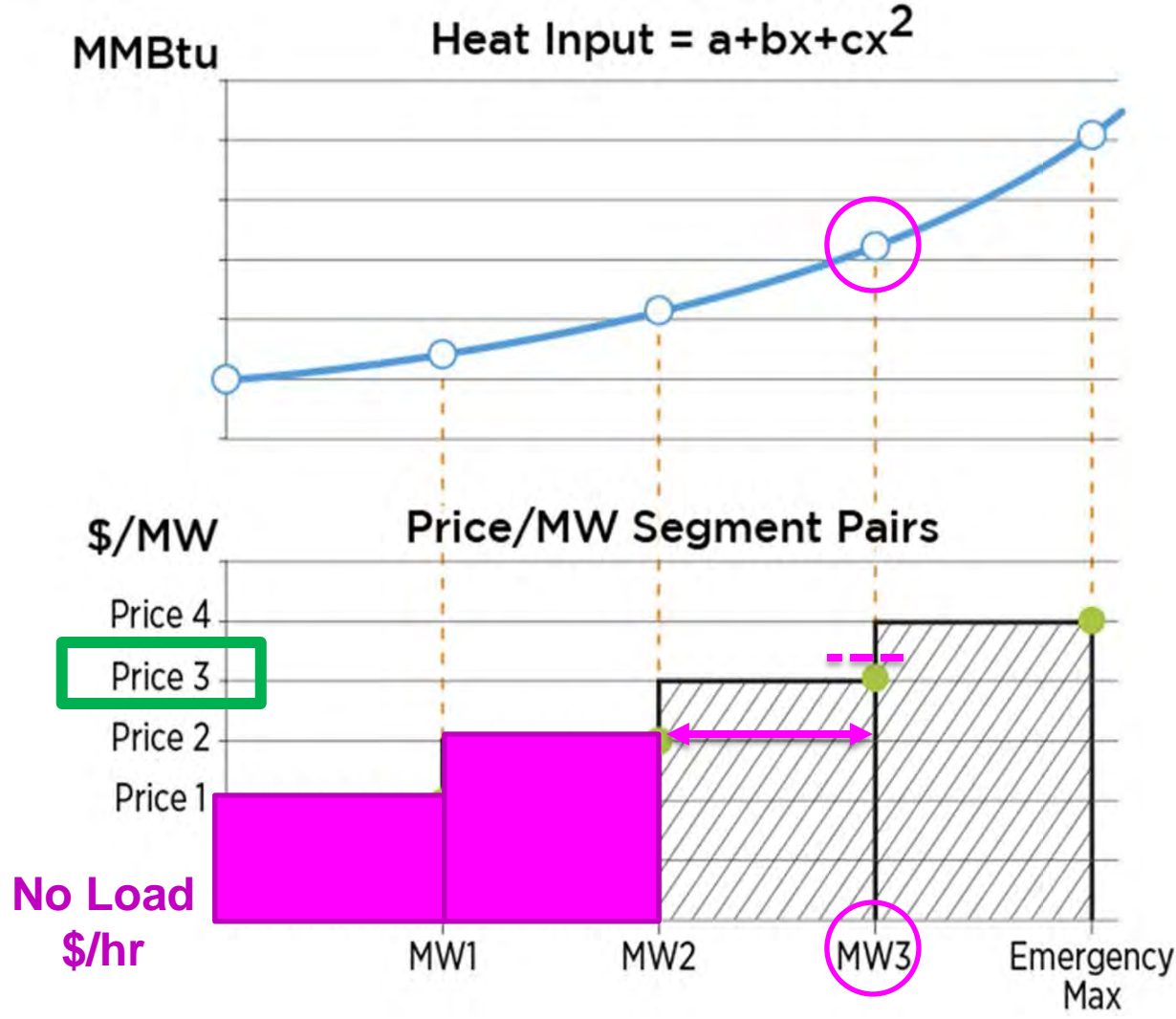
Segment 2 = Price$_2$ @ MW$_2$

Heat Input @ MW$_2$

Max Allow Op Rate$_2$ @ MW$_2$

$$BPC_1 = \text{Energy No Load} + (Pr_1 \times MW_1)$$

Price 2 verified if

$$\leq (MaxRate_2 - BPC_1) / (MW_2 - MW_1)$$

Segment 3 = Price$_3$ @ MW$_3$

Heat Input @ MW$_3$

Max Allow Op Rate$_3$ @ MW$_3$

$$BPC_2 = BPC_1$$
$$+ (Pr_2 \times (MW_2 - MW_1))$$

Price 3 verified if

$$\leq (MaxRate_3 - BPC_2) / (MW_3 - MW_2)$$
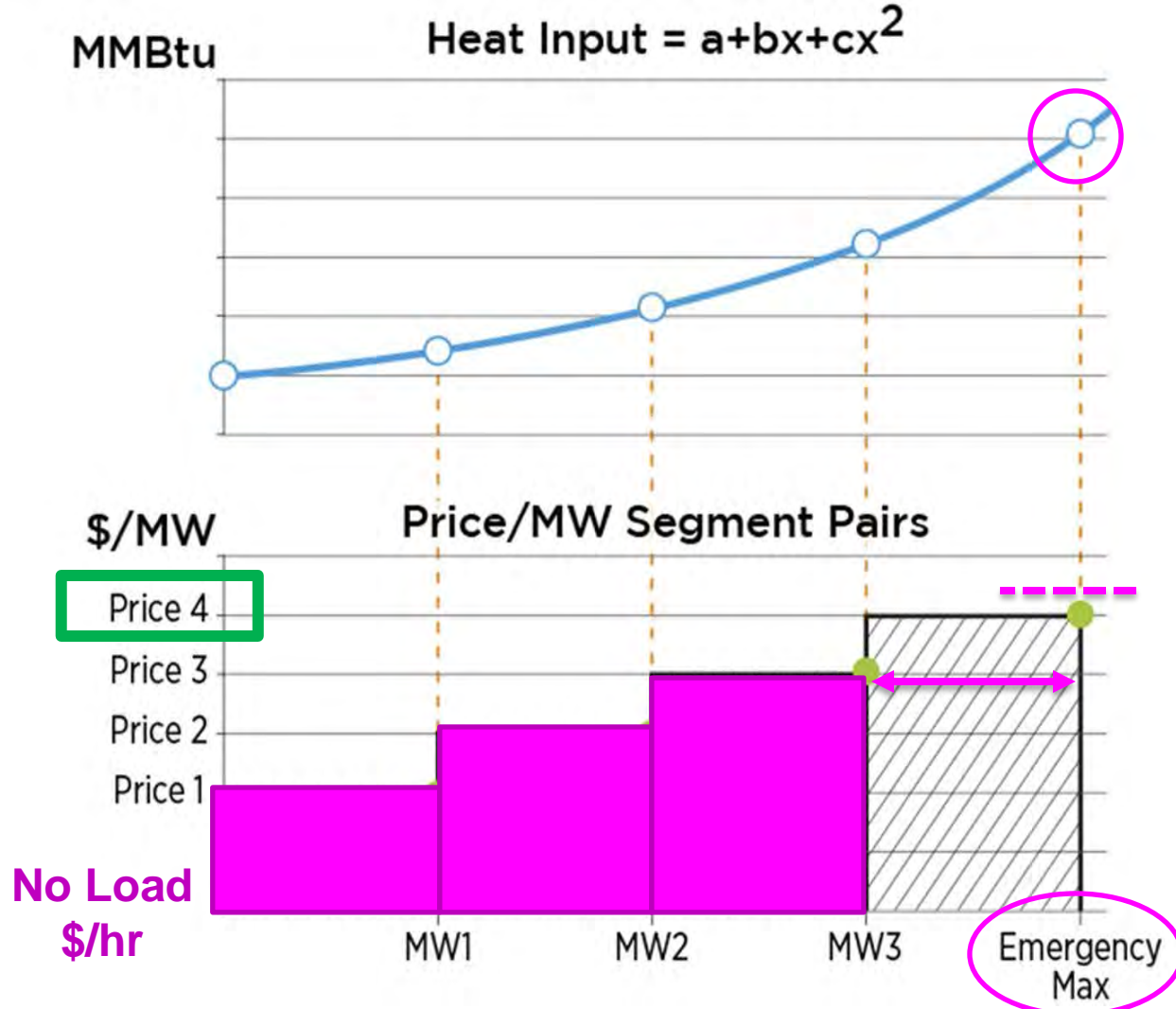
Segment 4 = Price$_4$ @ MW$_4$

Heat Input @ MW$_4$

Max Allow Op Rate$_4$ @ MW$_4$

$$BPC_3 = BPC_2$$
$$+ (Pr_3 \times (MW_3 - MW_2))$$

Price 4 verified if

$$\leq (MaxRate_4 - BPC_3)$$
$$/ (MW_4 - MW_3)$$

- The **Bid Production Cost** should align with the **Maximum Allowable Operating Rate**, since the incremental offer { price, MW } pairs are derived from the heat input curve

  - If any segment of the Incremental Cost ($/MWh) exceeds $1,000/MW, then the cost offer is subject to verification

  - Schedule is *verified* if all segments pass incremental cost test

- All units with an incremental of $1,000/MWh or greater are expected to provide documentation *ex post*, regardless of screening success

- PJM will not block any data entry in Markets Gateway
  - Data can be submitted up to 7 days in advance (status quo)
  - Verification will apply to a single market day, as fuel data exists
  - Once verified for a given market day, the offer will remain verified until the next cost update
- Offers that do not pass the automated Verification Process may use the Exception Process to request approval
  - Documentation of costs subject to manual review & verification
  - Cost Offer must conform to the approved Fuel Cost Policy

- DA, 06:00-10:30, verification of >$1,000/MWh cost schedules as new offer data is submitted into Markets Gateway

  – Schedules begin the day as unverified

  – Periodic update of commodity trading data from third party vendor

  – Member can retrieve verification status

- RT, up to 65 mins before each hour, verification of >$1,000/MWh cost schedules as new hourly offers are submitted

Available Schedule
- Committable on the schedule
- Dispatchable to any point on the submitted curve

Verified *ex ante*
- Eligible to set LMP up to $2,000/MWh
- Unit-specific make whole to costs above $2,000/MWh

Verified *ex post*
- Not eligible to set LMP
- Unit-specific after-the-fact make whole to verified costs

- Screening Process = *ex ante* verification of >$1,000/MWh cost offer
  - Automated Verification w/ best available data
  - Manual Verification w/ Member Submitted evidence

- Exception Process = Exception to the Screening Limits

- Verified Costs = Eligible to set LMP above $1,000/MWh

- Unit-specific Make Whole > $2,000/MWh or to *ex post* verified offer

- Unverifiable *ex post* = potential penalty