MARSDEN JACOB ASSOCIATES

economics
public policy
markets
strategy

2020/21 Energy Price Limits

Workshop Slides

A Marsden Jacob Presentation

Introduction

Under clause 6.20.6 of the WEM Rules, AEMO must annually review the appropriateness of the value of the Maximum STEM Price and the Alternative Maximum STEM Price.

Marsden Jacob was required to calculate revised values for the upper Energy Price Limits, as prescribed in clause 6.20.7 of the WEM Rules.

This required the following:

- Assess the methodology used in the previous 2019-20 Energy Price Limits Review
- Determine the upper Energy Price Limits
  - Maximum STEM Price (which applies if a Facility is running on non-liquid fuel)
  - Alternative Maximum STEM Price (which applies if a Facility is running on liquid fuel).

Introduction - Presentation structure

- Methodology, Statistical Modelling and Risk Margin
- Candidate Peaking Generator
- Variable O&M Costs
- Heat Rate & Loss Factors
- Gas & Distillate Costs
- Modelling Results
- Changes in Energy Price Limits from Previous Year
- Additional considerations

Methodology

Maximum prices serve several purposes in the WEM:

- Protect market customers from high prices that could result from generators exercising market power in the STEM and Balancing Market;
- Provide incentives for new generation investment (i.e. peaking generators);
- Enable existing generators to cover the costs incurred in providing peaking generation so that they are encouraged to provide their capacity during high price periods.

Methodology - Maximum STEM Price Formula

The Maximum STEM Price and Alternative Maximum STEM Price must be calculated using the following equation defined in clause 6.20.7(b) of the WEM Rules

$$\frac{1 + Risk\ Margin}{Loss\ Factor} \times \left(Variable\ O\&M_{\$/MWh} + \left(Heat\ Rate_{GJ/MWh} \times Fuel\ Cost_{\$/GJ}\right)\right)$$

$Risk\ Margin$ is a measure of uncertainty in the assessment of the mean short-run average cost of a 40 MW open cycle gas turbine generating station, expressed as a fraction;

$Variable\ O\&M$ is the mean variable operating and maintenance cost of a 40 MW open cycle gas turbine generating station, expressed in $/MWh, and includes, but is not limited to, start-up costs;

$Heat\ Rate$ is the mean heat rate at minimum capacity of a 40 MW open cycle gas turbine generating station, expressed in GJ/MWh;

$Fuel\ Cost$ is the mean unit fixed and variable fuel cost of a 40 MW open cycle gas turbine generating station, expressed in $/GJ; and

$Loss\ Factor$ is the marginal loss factor of a 40 MW open cycle gas turbine generating station relative to the reference node.

Methodology – Statistical Modelling

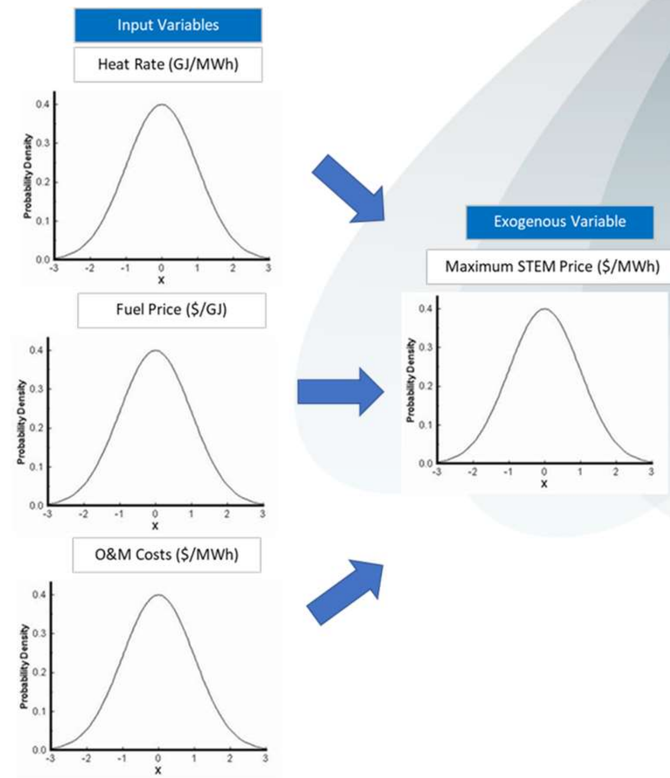
There is considerable uncertainty regarding many of the variables that make up the formula for the Energy Price Limits.

To address this, the probability distribution of each of the Maximum Prices is developed.

A probability distribution for each of the key input variables that are uncertain in each of the Maximum Price formula is required to be produced.

The probability distributions are convolved using a Monte Carlo approach. This has values sampled at random from the input probability distributions in the formula.

10,000 iterations of the model are used to generate the final probability distribution of possible Maximum STEM Price outcomes.



Methodology – Risk Margin

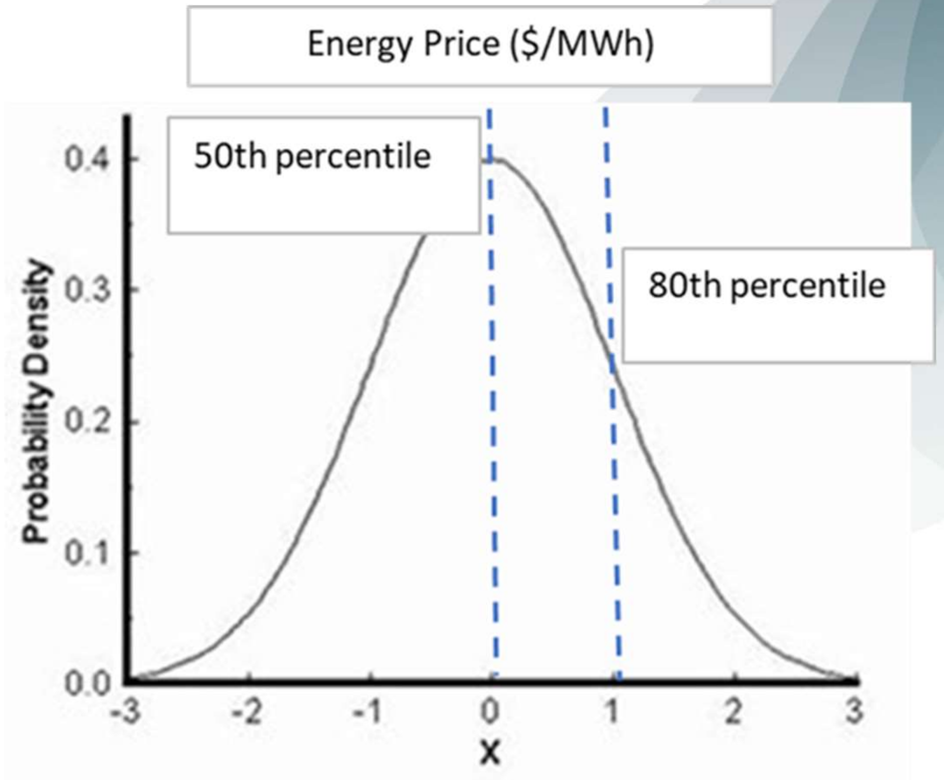
The Risk Margin is defined as the ratio above 1 such that the Maximum STEM prices covers 80% of the distribution.

$$Risk\ Margin = \frac{Maximum\ STEM\ Price_{\$/MWh}}{Mean\ Dispatch\ Cost_{\$/MWh}} - 1$$

The Risk Margin is a scale factor and has no units.

For the 10,000 simulations run 8,000 are at or below and 2,000 above.

Risk Margin is based on Mean Dispatch Cost not Median Dispatch Cost so depending on the shape of the distribution it is possible for the risk margin to be negative value.



Candidate Peaking Generator

The WEM Rules, Clause 6.20.7(b)(i)-(v) of the WEM Rules stipulate that the candidate units must be 40 MW OCGT units.

Stations considered as Peaking Candidate based on above included:

- Pinjar;
- Parkeston AG; and
- Mungarra.

On 1 October 2018, Western Power and Synergy entered into an NCS contract in relation to the Mungarra Units. As Mungarra Units will not be dispatched in the WEM except under the terms of the NCS they are not candidates.

The Pinjar and Parkeston Units were considered candidate OCGTs.

For Parkeston only units 2 and 3 were considered as unit 1 is primarily used to provide generation onsite and not export into the SWIS

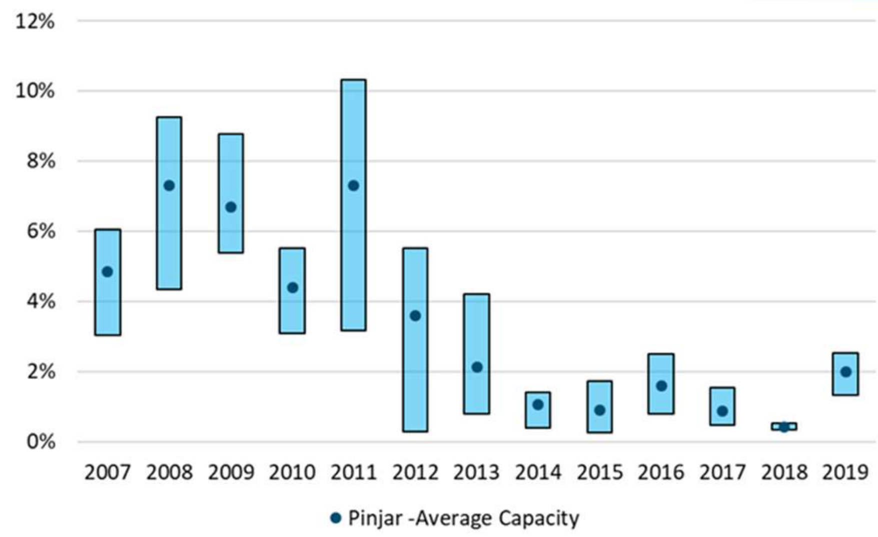
Candidate OCGT units for setting upper Energy Price Limits

Unit	Maximum Capacity (MW)	Technology
PINJAR_GT1	38.5	Industrial GT
PINJAR_GT2	38.5	Industrial GT
PINJAR_GT3	39.3	Industrial GT
PINJAR_GT4	39.3	Industrial GT
PINJAR_GT5	39.3	Industrial GT
PINJAR_GT7	39.3	Industrial GT
PRK_AG Unit 2	37	Aero-derivative
PRK_AG Unit 3	37	Aero-derivative

Candidate Peaking Generator - Pinjar

The Pinjar Units are owned and operated by Synergy and were fully operational by late 1990:

- Between 2014 and 2018 the average capacity factor of Pinjar has been less than 2%
- In 2019 the average capacity factor of Pinjar was around 2% the highest since 2013.

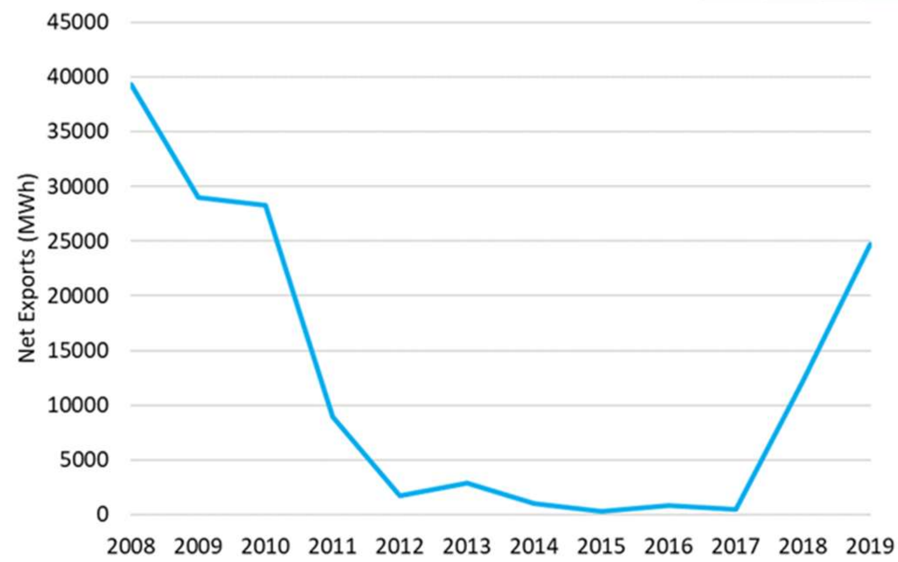


Unit	PINJAR_GT1	PINJAR_GT2	PINJAR_GT3	PINJAR_GT4	PINJAR_GT5	PINJAR_GT7
No. of Starts	44	33	36	38	31	44
Hours Operating	524	435.5	369.5	480	409	413
Average Output (MW)	16.0	13.8	14.9	16.3	17.0	16.6
Annual Generation (MWh)	8384	6009	5500	7804	6948	6843
Capacity Factor (%)	2.5%	1.8%	1.6%	2.3%	2.0%	2.0%

Candidate Peaking Generator - Parkeston

Parkeston Units provide electricity to a major mining customer in the Goldfields Region which typically has an average energy requirement of around 40 MW baseload.

Unit	PRK_AG
No. of Starts	296
Hours Operating	1392.5
Average Output (MW)	17.7
Annual Generation (MWh)	24682
Capacity Factor (%)	2.41%



PRK_AG is an aggregate of three 37 MW units

Variable O&M Costs - Method

To calculate O&M costs in terms of a distribution $/MWh the following steps were taken.

Step 1: determine a point estimate of maintenance costs per start based on (confidential) data provided by both Synergy and Goldfields Power Pty Ltd.

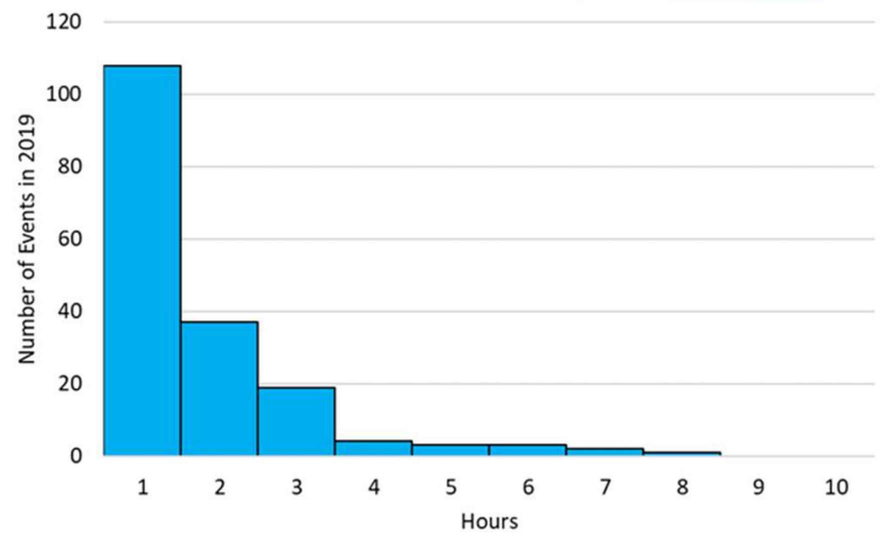
Step 2: create a distribution of start costs ($/Start) - the number of starts can vary which will change the overhaul maintenance cycle and hence the VOM costs per start.

Step 3: determine the relationship between the number of starts in a year and maintenance overhaul costs.

Step 4: determine the distribution of dispatch event MWh (generation) equal to or less than 6 hours.

Finally the outcomes from Step 3 ($/Start) and Step 4 (MWh/start) are combined to produce a distribution of ($/MWh) for variable O&M.

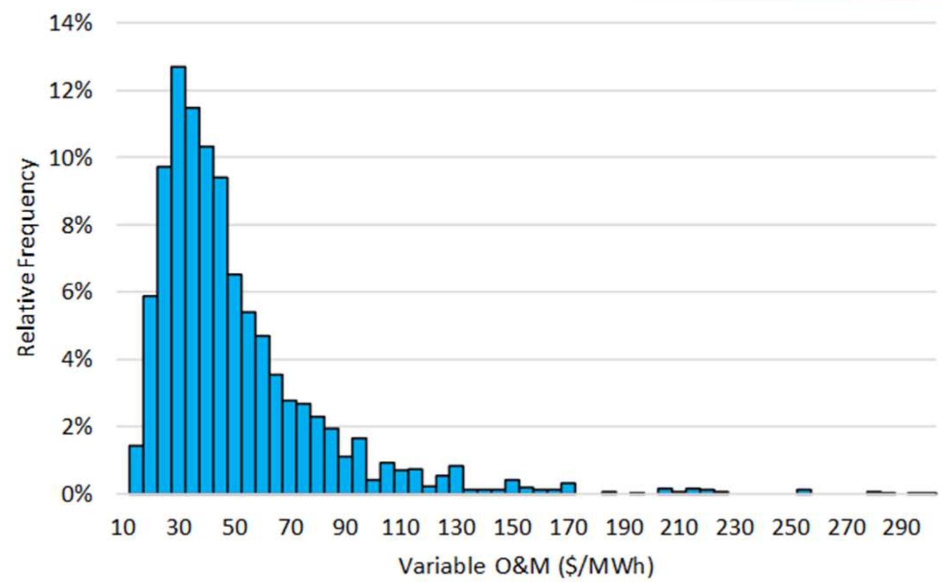
Number of events where Balancing Price continually exceeded $100/MWh in 2019



Variable O&M Costs - Distribution

- Both Pinjar and Parkeston (Displayed) had a similar shape distribution.
- The Variable O&M costs can vary greatly based on the level of dispatch in a year. Simulations with low annual dispatch can potentially have high costs as there is little generation to aggregate costs over .

Variable O&M distribution Parkeston



Heat Rate and Loss Factors – Heat Rates

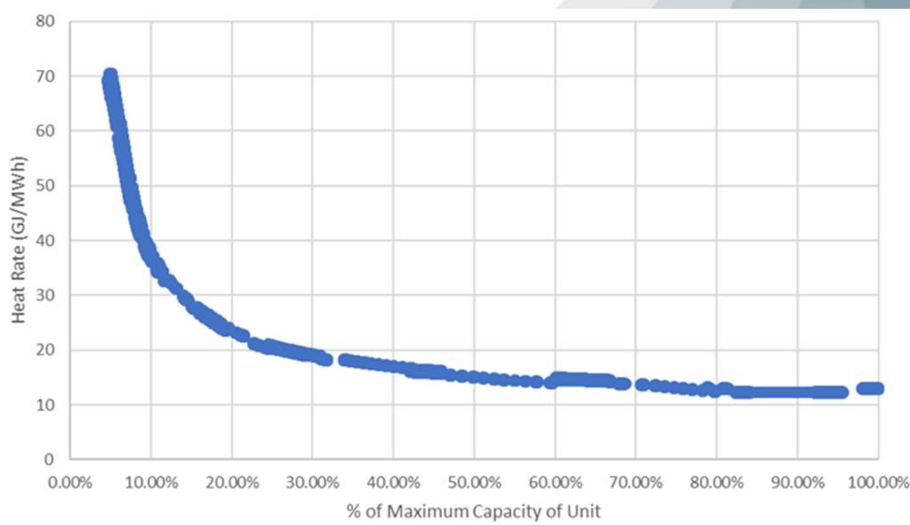
Heat rate curves for both Pinjar and Parkeston were provided (confidential) and used in the modelling:

- Mean heat rate for Pinjar was 19.19 GJ/MWh
- Mean heat rate for Parkeston was 15.31 GJ/MWh.

Pinjar mean heat was higher than Parkeston due to more times operation was at lower capacity factors

Start up fuel was also included in the calculations of fuel consumption. For a typical dispatch of Parkeston or Pinjar this accounted for equivalent to about 1-1.5 additional MWhs.

Example Heat rate Curve for OCGT unit



Heat Rate and Loss Factors – Loss Factors

Loss Factors are used to determine the quantity of sent out electricity that is delivered from a generator to a reference node.

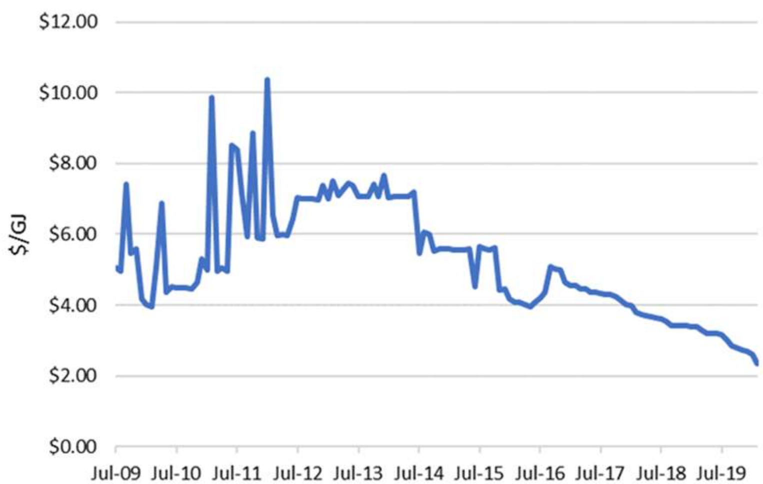
The SWIS has only one reference node, which is defined as the Muja 330 bus-bar.

Loss Factor Area Code	Description	Loss Factor	Start Date
WPJR	Pinjar Units	1.0369	1-Jul-19
WPKS	Parkeston Units	1.1633	1-Jul-19

Gas & Distillate Costs – Gas Commodity

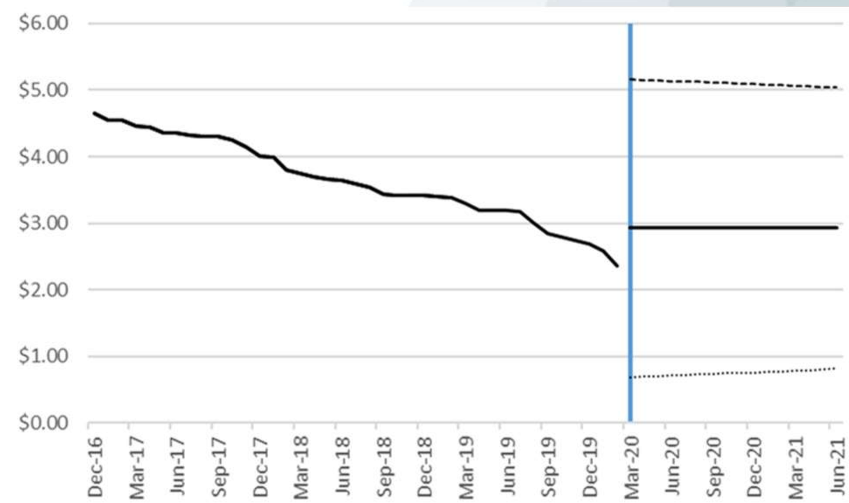
- Projections of maximum gas prices were developed using an ARIMA model of historical maximum monthly prices.
- A normal distribution was assumed to exist for projected prices.

Historical maximum gas prices



Source: gasTrading Australia, various Access dates

Projections of maximum gas prices 2020-21 (Includes bounds)



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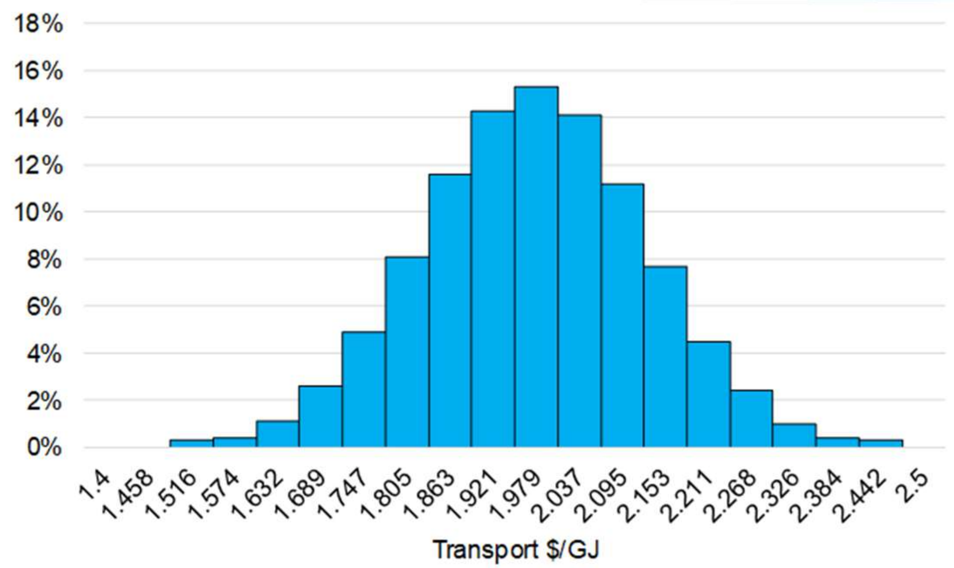
Gas & Distillate Costs – Gas Transport

Pinjar transports costs was based on a 15% premium above the T1 Reference Tariff applicable on the Dampier to Bunbury Natural Gas Pipeline.

Parkeston transports costs was based on the purchase of spot transport for covered services on the Goldfields Gas Pipeline and calculated to be $1.81GJ.

A standard deviation of $0.15/GJ was assumed for both Pinjar and Parkeston.

Pinjar Distribution of gas transport costs



Gas & Distillate Costs – Distillate

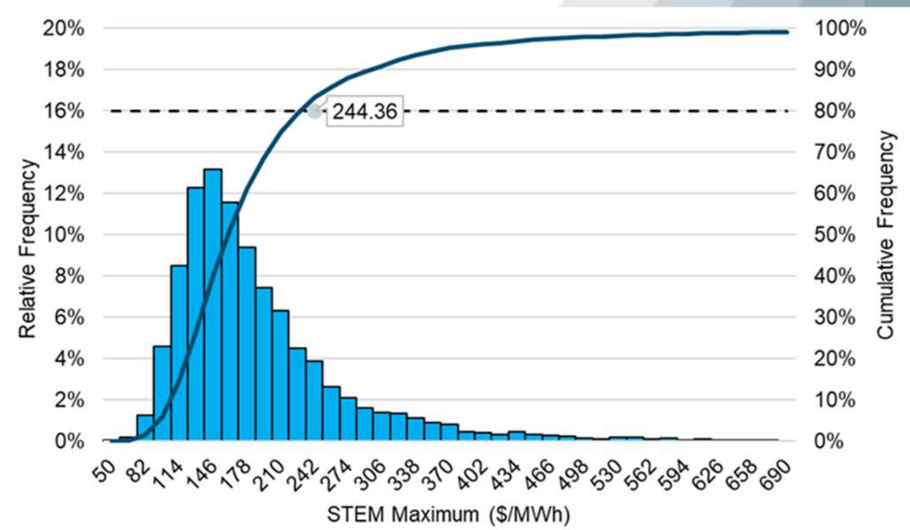
Distillate Costs were determined as follows:

- Remove GST and the Diesel Excise to derive a Terminal Gate Price that would be paid by local generators;
- Add in the cost of transport from the Kwinana refinery to the generation plant;
- Convert the delivered cost of distillate into a price in $/GJ;
- The distribution of in Distillate prices were based on the daily variation at the Perth Terminal.

Prices and Taxes	AUD cents per litre (ACPL)	AUD/GJ
Diesel TGP	135.6	
Excise	42.3	
GST	9.33	
Diesel TGP	84.0	21.75
Delivery Cost to Pinjar	1.2	
Delivery Cost to Parkeston	1.1	
Delivered Cost to Pinjar	85.2	22.06
Delivered Cost to Parkeston	85.1	22.04

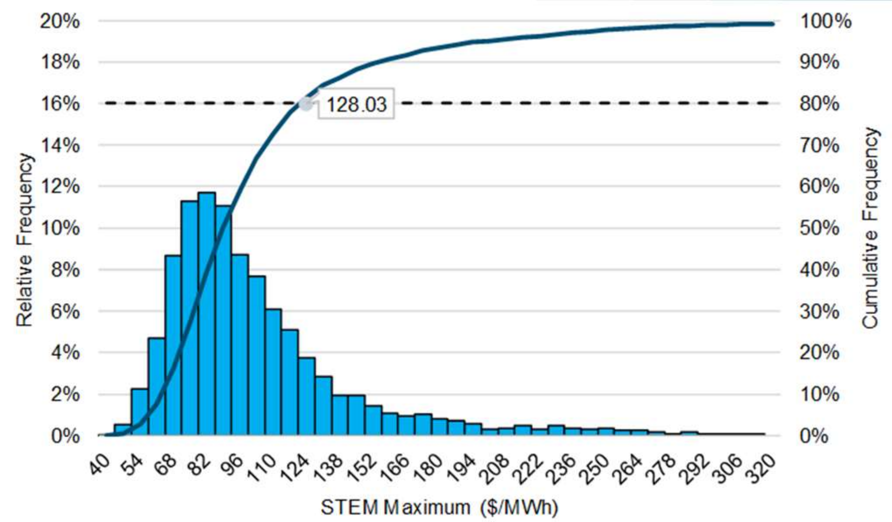
Modelling Results - Maximum STEM Price: Pinjar Units

Component	Units	Values
Mean Variable O&M Cost	$/MWh	110.48
Mean Heat Rate	GJ/MWh	19.19
Mean Fuel Cost (heat rate adjusted)	$/MWh	108.78
Loss Factor		1.0369
Before Risk Margin	$/MWh	211.45
Risk Margin Added	$/MWh	32.90
Risk Margin Value	%	15.56
Assessed Maximum STEM Price	$/MWh	244.36



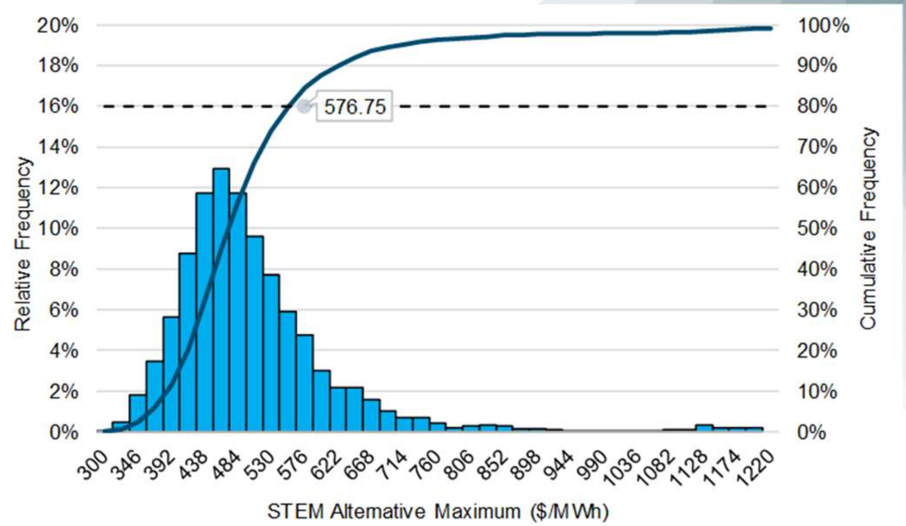
Modelling Results - Maximum STEM Price: Parkeston Units

Component	Units	Values
Mean Variable O&M Cost	$/MWh	50.55
Mean Heat Rate	GJ/MWh	15.31
Mean Fuel Cost (heat rate adjusted)	$/MWh	76.70
Loss Factor		1.1633
Before Risk Margin	$/MWh	109.39
Risk Margin Added	$/MWh	18.64
Risk Margin Value	%	17.04
Assessed Maximum STEM Price	$/MWh	128.03



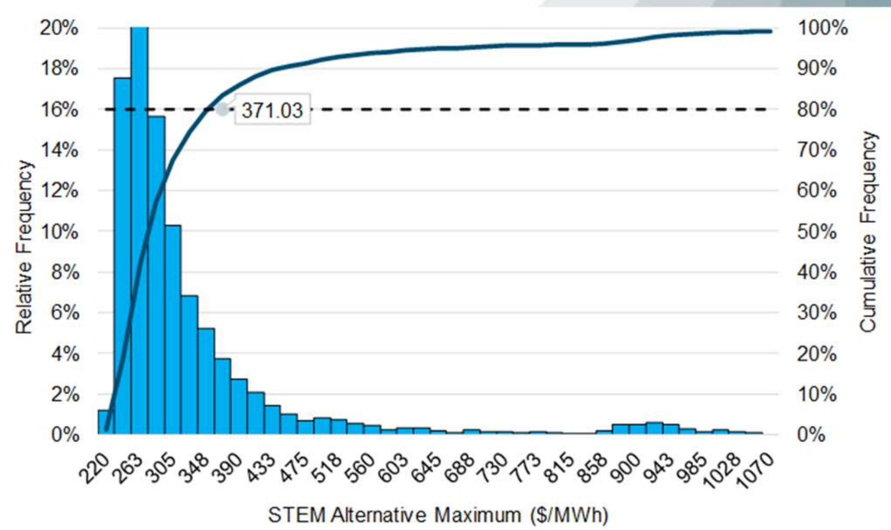
Modelling Results – Alternative Maximum STEM Price: Pinjar Units

Component	Units	Values
Mean Variable O&M Cost	$/MWh	110.48
Mean Heat Rate	GJ/MWh	19.07
Mean Fuel Cost (heat rate adjusted)	$/MWh	432.43
Loss Factor		1.0369
Before Risk Margin	$/MWh	523.59
Risk Margin Added	$/MWh	53.16
Risk Margin Value	%	10.15
Assessed Maximum STEM Price	$/MWh	576.75



Modelling Results – Alternative Maximum STEM Price: Parkeston

Component	Units	Values
Mean Variable O&M Cost	$/MWh	50.55
Mean Heat Rate	GJ/MWh	15.31
Mean Fuel Cost (heat rate adjusted)	$/MWh	352.93
Loss Factor		1.1633
Before Risk Margin	$/MWh	346.85
Risk Margin Added	$/MWh	24.18
Risk Margin Value	%	6.97
Assessed Maximum STEM Price	$/MWh	371.03



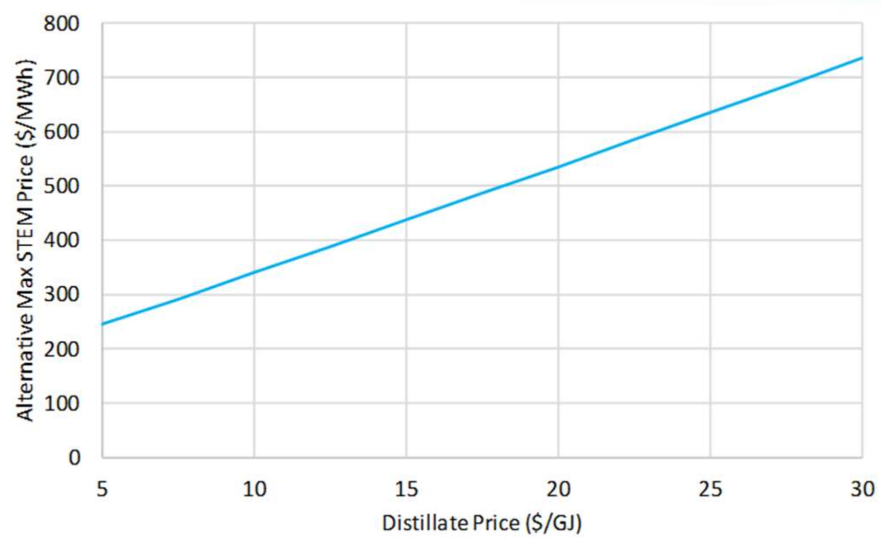
Modelling Results – Alternative Maximum STEM Price Vs Distillate Price

The Alternative Maximum STEM Price varies each month according to changes in the price of distillate.

Regression was used to separate out the cost components that depend on Fuel Cost and those components which are independent of Fuel Cost.

The regression involves:

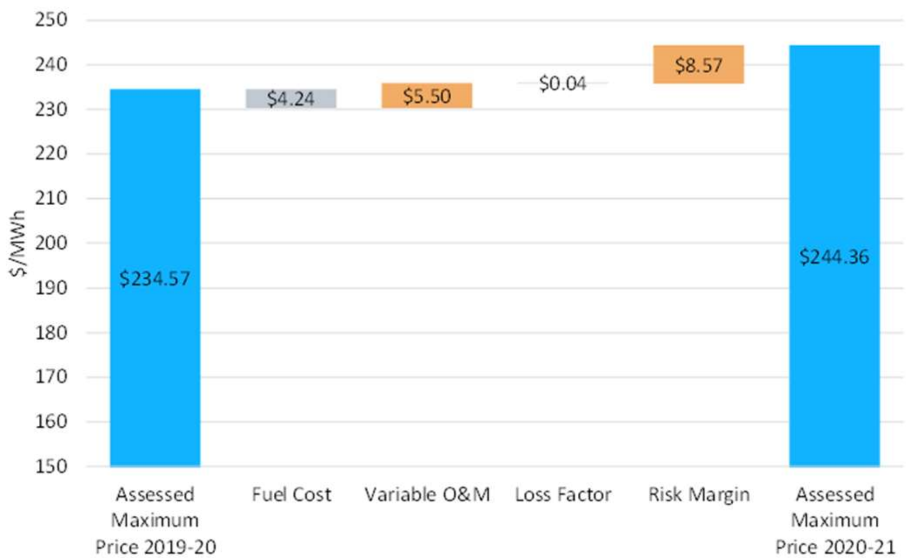
- A range of fixed distillate prices between \$5 and \$30/GJ
- Simulation run at step sizes of \$2.5/GJ
- Linear regression of simulations (Least Squares).



$$143.95_{\$/MWh} + (19.627_{GJ/MWh} \times Delivered\ Distillate\ Price_{\$/GJ})$$

Change in Energy Price Limit - Maximum STEM Price

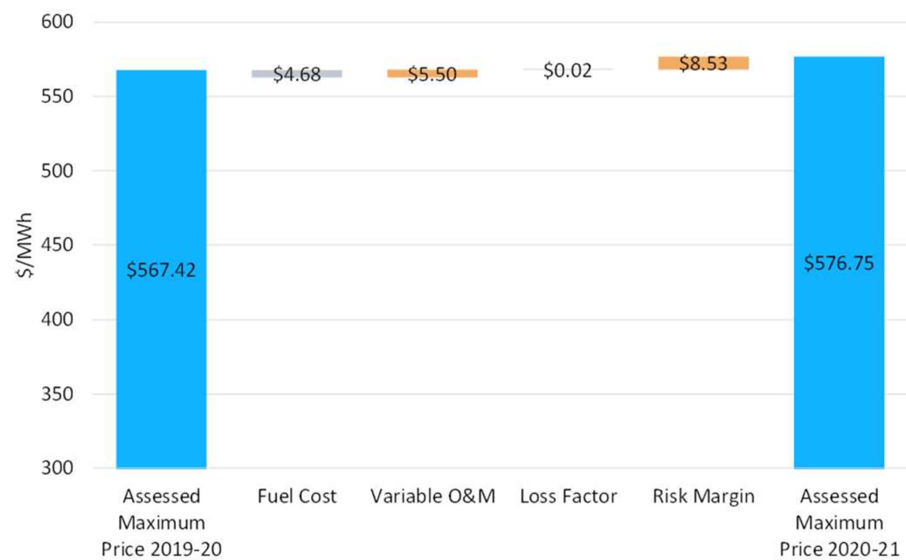
- Largest change in the Maximum STEM Price was the Risk Margin Component which increased by $8.57/MWh.
- Fuel costs had a slight reduction -$4.24/MWh. This was due to higher mean heat rates from higher operation in 2019.
- Variable O&M showed a slight increase by $5.5/MWh.



Component	Units	2020-21	2019-20	Change
Mean Variable O&M Cost (a)	$/MWh	110.48	104.98	5.50
Mean Heat Rate	GJ/MWh	19.19	20.62	-1.43
Mean Fuel Cost (heat rate adjusted) (a)	$/MWh	108.78	113.02	-4.24
Loss Factor		1.0369	1.0369	0.00
Before Risk Margin	$/MWh	211.45	210.24	1.21
Risk Margin Added	$/MWh	32.90	24.33	8.57
Risk Margin Value	%	15.56	11.57	3.99
Assessed Maximum STEM Price	$/MWh	244.36	234.57	9.79

Change in Energy Price Limit - Alternative Maximum STEM Price

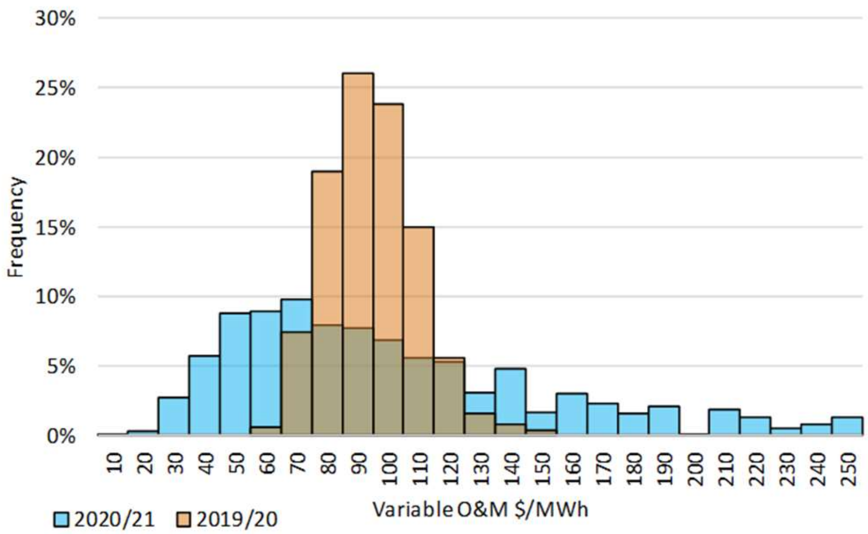
- Fuel costs had a slight reduction -$4.68/MWh due to higher mean heat rates from higher operation in 2019.



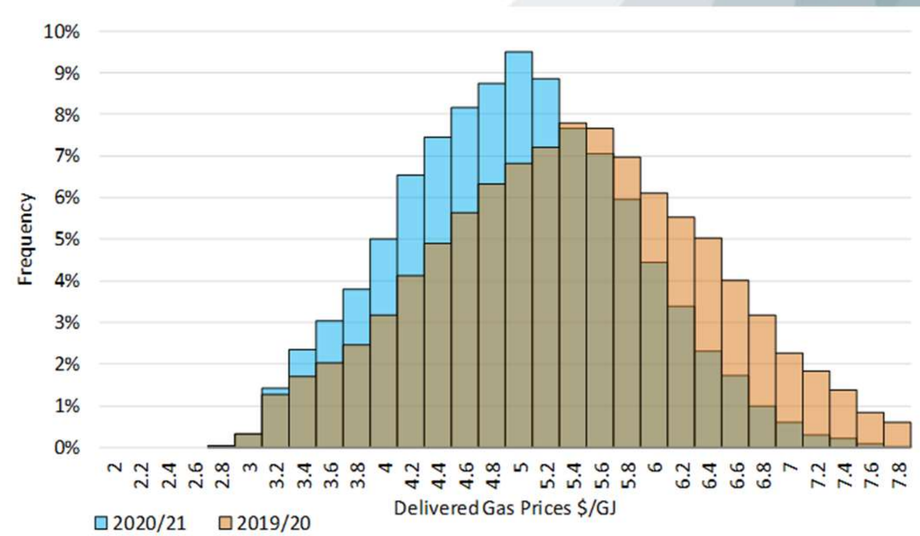
Component	Units	2020-21	2019-20	Change
Mean Variable O&M Cost (a)	$/MWh	110.48	104.98	5.50
Mean Heat Rate	GJ/MWh	19.07	20.62	-1.55
Mean Fuel Cost (heat rate adjusted) (a)	$/MWh	432.43	437.11	-4.68
Loss Factor		1.0369	1.0369	0.00
Before Risk Margin	$/MWh	523.59	522.79	0.80
Risk Margin Added	$/MWh	53.16	44.63	8.53
Risk Margin Value	%	10.15	8.54	1.61
Assessed Maximum STEM Price	$/MWh	576.75	567.42	9.33

Change in Energy Price Limit – Probability Density Functions

Comparison of probability density function for Variable O&M Costs ($/MWh)



Comparison of probability density function for Delivered Gas Costs ($/GJ)



Additional considerations - Perth Diesel Terminal Gate Price

- The Report was written during March 2020 and used Perth Diesel Terminal Gate Prices to the Feb with Prices at ~130 Cents per litre.
- Diesel Prices have dropped by over 40% in the past 2 months as a result of COVID 19.
- By April 30 the price was around 90 cents per litre a 40 cent reduction or around $11/GJ.
- Based on the regression formula this is around a $200/MWh reduction to the Alternative Maximum STEM Price.

Prices and Taxes	AUD cents per litre (ACPL)	AUD/GJ	AUD cents per litre (ACPL) ESTIMATE FROM 22 APRIL	AUD/GJ (ESTIMATE FROM 22 APRIL)
Diesel TGP	136		94.1	
Excise	42.3		42.3	
GST	9.33		5.18	
Diesel TGP	84	21.8	46.6	12.07
Delivery Cost to Pinjar	1.2		1.2	
Delivery Cost to Parkeston	1.1		1.1	
Delivered Cost to Pinjar	85.2	22.1	47.8	12.38
Delivered Cost to Parkeston	85.1	22	47.7	12.36