



# **Estimates of Long-run Marginal Cost (LRMC) of Energy and Cost of LGCs**

**A REPORT PREPARED FOR SYDNEY DESALINATION PLANT**

October 2016



# Estimates of Long-run Marginal Cost (LRMC) of Energy and Cost of LGCs

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Frontier Economics' engagement	1
1.2	This report	1
<b>2</b>	<b>Overview of modelling approach</b>	<b>2</b>
2.1	LRMC	2
2.2	Overview of modelling approach	2
2.3	Overview of modelling assumptions	3
<b>3</b>	<b>Modelling results</b>	<b>6</b>
3.1	LRMC of energy in NSW	6
3.2	Cost of LGCs	7
3.3	Conclusion	8
	<b>Appendix A – Modelling assumptions</b>	<b>9</b>
	Demand forecasts	9
	New generation technologies	10
	Fuel prices	12

# Estimates of Long-run Marginal Cost (LRMC) of Energy and Cost of LGCs

## Figures

Figure 1: LRMC of energy in NSW (\$2016/17)	7
Figure 2: Cost of LGCs (\$2016/17)	8
Figure 3: AEMO demand forecasts (NSW, Victoria and Queensland)	9
Figure 4: AEMO demand forecasts (South Australia and Tasmania)	10
Figure 5: Forecast capital costs for coal generation plant (\$2015/16)	11
Figure 6: Forecast capital costs for gas and renewable generation plant (\$2015/16)	12
Figure 7: LRMC of gas by State capital cities (\$2015/16) – Base Case	13
Figure 8: Coal prices for representative generators (\$2015/16) – Base Case	14

# 1 Introduction

The Independent Pricing and Regulatory Tribunal (**IPART**) is currently reviewing the charges associated with the Sydney Desalination Plant Pty Ltd (SDP).

IPART previously reviewed and determined the charges associated with SDP for the period 1 July 2012 to 30 June 2017 (2012 Determination). IPART is currently reviewing and will determine the charges with SDP for the period 1 July 2017 to 30 June 2022 (2017 Determination).

## 1.1 Frontier Economics' engagement

Frontier Economics has been engaged by SDP to advise SDP on estimates of:

- the long run marginal cost (**LRMC**) of energy in NSW
- the cost of Large-Scale Generation Certificates (**LGCs**) created under the Large-Scale Renewable Energy Target (**LRET**).

Frontier Economics previously advised IPART on these matters as part of IPART's 2012 Determination. Frontier Economics' report to IPART is available on IPART's website.<sup>1</sup> We have been asked by SDP to estimate the LRMC of energy and the cost of LGCs using the same approach as used in our advice to IPART for its 2012 Determination.

## 1.2 This report

This report sets out our advice on estimates of the LRMC of energy. This report is structured as follows:

- Section 2 provides a brief overview of the modelling approach and input assumptions we have used to estimate the LRMC of energy and the cost of LGCs
- Section 3 sets out the results of our modelling.

Appendix A provides further detail on the input assumptions we have used in our modelling.

---

<sup>1</sup> Frontier Economics. *Energy costs for Sydney Desalination Plant Pty Ltd*, A Report Prepared for IPART, November 2011. Available at:

[https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/consultant\\_report\\_-\\_energy\\_costs\\_for\\_sydney\\_desalination\\_plant\\_pty\\_ltd\\_-\\_frontier\\_economics\\_-\\_november\\_2011\\_pdf\\_version.pdf](https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/consultant_report_-_energy_costs_for_sydney_desalination_plant_pty_ltd_-_frontier_economics_-_november_2011_pdf_version.pdf)

## 2 Overview of modelling approach

This section provides a brief overview of the modelling approach and modelling assumptions that we have used to estimate the LRMC of energy and the cost of LGCs.

### 2.1 LRMC

For the purposes of the 2012 Determination, we advised IPART on estimates of the LRMC of energy in NSW as a basis for forming a view on the likely energy price in NSW over the period to 2016/17 (and ultimately to 2029/30).

While there may be other approaches to establishing the efficient energy costs faced by SDP and these may provide higher or lower forecasts of energy costs and LGC prices – depending on the allocation of risk and the impacts on customers – an analysis of these approaches is beyond the scope of this report.

### 2.2 Overview of modelling approach

We have estimated the LRMC of energy in NSW using an ‘incremental’ LRMC approach. This approach measures the incremental fixed (therefore, long run) and variable costs of supplying an additional unit of load. This approach seeks to price load on the basis of the least cost way of adding to the existing stock of plant.

For the purposes of estimating both the LRMC of energy and the cost of LGCs, Frontier Economics uses *WHIRLYGIG*, Frontier’s cost optimisation model.

*WHIRLYGIG* optimises total generation cost in the electricity market, calculating the least cost mix of existing generation plant and new generation plant to meet energy demand. When used to model the National Electricity Market (**NEM**), *WHIRLYGIG* incorporates a representation of both the supply-side and demand-side of the market. On the supply-side, the model includes all existing scheduled generators in the NEM (including a representation of their costs and their key technical characteristics), options for new generation projects in the NEM (including a representation of the costs and key technical characteristics of new generation plant) and each inter-regional interconnector between NEM regions. On the demand-side, the model includes forecasts of demand in each NEM region. The model also incorporates regulatory policies relevant to the energy market, including the LRET.

*WHIRLYGIG* can be used to calculate both the LRMC of energy (the additional costs associated with an increase in energy demand) and the LRMC of LGCs (the additional costs associated with an increase in the target under the LRET).

When used to calculate the LRMC of energy in NSW for SDP, our estimate includes both short run marginal costs (that is, fuel costs and other variable costs

of generating electricity) and capital costs. The capital cost component that we include in our modelling is not discounted in any way to reflect the number of years before additional capital investment is required in the market. This is consistent with the approach in our 2011 report for IPART.

## 2.3 Overview of modelling assumptions

*WHIRLYGIG* requires a range of input assumptions in order to give effect to the model's representation of the supply-side and demand-side of the NEM.

These input assumptions are summarised in this section and set out in more detail in Appendix A.

### **Discount rate**

*WHIRLYGIG* optimises the total system costs of meeting demand over the entire modelling period. Total system costs are calculated as a net present cost in a specified base year using an assumed discount rate. The objective to be minimised by the model is the net present cost.

We use a pre-tax, real WACC of 8.3 per cent for electricity generation to discount future values for the optimisation process. The discount rate that we have adopted is based on the discount rate determined by IPART as part of their most recent regulatory determination. We have updated relevant parameters used in the calculation of these discount rates to account for current market conditions.

### **Demand forecasts**

The energy and maximum demand projections for each NEM region that we use are based on AEMO's National Electricity Forecasting Report for 2016 (AEMO 2016 NEFR). We use the medium growth, 50 per cent probability of exceedance (POE) projections from the AEMO 2016 NEFR for the purposes of determining the energy and maximum demand projections, and the medium growth, 10 per cent POE projections for summer and winter for the purpose of modelling reserve constraints.

A summary of these demand forecasts is provided in Appendix A.

Using demand forecasts for each NEM region provides an estimate of the LRMC of meeting regional demand (i.e. the LRMC of meeting NSW demand). In forming a view about long-term prices, it is appropriate to estimate the LRMC to meet regional demand, since market prices are determined relative to regional demand. While the LRMC of other load shapes could be estimated (for instance the load shape of SDP), these would be more appropriate to estimating the resource costs of meeting those load shapes.

### **Existing NEM generation plant**

We use the latest information available from AEMO's website<sup>2</sup> on existing and committed scheduled and semi-scheduled generation plant in each region of the NEM. This provides both the identity of existing and committed generation plant and the summer and winter capacity of these generation plant.

In addition, our modelling requires key technical<sup>3</sup> and cost information<sup>4</sup> for existing generation plant. The technical and cost information that we use in our modelling is our current base case set of input assumptions. For existing generation plant, our base case set of technical and cost information for existing generation plant is largely based on the input assumptions developed by AEMO as part of their National Transmission Network Development Plan (NTNDP). The key exception is for fuel costs, which are discussed in more detail below.

### **New generation plant**

Our modelling incorporates the opportunity to invest in new generation plant from a number of generic technologies that are available in the NEM. This includes a number of generic renewable technologies.

For each of these technologies, our modelling requires key technical<sup>5</sup> and cost information.<sup>6</sup> This information is based on our own analysis, including our own detailed database of costs and characteristics of generation plant.

The generic technologies that we model, and our estimates of the capital costs for these generation plant, are summarised in Appendix A.

### **Fuel costs**

The power station fuel prices that we use in our modelling are based on modelling and analysis of the Australian gas and coal markets. We maintain a Base Case that

---

<sup>2</sup> AEMO, Generation Information Page:

<https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information>

<sup>3</sup> The power station technical information incorporated in our modelling includes thermal efficiency, emissions intensity, maximum capacity factor, outages rates and auxiliary power use.

<sup>4</sup> The cost information for existing generation plant incorporated in our modelling includes variable costs only (variable operating costs and fuel costs). Since the decision to invest in existing generation plant has already been made, fixed costs for this plant are not relevant to economic decisions regarding this plant.

<sup>5</sup> The power station technical information incorporated in our modelling includes thermal efficiency, emissions intensity, maximum capacity factor, outages rates and auxiliary power use.

<sup>6</sup> The cost information for new generation plant incorporated in Frontier Economics' modelling includes variable costs (variable operating costs and fuel costs) and fixed costs (fixed operating costs and capital costs).



reflects current estimates of key inputs such as production and transport costs, gas and coal exports and long term export prices for LNG and coal.

A summary of these fuel price forecasts is provided in Appendix A.

### ***Carbon price***

Reflecting current policy, our modelling does not include a carbon price for electricity generation.

### ***LRET target***

Reflecting current policy, our modelling includes the current LRET target, reaching 33,000 GWh in 2020.

## 3 Modelling results

This section sets out our estimates of the LRMC of energy in NSW and of LGCs.

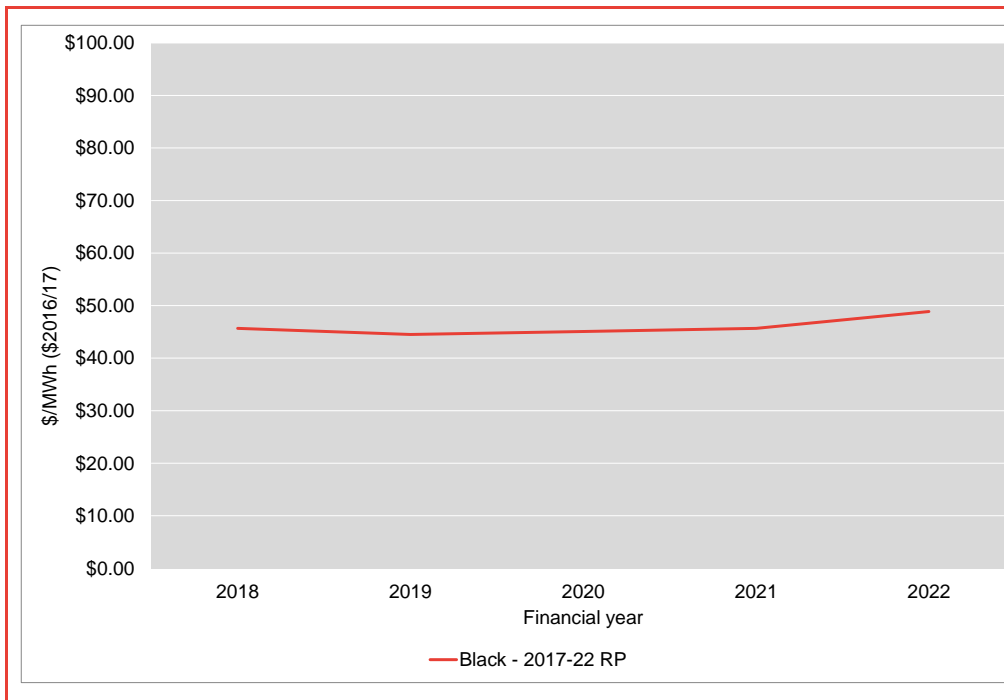
### 3.1 LRMC of energy in NSW

We have estimated the LRMC of energy in NSW using an incremental LRMC approach and the forecast regional demand for NSW (and other NEM regions). This approach assumes that the existing mix of generation plant in the system is in place and that demand can be served using both existing generation plant and new generation plant. Estimating the LRMC using this approach is most appropriate for the purpose of considering long-term wholesale energy prices.

In contrast, for the purposes of IPART's reviews of retail electricity tariffs, we have estimated the LRMC of meeting the regulated load shape using a stand-alone LRMC approach. This approach assumes that there is currently no plant available to serve the required load. Estimating the LRMC using this approach is most appropriate for the purpose of considering the resource cost of meeting a particular electricity load.

The results of our estimate of the LRMC of energy in NSW are shown in Figure 1. The LRMC of energy is between \$45/MWh and \$50/MWh for the five years of the next regulatory period. These estimates of the LRMC of energy in NSW are a little lower than the equivalent estimates of the LRMC of energy in NSW over this period from our 2011 report for IPART (once the estimates from our 2011 report are inflated to 2016/17 dollars). These differences reflect the updated input assumptions, including demand, capital costs and fuel costs.

Figure 1: LRMC of energy in NSW (\$2016/17)

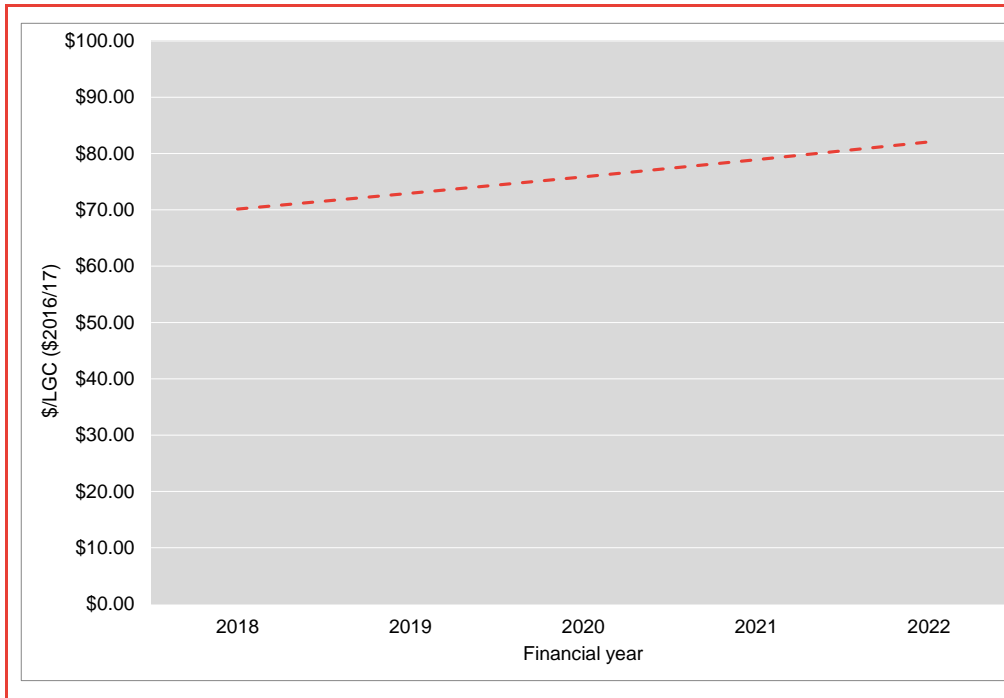


Source: Frontier Economics

### 3.2 Cost of LGCs

The results of our estimate of the cost of LGCs are shown in Figure 2. The cost of LGCs starts at around \$70/LGC and increases to a little over and \$80/LGC over the five years of the next regulatory period. These estimates of the cost of LGCs are a little lower than the equivalent estimates of the cost of LGCs over this period from our 2011 report for IPART (once the estimates from our 2011 report are inflated to 2016/17 dollars). These differences reflect the updated input assumptions, including demand, capital costs and fuel costs.

Figure 2: Cost of LGCs (\$2016/17)



Source: Frontier Economics

Our modelling of the cost of LGCs incorporates the renewable energy shortfall charge: where the tax-effective shortfall charge is lower than the cost of additional renewable generation, our modelling will result in a shortfall of LGCs paid for at the shortfall charge. Our modelling indicates that it is least cost for some shortfall to occur, and this shortfall occurs in the mid-2020s. As a result, our modelling cost of LGCs in any year of the next regulatory period is the cost of the shortfall charge at the time the shortfall occurs, discounted to the relevant year.

### 3.3 Conclusion

The results discussed above are summarised in Table 1.

Table 1: Summary of LRMC results (\$2016/17)

Financial year	2018	2019	2020	2021	2022
LRMC of energy in NSW	\$45.66	\$44.50	\$45.07	\$45.67	\$48.87
Cost of LGCs	\$70.14	\$72.95	\$75.86	\$78.92	\$82.07
Total	\$115.81	\$117.44	\$120.94	\$124.59	\$130.95

Source: Frontier Economics

## Appendix A – Modelling assumptions

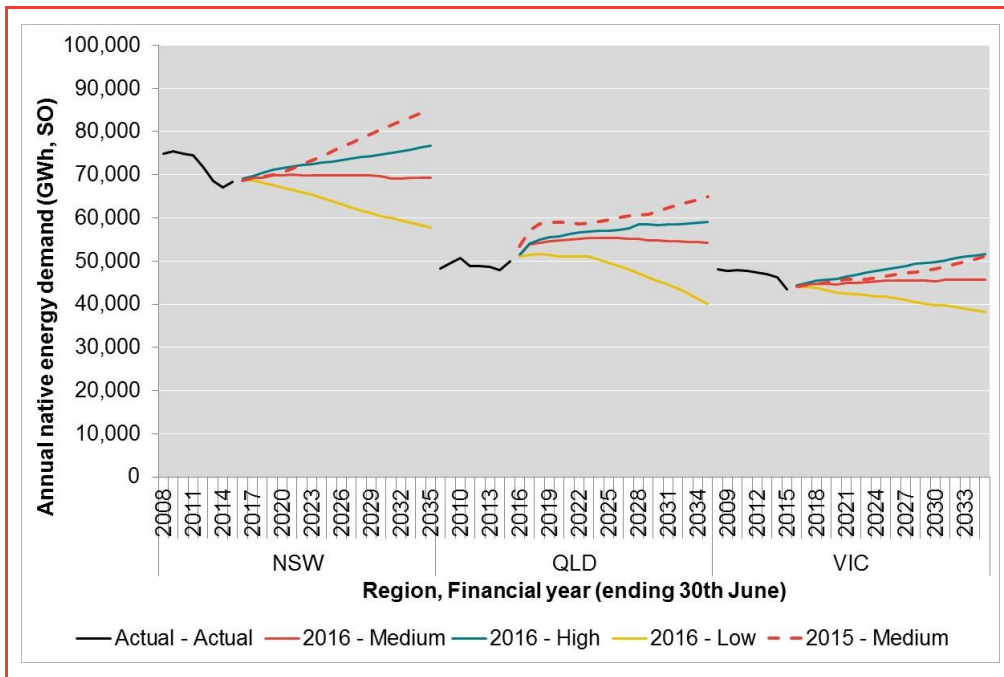
This Appendix summarises those input assumptions that are most material to our modelling results. These are: demand forecasts, new generation technologies and their capital costs, and fuel costs.

### Demand forecasts

AEMO’s 2016 NEFR includes demand forecasts for three scenarios: Low, Medium, and High. Figure 3 and Figure 4 shows these annual energy forecasts from AEMO, as well as showing the Medium demand forecast from the AEMO 2015 NEFR for the purposes of comparison. Figure 3 shows the demand forecasts for New South Wales, Victoria and Queensland, and Figure 4 shows the demand forecasts for South Australia and Tasmania (on a different scale).

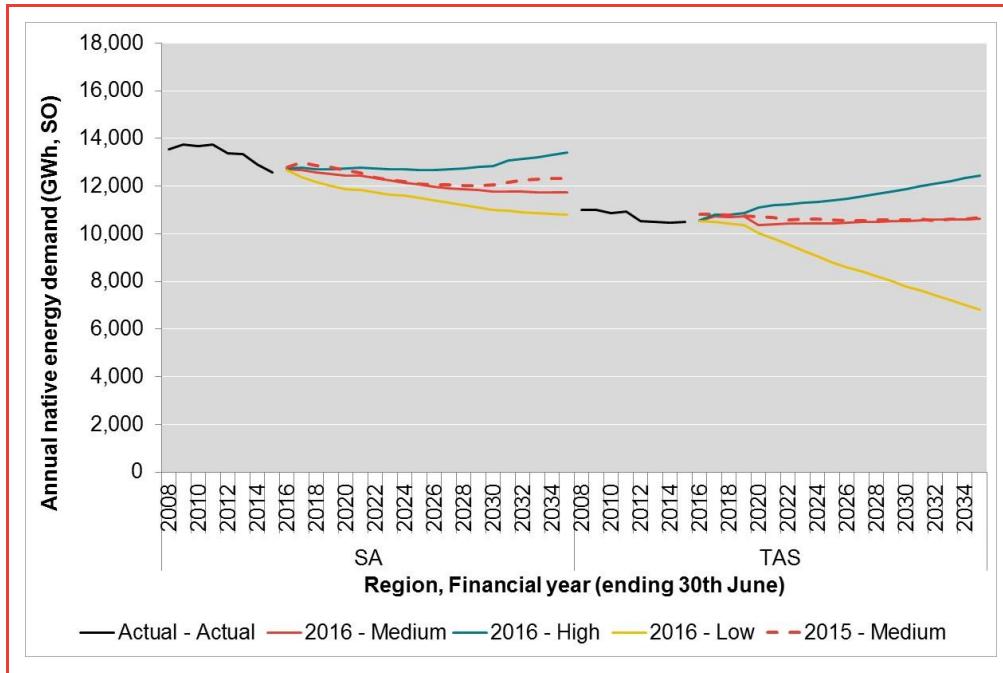
As can be seen, this year's Medium forecast predicts far less growth in demand than the 2015 Medium case; demand is expected to be lower in both the short and longer term in NSW, Victoria and Queensland. Indeed, in most regions, this year’s Medium forecast has annual energy relatively flat over the forecast period in all jurisdictions.

Figure 3: AEMO demand forecasts (NSW, Victoria and Queensland)



Source: AEMO 2016 NEFR and AEMO 2015 NEFR

Figure 4: AEMO demand forecasts (South Australia and Tasmania)



Source: AEMO 2016 NEFR and AEMO 2015 NEFR

## New generation technologies

Our modelling includes a range of generic generation technologies that can be built to meet growing demand, replace retiring generation plant or meet the renewable energy target. These technologies include different black coal and brown coal technologies, open cycle and combined cycle gas turbines and a number of renewable technologies.

For each of these technologies we have estimated a capital cost. Our estimates of capital costs are intended to reflect the capital costs for a representative generation plant for each of the generation technologies considered in this report.

Our estimates of capital costs include the direct costs of all plant, materials, equipment and buildings inside the power station fence, all labour costs associated with construction, installation and commissioning, as well as owner's costs such as land, development approvals, legal fees, inventories, etc. Our estimates of capital costs do not include the costs of connection to the network, but we have added these connection costs to our capital cost estimates for new generation plant so that the modelled capital cost includes the capital costs 'inside the fence' as well as the cost of connecting to the network.

Our estimates of capital costs are overnight capital costs, expressed in 2015/16 Australian dollars. That is, our estimates do not include interest (or escalation) during construction. These costs are accounted for in the financial model that we

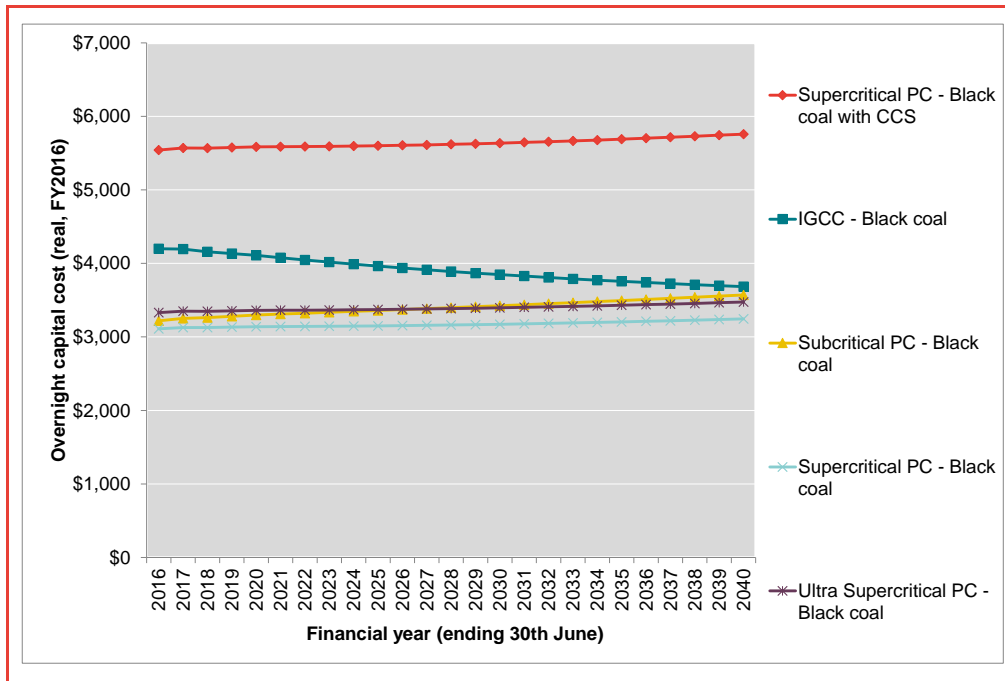
## Modelling results

use to convert overnight capital costs (in \$/kW) into an amortised capital cost (in \$/MW/hour) that is used in our electricity market models.

Our estimates of capital costs are expressed in \$/kW at the generator terminal (or \$/kW GT). Power station auxiliaries (and network losses) associated with the operation of power stations are separately accounted for in our modelling.

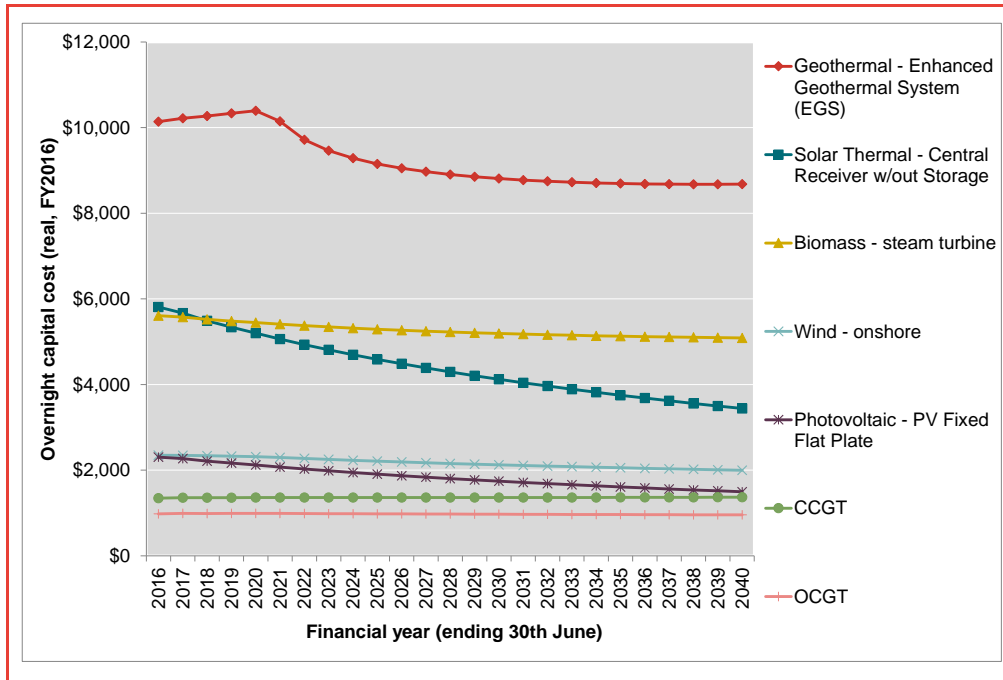
Our estimates of capital costs for black coal generation are presented in Figure 5 and our estimates of capital costs for gas and renewable generation are presented in Figure 6.

Figure 5: Forecast capital costs for coal generation plant (\$2015/16)



Source: Frontier Economics

Figure 6: Forecast capital costs for gas and renewable generation plant (\$2015/16)



Source: Frontier Economics

## Fuel prices

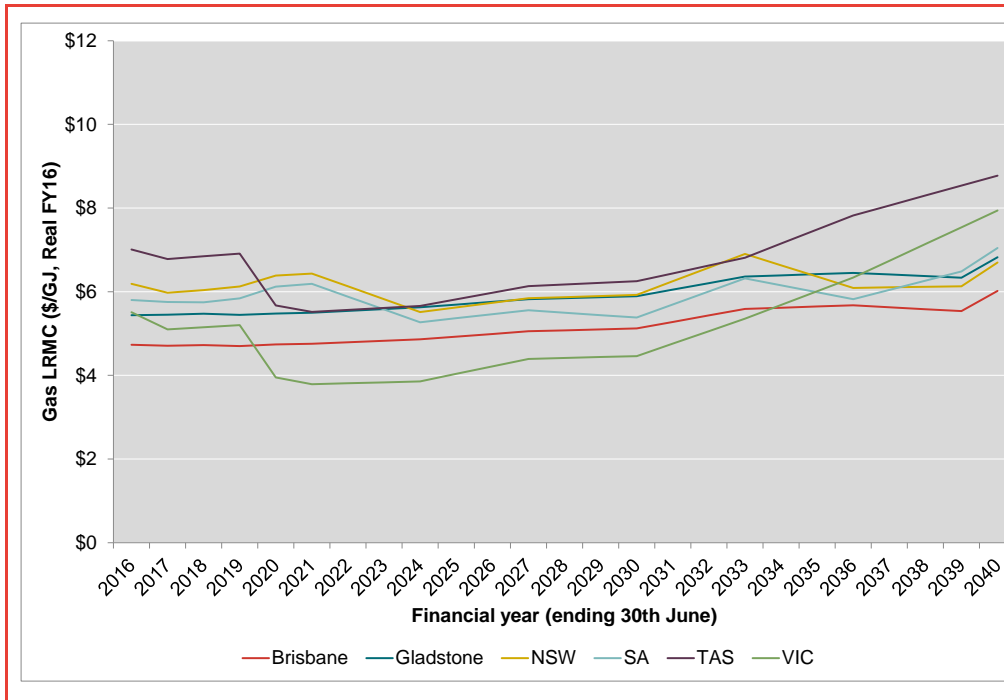
The power station fuel prices that we use in our modelling are based on modelling and analysis of the Australian gas and coal markets. We maintain a Base Case that reflects current estimates of key inputs such as production and transport costs, gas and coal exports and long term export prices for LNG and coal.

### Gas prices

Our gas price forecasts are developed using our gas market model – *WHIRLYGAS*. Gas prices are driven by demand for gas, international LNG prices, foreign exchange rates and underlying resource costs associated with gas extraction and transport. Our Base Case forecasts, which we have used in our modelling for SDP, are shown in Figure 7 for a selection of pricing zones across Australia.



Figure 7: LRMC of gas by State capital cities (\$2015/16) – Base Case

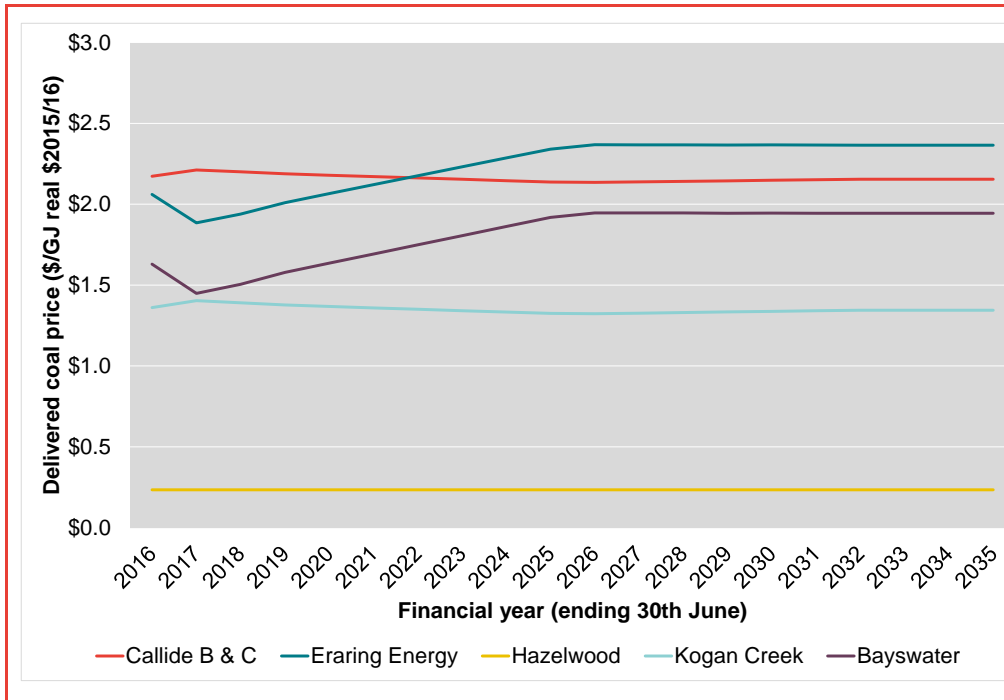


Source: Frontier Economics

### Coal prices

Our coal price forecasts are developed using a model of the supply of coal to coal-fired generators in the NEM. Coal prices are driven by demand for coal, international export coal prices (for export exposed power stations), foreign exchange rates and underlying resource costs associated with coal mining. Our Base Case forecasts, which we have used in our modelling for SDP, are shown in Figure 8 for representative power stations (both export exposed and mine-mouth stations).

Figure 8: Coal prices for representative generators (\$2015/16) – Base Case



Source: Frontier Economics

Frontier Economics Pty Ltd in Australia is a member of the Frontier Economics network, which consists of separate companies based in Australia (Brisbane, Melbourne & Sydney) and Europe (Brussels, Cologne, London & Madrid). The companies are independently owned, and legal commitments entered into by any one company do not impose any obligations on other companies in the network. All views expressed in this document are the views of Frontier Economics Pty Ltd.

#### Disclaimer

None of Frontier Economics Pty Ltd (including the directors and employees) make any representation or warranty as to the accuracy or completeness of this report. Nor shall they have any liability (whether arising from negligence or otherwise) for any representations (express or implied) or information contained in, or for any omissions from, the report or any written or oral communications transmitted in the course of the project.

