

# **Availabilities and Costs of Sources of Energy for Generating Electricity**

## **Technical Note**

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## Introduction

The Ministry of Economic Development commissioned East Harbour Management Services Ltd to produce two reports with information on the costs of generating electricity: Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat (September 2002), and Costs of Fossil Fuel Generating Plant (May 2002).

Information from these reports has been drawn on in the Ministry's Energy Outlook (October 2003).

However, the information in the 2002 reports has not been used directly in the Outlook. A number of adjustments have been made to provide for a series of factors including, for example, the application of a different exchange rate. This technical note explains the adjustments made between the 2002 reports and the Outlook.

## Generation from Renewable Energy

The East Harbour renewables report discusses the availability and costs of generation from hydropower, geothermal, wind power, biomass and solar energy. The identified potential biomass and solar energy is not used in the Energy Outlook because it is relatively small and high cost (the Outlook does however include biomass projections derived from estimates of forestry wood waste).

The East Harbour report gives energy supply costs and availabilities for three levels of confidence: high, medium and low. Costs are derived using a weighted average cost of capital (WACC) set at 5% and also at 10%. For the Energy Outlook, figures were taken corresponding to the high confidence estimates at the 10% WACC.

The availability in the East Harbour report is presented as the potential capacity (MW) or potential annual generation (GWh per year) over 2 c/kWh cost bands; ie 2-4 c/kWh, 4-6 c/kWh, etc. Point costs representative of each band were taken as the cost inputs for modelling purposes. Only renewable energy available up to and including the 8-10 c/kWh band is considered in the Energy Outlook.

There were no adjustments to the renewable energy costs for the exchange rate as the renewables report used the same exchange rate assumptions for 2012 and 2025 as the Energy Outlook.

### ***Hydro Developments***

In the East Harbour report the potential identified for hydro developments, at the high confidence level and 10% WACC (page 20) is:

c/kWh	MW	GWh pa
4-6	570	3200
6-8	130	630
8-10	200	1095

The cost of potential new hydro developments shown in the Energy Outlook (Box 2 on page 8) is:

	c/kWh	MW	GWh pa	Average Load %
Project Aqua Stage 1	4.5	285	1600	64
Project Aqua Stage 2	4.5	285	1600	64
Medium Cost	7.0	50	250	55
High Cost	8.5	280	1350	55

Project Aqua is the 570 MW / 3200 GWh project divided into two stages to reflect the expected construction schedule. It is costed at 4.5 c/kWh based on public information from Meridian Energy.

The medium and high cost hydro is the remaining 330 MW from the East Harbour report. A breakdown of this data showed that 50 MW of the 130 MW in the 6-8 c/kWh band is close in cost to 7 c/kWh, with the remaining 80 MW closer to 8 c/kWh. Combined with the 200 MW in the 8-10 c/kWh band, this makes a total of 280 MW (representing a number of different hydro projects) costing around 8.5 c/kWh.

The total GWh for the medium and high cost hydro is less than given in the renewables report because a lower average load has been assumed. There is also a small difference due to rounding.

### ***Geothermal Developments***

The East Harbour report gives the following figures for the annual GWh available from geothermal energy, at the high confidence level and 10% WACC (page 24):

c/kWh	2012 GWh	2025 GWh
2-4	200	200
6-8	1790	4780
8-10	320	460

As in the case of hydro, these represent a number of different projects. The availability of energy varies with time because it is assumed that staged development will be necessary.

In the Energy Outlook, the GWh figures are converted to MW at an average load of 90%. From inspecting the data, point costs were chosen at 4 c/kWh, 6.2 c/kWh and 8.5 c/kWh based on how the individual project costs are grouped within each cost band.

This results in the following figures presented in the Energy Outlook:

	c/kWh	MW	GWh pa	Average Load %
2006-2010	4.0	25	200	90
2011-2020	6.2	225	1800	90
2021-2025	6.2	380	3000	90
2006-2025	8.5	60	475	90

The year ranges show the periods covering from when the resource is first available to when it is most likely to be fully utilised. The 1800 GWh in 2011-2020 is obtained from

rounding the 1790 GWh in the 6-8 c/kWh band for 2012. The additional 3000 GWh in 2021-2025 is the increase (rounded) in this band from 1790 GWh to 4780 GWh in 2025. The 475 GWh at 8.5 c/kWh over the period 2006-2025 is an upward revision of the figures reported by East Harbour in the 8-10 c/kWh band.

### **Wind Developments**

The potential availability of wind power reported by East Harbour at the high confidence level and 10% WACC (pages 27 & 28) is:

c/kWh	2012		2025	
	MW	GWh pa	MW	GWh pa
4-6	125	500	380	1405
6-8	520	1700	510	1440
8-10	380	945	345	730
10-12	250	500	230	395
12-14	195	330	165	235

The costs of these projects are evenly spread within each band and are not clustered around any particular point cost figures. Consequently it was decided to use the same point costs as for geothermal generation at 6.2 c/kWh and 8.5 c/kWh. This enables the available quantities of wind and geothermal to be compared on a like cost basis. An intermediate point cost at 6.5 c/kWh was included to provide a finer breakdown. The reported wind MW and GWh figures were then scaled to fit around these new point costs.

The increasing quantities in the lower price bands reflects the fact that wind is a rapidly maturing technology associated with falling capital costs.

After scaling, the following figures were obtained:

c/kWh	2012		2025	
	MW	GWh pa	MW	GWh pa
6.2	190	750	430	1590
6.5	200	750	200	750
8.5	630	1800	600	1800

In the Energy Outlook, these are presented as:

	c/kWh	MW	GWh pa	Average Load %
2006-2010	6.2	190	750	45
2011-2020	6.2	240	840	40
2021-2025	6.5	250	750	35
2006-2025	8.5	600	1800	35

The 240 MW and 840 GWh figures for 2011-2020 at 6.2 c/kWh are the respective increases from 2012 to 2025 in the previous table. The MW figure at 6.5 c/kWh increased to 250 MW from 200 MW as a result of applying a lower average load figure (35% instead of 43%).

## Generation from Fossil Fuels

The East Harbour fossil fuels report provides cost information on two types of coal-fired generation and four types of gas-fired generation. These are:

- Conventional pulverised coal with flue gas desulphurisation (FGD)<sup>1</sup>
- Integrated coal gasification combined cycle
- Gas combined cycle
- Advanced gas combined cycle
- Combustion turbine
- Advanced combustion turbine.

For the Energy Outlook, the gas-fired generation costs used were the average of those given in the East Harbour report for the gas combined cycle and the advanced gas combined cycle technologies.

For coal, the Energy Outlook used costs for pulverised coal plant without FGD. The capital cost for a pulverised coal plant without FGD is given by the East Harbour report as \$416/kW less than with FGD.

The report provides a set of cost figures at a 5% discount rate and another set at a 10% discount rate. The Energy Outlook used the figures at the 10% discount rate.

The capital costs from the East Harbour report were adjusted for the Energy Outlook to allow for two factors. Firstly, the report used an exchange rate of NZ\$1.00 = US\$0.42 to calculate the cost in New Zealand of the imported component of the various plant options. These imported costs were adjusted to reflect the Energy Outlook exchange rate assumption of NZ\$1.00 = US\$0.50 using the methodology described in the East Harbour report. This was done by taking 80% of the capital cost to be imported and 67% of the non-fuel operating and maintenance cost.

Second, the load factor was altered from the 90% used in the fossil fuels report to 75%.

The resulting capital costs and operating and maintenance figures were used in the model where they were combined with their respective fuel costs calculated endogenously within the modelling process. To depict the costs in tabular form in the Energy Outlook, fuel costs were taken at \$3.50/GJ for coal and from \$4.00/GJ to \$7.00/GJ for gas, excluding the carbon charge. Including the carbon charge raises the coal fuel cost by \$1.48/GJ and the gas fuel cost by \$0.80/GJ.

These fuel cost figures also differ from those used in the fossil fuels report. However here the fuel costs were not projections but merely provided to illustrate the full generation costs over a range of possible fuel cost outcomes.

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<sup>1</sup> A fluidised bed plant would have similar capital and operating and maintenance costs to pulverised coal plant with FGD.