SINCLAIR KNIGHT MERZ

SKM

Independent Market Operator

IMO

Wholesale Electricity Market

Review of the Maximum Reserve Capacity Price 2008- Power Station Elements

- Final Report (rev1)
- 7 January 2009

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1. Introduction

As part of the Government of Western Australia's commitment to establishing a wholesale Electricity Market within the South West Interconnected System, the Government of Western Australia has set up an Independent Market Operator to administer and operate the Wholesale Market.

The Market rules require the Independent Market Operator to conduct a review of the Maximum Reserve Capacity Price each year. As part of this process Sinclair Knight Merz have been commissioned to determine the following for the year 2008:

- Capital cost (procurement, installation and commissioning, excluding land cost) of a generic, industry standard liquid fuelled 160MW OCGT power station;
- Fixed Operation & Maintenance costs of the above facility with capacity factor of 2%. The cost shall be in 5 year periods covering 1 to 30 years;
- Owners costs such as legal, approval, environmental and financing costs associated with term 'M' used in Wholesale Electricity Market Rule.

This report should be read in conjunction with the scope of work agreed between IMO and SKM which explains the scope of this report in detail and is attached in **Appendix A**.

Given that this report will focus on power station elements, it should be read in conjunction with SKM report titled "Review of the Maximum Reserve Capacity Price 2008 – Non Power Station Elements".

2. Generation Plant Capital Cost

Taking into account the review completed for the IMO as part of its Maximum Reserve Capacity Price Advisory Group, SKM has estimated the capital cost (procurement, installation and commissioning, excluding land cost) of a generic dual fuel E-class Open Cycle Gas Turbine (OCGT) power station. An E-class OCGT will have a nominal capacity of 160MW for gas fuel operation. For operation on liquid fuel with water injection for NO_X control the plant will have a nominal capacity of 170MW. The estimate includes all components and costs associated with a complete gas turbine project.

2.1. Methodology

In order to establish capital costing for a generic 160MW open cycle gas turbine plant, SKM undertook the following steps:

- Development of a table of prices for a number of open cycle gas turbine plant using version 18 (March 2008) of Thermoflow GT Pro/Peace software;
- Normalisation of existing project data on recent similar sized plant developments, (removal of non-typical costs such as significant ground preparation, pilling, excessive environmental costs etc);
- Correlation of the Thermoflow GT Pro/Peace derived cost data with the normalised reference data; and
- Normalisation of combined Thermoflow and existing project data to comprise costing for a generic 160MW open cycle gas turbine plant.

2.2. Thermoflow GT Pro / Peace Derived Costs

SKM has utilised Thermoflow GT Pro®/PEACE® together with its in-house cost data to develop capital costs for a number of single unit OCGT plants with nominal output of 160MW (exact plant capacities are dependent on the nearest matching gas turbine).

In developing the matrix of costs, SKM has utilised:

- knowledge and experience of generation project development;
- database for power station capital and operating costs;
- knowledge of the impact of the flow through of commodity price increases, labour costs etc on generation station capital costs and hence appropriate escalation indices; and
- knowledge and experience in generation project costing, including typical allowances for owners costs.

In developing the cost estimates, SKM has assumed a standard green field site located in Western Power's South Western region and having no special geological, environmental, permitting or consenting peculiarities. In particular it has been assumed that there are no unusual requirements for ground preparation, such as piling or land remediation etc.

As a location has not been specified SKM has also assumed average annual conditions for the region of 25°C and 60% relative humidity at an elevation of 25m.

2.3. Project Data Price Review

In developing the end cost estimate, SKM has also utilised information garnered from a number of projects that it has been involved with over the past several years. These projects have been in varying stages of the project development lifecycle and include projects in the initial feasibility study stage, project scope development stage, tendering to specification stage, front end engineering stage, construction stage and project implementation management to identify project cost data for generating plant of sizes similar to this study.

Capital cost of plant development in Australia has increased above that of CPI and to this end, CPI over the past few years does not provide an accurate picture of plant development escalation. SKM has developed and utilises a number of escalation factors for varying aspects of a power plant and has hence applied these to bring the total capital estimate to June 2008 money terms.

The reference project data has then been further revised to take out non-generic project costs to produce a table of 'normalised' project data costing comparable to that produced by the Thermoflow modelling software.

These costs were normalised to ensure they covered the same cost items as the Thermoflow software (e.g. excluding network connection costs and owners costs covered in Section 4). Much of this data has been sourced from confidential projects and so cannot be directly presented in this report.

2.4. Development of the Generic OCGT Capital Cost Estimate

SKM has statistically compared and correlated the two sets of costing data to develop a generic OCGT capital cost estimate for a generic 160MW open cycle gas turbine plant. Where slight inaccuracies occurred, existing project data was normalized and then used to compensate for any cost inaccuracies of the modelling software. In this manner, the anonymity of the reference project data was maintained.

2.5. OCGT Capital Cost Estimate

A breakdown of the capital cost estimate for a 160MW generic OCGT plant is given in **Table 2-1** below. The estimate represents a generic cost for an OCGT Plant constructed on and EPC basis. Owners costs additional to the EPC Contract have been excluded and are accounted for

This equates to a capital cost of **AUD$663/kW** at the assumed conditions (25^{o}C, 60% RH, 25m).

- **Table 2-1 Generic 160MW OCGT capital cost estimate**

Item		Cost [$]
1	Main Plant Equipment	$ 67,390,000
2	Balance of Plant	$ 2,370,000
3	Civil Works	$ 8,940,000
4	Mechanical Works	$ 6,840,000
5	Electrical Works	$ 2,540,000
6	Buildings	$ 1,820,000
7	Engineering & Plant Startup	$ 3,870,000
8	Contractor's Costs	$ 12,380,000
Total EPC Cost		$106,150,000

3. Generation Operation & Maintenance Costs

3.1. Assumptions and Estimated Maintenance Costs

An OCGT plant based on a single gas turbine capable of delivering a nominal 160MW output operating on natural gas has been evaluated for a 30 year operating life.

SKM has developed an estimate for O&M costs for the plant based on:

- 2% capacity factor;
- 4 hours running per start; 44 starts per annum for a 2% capacity factor;
- no fast starts[1]; and
- one full load trip to be assumed per annum.

3.1.1. Expected Maintenance Costs

The fixed O&M cost elements shown below in **Table 3-1** have been developed from cost data derived from a range of sources including an amalgam of data from current and recent similar OCGT projects. These costs have been escalated, where appropriate, to June 2008 dollar terms. Transmission line connection O&M has been excluded.

[1] *Given that there is no balancing market in the SWIS Wholesale Electricity Market, the Independent Market Operator has advised that there will be no requirement for fast starts in the operating regime and hence it is assumed that the plant will be dispatched with sufficient forward notice to avoid the need for fast starts.*

- **Table 3-1 OCGT plant fixed O&M costs**

O&M Cost Component	[$M pa]
Plant operator labour	0.450
OCGT Substation (connection to tie line)	0.220
Rates	0.055
Market Fee	0.055
Gas Connection (excludes amortised gas pipeline connection costs)	0.055
Balance of plant	0.110
Consent (EPA annual charges emissions tests)	0.028
Legal	0.024
Corporate Overhead	0.200
Travel	0.023
Subcontractors	0.300
Engineering Support	0.060
Security	0.110
Electrical (Including Control & Instrumentation)	0.110
Fire	0.055
Total	**1.855**

Five yearly aggregate fixed + variable OCGT O&M costs are provided in **Table 3-2** for each five year period of the 30 year operating life.

The variable O&M costs are estimated on the basis that the first major overhaul utilises new parts and the second major overhaul utilises reconditioned parts taken out at the first major overhaul.

- **Table 3-2 Fixed + variable OCGT plant O&M costs (June 2008 dollars)**

Five yearly costs (Years)	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	1 to 30
Fixed O & M @ 2% CF	$ 9,275,000	$ 9,275,000	$ 9,275,000	$ 9,275,000	$ 9,275,000	$ 9,275,000	$ 55,650,000
Variable O & M @ 2% CF	$ 220,000	$ 320,000	$24,000,000	$ 335,000	$ 5,100,000	$ 220,000	$ 30,195,000
Combined O & M @ 2% CF	$ 9,495,000	$ 9,595,000	$33,275,000	$ 9,610,000	$14,375,000	$ 9,495,000	$85,845,000

4. Calculation of the term 'M'

4.1. General Issues and Assumptions

The IMO's market procedure for making a determination of the maximum reserve capacity price, defines the term 'M' as; "*a margin to cover legal, approval, and financing costs and contingencies.*"[2]

SKM understands that the inclusion of term 'M' accounts for additional "Owners Costs" encountered during the development of a power station and is incorporated into the capital cost determination as a margin i.e. a fixed percentage, added to the capital cost:

According to Chapter 4 of the WEMAR the IMO is responsible for proposing revised values for the Maximum Reserve Capacity Price using Appendix 4 of the rules. The appendix specifies that the following equations be used to calculate the maximum reserve capacity price (the "price cap")[3]:

$$PRICECAP[t] = k \times (FIXED\_O\&M[t] + ANNUALISED\_CAPCOST[t] / (CAP / SDF))$$

$$CAPCOST[t] = (PC[t] \times (1 + M) \times CAP \times (1 + 1.5D + 0.5xD2)) + TC[t] + FFC[t]$$

$$PC[t] = GTP[t-x] \times (USCPI[t] / USCPI[t-x]) \times ER[t,t-x]$$

The first equation specifies how the capital cost is used to generate the price cap and is not part of the capital cost estimate. The second equation adds costs for connection to the electricity grid and fuel capacity and applies margins to the base capital cost for legal/financial overheads and interest during construction. These factors are consistent with industry methodology and so it is the third equation, regarding the OCGT plant capital cost, which is the focus of the analysis in this report. In the report we refer to this as the "current IMO methodology"..

In calculating a suitable figure for 'M,' SKM has estimated the Legal, Approval and Financing costs for a generic 160MW open cycle gas turbine plant, which is defined as the "*Power Station upon which the maximum reserve capacity price shall be based*" in section 1.5 of the IMO's proposed methodology.

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[2] IMO 2008, "Proposed Market Procedure for Determination of the Maximum Reserve Capacity Price, 01 August, P10.

[3] A detailed explanation of these equations can be found in Appendix 4 of the Wholesale Electricity Market Amending Rules which is added as an appendix to this report.

The costs have been estimated from in-house data and knowledge of comparable recent developments. SKM has statistically compared and correlated the costing data of several projects to develop a generic OCGT legal; approval and financing cost estimate for a generic 160 MW liquid fuelled open cycle gas turbine plant.

The varying costs were each normalised and any abnormal cost variations relating to unique or unusual project factors removed. Much of the original data has been sourced from confidential projects and so cannot be directly presented in this report.

The insurance cost figure presented in this section, was derived from knowledge gained through undertaking a number of comparable EPC projects, due diligence reviews, as well as recent discussions between SKM and major energy project insurers during the development and/or review of EPC project estimates.

The figure for 'Interest During Construction' (IDC) has been developed based on an understanding of the typical period of construction for a 160MW OCGT power station and the resultant draw down profile of project financing. Power station construction projects involving longer periods of construction, such as coal fired plants, typically display IDC figures in the region of 11.2 – 16.8%.

Table 5-1 shows SKM's estimate for the term 'M' used in appendix 4 of the Wholesale Electricity Market Rule, with due consideration given to standard industry practices. These costs include:

- legal cost associated with the design, construction and operation of the power station;
- approval cost including environmental consultancies and approvals, and local, state and federal licensing, planning and approval costs; and
- financing costs relating to IDC.

- **Table 5-1 Estimate of term 'M'**

Component of 'M'	% of Total EPC
Project Management	1.9%
Project Insurance	1.5%
Contingencies	5.0%
Owners Engineering Costs to Oversee, Witness Tests etc.	3.0%
Financing charges (IDC)	7.0%
Environmental Approvals	0.7%
Legal Costs	1.2%
Owners Engineers - Part A (Including concept design, specification, tendering, contract negotiations)	0.4%
Owners Engineers - Part B (Including Construction Phase OE Costs, oversee project, witness tests & Commissioning)	0.9%
Initial Spares requirements	0.8%
Site Services (Provision of potable water, construction power, communications, domestic sewerage etc. at site)	0.1%
Total M as a percentage of CAPEX	**22.5%**
Multiplier in CAPEX equation 2	**(1 + 0.225)**

Appendix A Scope of Work

Extract from proposal letter HAP9923

The project shall consist of three discrete elements as follows:

1.1. Power Station Estimate

1.1.1. Estimate the capital cost (procurement, installation and commissioning, excluding land cost) of a generic, industry standard liquid fuelled 160MW Open Cycle Gas Turbine power station. The estimate will include all the components and costs associated with a complete gas turbine project; and

1.1.2. Estimate the fixed operation and maintenance costs of the liquid fuelled OCGT power station of 160MW with capacity factor of 2% to mid 2008 value. The cost shall be in 5 year periods covering 1 to 5 years; 6 to 10 years; 11 to 15 years; 16 to 20 years; 21 to 25 years; and 26 to 30 years respectively.

1.2. Connection Works Estimate

1.2.1. Estimate the capital cost (procurement, installation and commissioning, excluding land cost) of a generic, industry standard 330kV substation to mid 2008 value that facilitates the connection of the above mentioned power station. The estimated cost will be based on a generic three breaker mesh substation configured in a breaker and a half arrangement. The substation will be located under an existing transmission line and include an allowance for 2km of 330kV overhead single circuit line to the power station that will have one road crossing. It shall be assumed that the switchyard will be located on 50% flat - 50% undulating land, 50% rural - 50% urban location and there will be no unforeseen environmental or civil costs associated with the development. The connection of the switching station into the existing transmission line will be turn-in, turn-out and will be based on the most economical (i.e. least cost) solution. It is assumed that the existing transmission line will not require modification to allow the connection with the exception of one new tower located at the substation to allow a point of connection. Shallow easement connection costs will be considered. Costs associated with any staging works will not be considered. The estimate will include all the components and costs associated with a standard substation;

1.2.2. Estimate the fixed operation and maintenance costs of this transmission line and meshed switchyard to mid 2008 value. The cost shall be in 5 year periods covering 1 to 5 years; 6 to 10 years; 11 to 15 years; 16 to 20 years; 21 to 25 years; 26 to 30 years; 31 to 35 years; 36 to 40 years; 41 to 50 years; 51 to 55 years; and 56 to 60 years respectively; and

1.2.3. Ensure the above mentioned transmission line and substation design and arrangement comply with the requirements of Western Power's technical rules for new developments.

1.3. Legal, Approval and Financing Estimate

1.3.1. Estimate a reasonable margin for the term 'M' used in the Market Procedure for: Determination of the Maximum Reserve Capacity Price (see attachment) giving due consideration to standard industry practices. It is expected that this will cover the following:

a. Legal cost associated with the design, construction and of the power station;

b. Approval cost including environmental consultancies and approvals, and local, state and federal licensing, planning and approval costs;

c. Estimate reasonable design costs associated with the power station.

d. Insurance costs required to insure the replacement of capital equipment and infrastructure