



**AEMO**

# 2019 Benchmark Reserve Capacity Price for the South West Interconnected System

September 2018

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# 1. Introduction

## 1.1 General

The Australian Energy Market Operator (AEMO) is required each year to determine and publish a Benchmark Reserve Capacity Price (BRCP), as required under clause 4.16 of the Western Australian (WA) Wholesale Electricity Market (WEM) Rules. The BRCP is used to set the maximum price that may be offered in a Reserve Capacity Auction or as an input in the determination of the administered Reserve Capacity Price if an auction is not required.

The Market Procedure outlines the methodology used to determine the BRCP, which is calculated by undertaking a technical, bottom-up, cost evaluation of the entry of a new 160 MW Open Cycle Gas Turbine (OCGT) generation facility in the South West interconnected system (SWIS). The power station must:

- a. Be representative of an industry standard liquid-fuelled OCGT power station.
- b. Have a nominal nameplate capacity of 160 MW prior to the addition of any inlet cooling system.
- c. Operate on distillate as its fuel source with distillate storage for 14 hours of continuous operation.
- d. Have a capacity factor of 2 per cent.
- e. Include low nitrous oxide (NO<sub>x</sub>) burners or associated technologies (for example water injection) as considered suitable and required to demonstrate good practice in power station development.
- f. Include an inlet air cooling system where this would be cost effective.
- g. Include water delivery and storage capability to support 14 hours of continuous operation.
- h. Include the minimum level of equipment or systems required to satisfy the Balancing Facility Requirements.

## 1.2 Scope

The WEM Rules require that a review be conducted of the Benchmark Reserve Capacity Price (BRCP) each year. GHD was commissioned by AEMO to carry out a bottom up cost evaluation, for an OCGT Power Station as at April 2021 (Year 3 of the 2019 Reserve Capacity Cycle) which includes the following items:

- The power station costs for a single liquid fuelled 160 MW OCGT unit inclusive of components for gas turbine plant, and all other costs that would normally be applicable to such a power station;
- The fixed operating and maintenance costs (O&M) for the power station operating with a capacity factor of 2%;
- The fixed fuel costs (FFC) for the power station inclusive of a 1000 tonne capacity fuel storage tank, fuel handling facility, and initial supply of fuel sufficient for power station operation for 14 hours at maximum capacity;

- The value of Margin M, which constitutes the following costs associated with the development of the power station project:
  - Legal costs associated with the design and construction of the power station.
  - Financing costs associated with equity raising.
  - Insurance costs associated with the project development phase.
  - Approval costs including environmental consultancies and approvals, and local, state and federal licensing, planning and approval costs.
  - Other costs reasonably incurred in the design and management of the power station construction.
  - Contingency costs.

### **1.3 Disclaimer**

*This report: has been prepared by GHD for AEMO and may only be used and relied on by AEMO for the purpose agreed between GHD and AEMO as set out in section 1.1 & 1.2 of this report.*

*GHD otherwise disclaims responsibility to any person other than AEMO arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.*

*The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.*

*The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.*

*The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.*

*GHD has prepared the cost estimate/prices set out in this report using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.*

## 2. Cost for Power Plant

### 2.1 Methodology used to estimate cost for power plant

GHD used the current version 27.0 of GTPro/Peace, which is a proprietary software package marketed by Thermoflow. This software allows the user to evaluate the performance output for any commercially available gas turbine as well as provide an updated cost estimate for the gas turbine and balance of plant, which in this case, is applicable to a gas turbine configured as an open cycle GT (OCGT). Thermoflow updates the software annually by interviewing relevant Original Equipment Manufacturers (OEM) such as GE, Siemens, Mitsubishi, etc., to obtain current performance and cost details from each OEM.

The list of available gas turbines in GTPro includes key models that are provided by OEMs as well as their variants. For this reason, GTPro is considered to be a more accurate source for gas turbine performance (output, efficiency, etc.) than other sources such as the internet and websites which tends to provide performance output for a specifically configured model, under assumed site conditions.

Our approach to model the 160 MW OCGT for both performance and project cost was:

- Choose a suitable gas turbine and configure the turbine with the relevant balance of plant equipment for OCGT operation and configure it to run on diesel fuel; (using assumption outlined in section 2.3).
- Adjust the labour cost and commodity factors in the software's input assumption list to reflect that the plant is to be built in WA;
- Run the model for ISO conditions and record the performance output;
- Re-run the model at the required site conditions and record the performance output
- Obtain a cost estimate output from the model configured to operate at site conditions (all costs are provided in US\$ and GHD used the US\$/A\$ currency exchange to convert these costs to A\$);

### 2.2 Overview of diesel fuelled power plant

#### 2.2.1 Multi-unit OCGT configurations

GHD investigated the potential for a multi-unit configuration to make up the 160 MW (nominal) output at the required site conditions. The four options investigated are shown in the following table.

GT Model	Site Conditions		EPC Capital Cost (A\$)	Comments
	Gross output (MW)	Net Output (MW)		
Pratt & Whitney FT8	165.14	162.46	209,298,000	4 unit configuration
GE 6F.03	140.68	138.41	155,418,000	2 unit configuration
GE 6F.01	182.73	179.71	235,754,000	4 unit configuration
Siemens SGT800-50	181.28	178.27	199,036,000	4 unit configuration

As shown by the table above, the multi-unit options were either too expensive and/or were not suitable to comply with 160 MW nominal output at site conditions. Therefore, the multi-unit configurations were not considered further.

## 2.2.2 Single unit OCGT configuration

After the multi-unit configurations were deemed not cost effective and/or not suitable to comply with the site output required, analysis proceeded with the development of capital cost estimates for a single unit, industrial type, liquid fuelled 160 MW open cycle gas turbine power plant located in the SWIS region of Western Australia.

GHD has reviewed the following gas turbines for suitability for the 160 MW OCGT power plant:

**Table 1 OCGT Units considered for this cost estimate**

Gas Turbine	Comments
Siemens SGT5-2000E (33MAC)	<p>The 33MAC variant of this unit was used in the last several years to develop the Benchmark Reserve Capacity Price.</p> <p>There are three variants of the SGT5-2000E (nameplate capacity at ISO conditions shown in brackets): the 25MAC (188 MW), 33MAC (184 MW), and 41MAC (181 MW). All variants feature evaporative cooling, and dry low NOx combustion. The 33MAC is also able to be water injection for power augmentation.</p> <p>At the prevailing site conditions (41°C, 30% relative humidity) the 33MAC is modelled to have a net capacity of 162.01 MW (net at site conditions), and is therefore the closest of the three variants to the target 160 MW. All variants are reported by GTPRO to have almost identical CAPEX and efficiency.</p>
Alstom GT13E2 (MXL2), now owned by GE by previously by Alstom	<p>The nameplate rating for this unit on diesel fuel is 179.6 MW (gross) at ISO conditions.</p> <p>The unit comes in 2 versions; the GT13E2 and GT13E2 (MXL2). The MXL2 features dry low NOx combustion, but is also compatible with water injection for power augmentation.</p> <p>For a prevailing site conditions (41°C, 30% relative humidity) this unit will have a net rating of 162.2 MW (net at site conditions with evaporative cooling and water injection for power augmentation).</p>
GE 9E.04	<p>The nameplate rating for the 9E.04 unit is 148 MW (gross) at ISO conditions. The 9E.04 features dry low NOx combustion, but is also compatible with water injection for power augmentation.</p> <p>The GE 9E unit comes in two version; the GE 9E.03 and 9E.04, with the 9E.03 variant having a lower capacity than the 9E.04 at 133 MW (gross) nameplate capacity at ISO conditions.</p> <p>There is no larger variant of the 9E, with the next step up being the 9F.03 model with a gross capacity in excess of 260 MW.</p> <p>At the prevailing site conditions (41°C, 30% relative humidity) the 9E.04 is modelled to have a net rating of 129.9 MW (with water injection for power augmentation).</p>

From the results obtained for the single unit OCGT configurations GHD has chosen the Siemens SGT5-2000E OCGT 33MAC on which to base this year's report. This is due mainly to the fact that the SGT5-2000E 33 MAC closely matches the requirement for a 160 MW OCGT at the required site conditions and provides good value in terms of capital and O&M costs.

As outlined in previous text, in developing the capital cost estimate, GHD used the latest version of GTPro (version 27.0) to model the SGT5-2000E 33MAC machine at ISO conditions at a typical power plant site in the SWIS (Muja PS). We then applied the necessary inlet cooling system and water injection rate for the gas turbine operating a 41°C ambient condition and providing the lowest NOx emissions. The capital cost estimate for the reference power plant was obtained from GTPro's "PEACE" output, which has current cost data for 2018. A cross check with last year's estimate (2017) for the same machine was carried out to identify any significant variations. Where possible cost references were made to Australian power projects involving the SGT5-2000E machines<sup>1</sup>. GHD applied the relevant escalation to establish a year 2018 project cost for these projects and compared them with the project cost obtained from GTPro. The cost obtained from GTPro was found to be within the limit of accuracy<sup>2</sup>.

In Australia the SGT5-2000E has been installed for the following power plants:

- One unit in Queensland at the Townsville Power Station (firing gas) (Yabulu PS)
- Three units in Queensland at the Braemar 2 Power Station (firing gas)
- Two units in Queensland at Oakey Power Station (firing gas).
- Two units in Victoria at Laverton Power Station (firing gas & diesel)
- Four units in New South Wales at Uranquinty Power Station

For all evaluation of the cost for the power station, GHD has applied a cost escalator that is based on the mid-point of the forecasts of the Reserve Bank of Australia (RBA).

### **2.3 Assumptions**

The capital cost for the liquid fuelled OCGT power plant has been estimated by GHD on the basis of an EPC contracting strategy where the capital cost is comprised of engineering, procurement and construction (inclusive of commissioning and testing).

The following assumption apply to the capital cost for the power plant:

- A SGT5-2000E machine was used as the basis of the OCGT plant;
- Evaporative air cooling is included in the supply package for the power plant;
- Water injection for NOx emission abatement is used for distillate fuel operation;
- Distillate fuel storage and handling is not included in the cost for the power plant (it is treated separately in Section 5);
- Site conditions having the following values:
  - A site elevation of 217 metres above sea level (based on Muja PS)
  - A maximum ambient temperature of 41°C
  - Relative humidity of 30%
  - The power plant site is assumed to be relatively flat, requiring minimal civil works, and all foundations are of the spread footing type

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<sup>1</sup> All these projects were constructed pre 2010 and the appropriate escalation was used to compare prices.

<sup>2</sup> For cost estimates produced by GTPro without front end engineering design (FEED) the level of accuracy is usually about +/-30%.

- Natural ground water table is assumed to be below the depth required for excavation
- Plant and equipment can be transported from a nearby sea port to the site over existing roads and bridges;
- Land cost is not included.
- A demineralised water treatment plant together with a 1200 tonne demineralised water storage tank is included in the cost estimate.
- A storage tank for potable water of 300 tonne capacity plus a fire water storage tank is included in the cost estimate;

## 2.4 Plant output at ISO and 41°C ambient temperature

The site assumptions applied in the GTPro model are as shown in section 2.3. based on the output from the model the performance data from the SGT5-2000E gas turbine is provided in the table below.

**Table 2 Performance for the SGT5-2000E 33MAC at site conditions**

Description	Units	Value
Ambient Conditions	Deg C / % RH	41.0 / 30% RH
Gross Power	MW	164.4
Net Power	MW	162.0
Auxiliary/Losses	MW	2.4
Gross Heat Rate / Efficiency (LHV)	kJ/kWh / (%)	10,669 / 33.74%
Net Heat Rate / Efficiency (LHV)	kJ/kWh / (%)	10,829 / 33.25%
Air temperature post evaporative cooler	Deg C	27.0
Diesel Fuel Consumption	Tonnes	40.9

As mention in section 2.1, the SGT5-2000E 33MAC unit was modelled first using ISO conditions to obtain the respective gross (at generator terminal) and net (export to the grid) output. Next the SGT5-2000E was modelled at site conditions. This year's results show the same outputs as last year's results for the SGT5-2000E.

The ISO output for the SGT5-2000E machine is 175.58 MW (gross) and 173.28 MW (net).

For the 160 MW (generic) power plant, GHD set the gross output for the generic power plant to 160 MW and applied the same ratio of net to gross output as for the SGT5-2000E power plant. The ISO net output for the generic 160 MW power plant was established to be 157.90 MW.

For the SGT5-2000E machine at site conditions, with evaporative cooling, the gross and net outputs reduces to 164.44 MW and 162.01 MW respectively.

For the Generic 160 MW machine at site conditions, with evaporative cooling and water injection, the gross and net outputs reduces to 153.80 MW and 151.40 MW respectively.

The performance of the SGT5-2000E 33MAC and the generic 160 MW power plant is provided in the table below:

**Table 3 Seimens SGT5-2000E Performance**

Case	ISO Conditions		Site Conditions	
	MW (gross)	MW (net)	MW (gross)	MW (net)
Siemens SGT5-2000E	175.58	173.28	164.44	162.01
160 MW (generic)	160.00	157.90	153.80	151.40

## 2.5 Capital Cost Estimate

The cost breakdown for the OCGT power plant is provided in Table 4 below

**Table 4 Capital cost breakdown for the power plant**

Cost Item	Based on Siemens SGT5-2000E *	Equivalent 160 MW Power Station
Specialised Equipment**	70,647,200	64,359,600
Other Equipment**	4,832,100	4,402,700
Civil works**	11,941,000	10,878,300
Mechanical Works**	8,895,400	8,103,800
Electrical Works**	3,205,300	2,920,000
Building & Structures	2,936,900	2,936,900
Engineering & Plant Start-up	4,970,200	4,970,200
Contractor soft cost & Misc. Costs	23,945,600	23,945,600
Total	131,373,700	122,517,100
A\$/kW (net)	810.9***	809.2**** (say 809)

\* All costs are in 2018 dollars

\*\* Scalable costs

\*\*\* (\$131,373,700/162.01)

\*\*\*\* (\$122,517,100/151.40)

The costs were established from GTPro (PEACE) and were converted from US\$ using an exchange rate of AU\$1.00 = US\$0.7584<sup>3</sup>. From the table above, the capital cost for a 160 MW liquid fuelled OCGT is \$809/kW.

The reference capital cost used to check the output of GTPro Peace estimates are based on recent power plant projects (Braemar PS and Mortlake PS – there have been more recent project completed or in the process of being completed but these projects are based on aero-derivative gas turbines not industrial turbines such as the unit assumed for this report).

Based on last year's capital cost estimate for the generic 160 MW plant, there is a variation of +\$2.711 million from this year's cost estimate. The price variation is due mainly to the reduced exchange rate for the Australian dollar against the US dollar<sup>4</sup>.

<sup>3</sup> Average of 2017/18 exchange rate from Oct 17 to Sept 18

<sup>4</sup> Last year's exchange rate was AU\$1.00=US\$0.763.

## 3. Cost Escalation

### 3.1 Escalation factors provided by AEMO

This year AEMO has engaged a Consultant (PWC) to provide the following annual forecast escalation factors as at August 2018:

**Table 5 Escalation factors provided by AEMO**

	FY ending June 2019	FY ending June 2020	FY ending June 2021	FY ending June 2022	FY ending June 2023
WPI – EGW <sup>5</sup>	1.85%	2.85%	3.10%	3.35%	3.35%
WPI – Construction <sup>6</sup>	1.75%	2.75%	3.00%	3.25%	3.25%
AUD/USD (\$)	0.7304	0.7363	0.7513	0.7650	0.7628
Steel Price	9.03%	-10.70%	-1.98%	-1.29%	0.48%
Copper Price	4.14%	5.27%	-0.33%	-1.56%	0.53%

The escalation factors shown in the table above were used for determination of the power plant cost, fixed operating & maintenance cost, fixed fuel cost, and M Margin costs.

### 3.2 Australian Consumer Price Index (CPI)

Forecast data was obtained from the Reserve Bank of Australia (RBA) Statement of Monetary Policy (SOMP) for August 2018<sup>7</sup>. The RBA CPI inflation figures are released twice yearly. Table 5.1 of the RBA SOMP outline the short term RBA forecast for CPI for the next two years.

The five-year Australian CPI % change forecast (to end of June) is summarised in Table 6 below.

**Table 6 Australian CPI % change forecast**

Year to June	2018 Actual	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast
CPI % Change	2.10%	2.00%	2.25%	2.38%	2.50%	2.50%

### 3.3 Capital Cost Escalation Factors

The complete OCGT Siemens SGT5-2000E weighs approximately 236 tonnes. Based on previous work carried out by GHD our estimate for steel in an OCGT of 160 MW capacity contains 1.3 tonnes/MW and our estimate for copper in an OCGT of 160 MW capacity contains 0.175 tonne/MW.

<sup>5</sup> WPI – EGW : Australian Electricity, Gas, Water and Waste Water (EGW) Labour Wage Price Index (WPI)

<sup>6</sup> WPI – Construction : Labour Wage Price Index (WPI) for Construction

<sup>7</sup> <https://www.rba.gov.au/publications/smp/2018/aug/overview.html>,

Using these figures and the forecasts for WPI Construction, exchange rate, copper and steel prices in Table 1 above GHD has evaluated power station capital cost escalation, to end of June for the next 5 years, as shown in Table 7 below.

**Table 7 Annual capital cost escalation factors**

Year to June	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast
Power station	5.3%	-1.1%	0.1%	0.6%	3.3%

Using the escalation factors in the above table, the total capital cost estimate of the power plant on **1 April 2021** is forecast to be **\$127,662,250**, which equates to **\$843/kW<sup>8</sup>**.

This estimate is **\$530,310** lower than last year's estimate. This decrease is mainly due to the negative steel escalation factor in 2020 and 2021 and a lower copper escalation factor in 2021.

This estimate is as per the Market Procedure for the BRCP which requires the estimate to be as at April in year 3 of the Reserve Capacity Cycle.

### 3.4 Fixed Operational & Maintenance Cost Escalation Factors

The annual operating and maintenance cost escalation factors determined by GHD for the forecast year to end of June for the next 5 years are shown in the table below.

**Table 8 Annual Fixed O&M cost escalation factors**

Year to June	2019 Forecast	2020 Forecast	2021 Forecast	2022 Forecast	2023 Forecast
Power station <sup>9</sup>	1.9%	2.4%	2.1%	2.4%	3.4%
Connection Switchyard <sup>10</sup>	2.3%	3.3%	2.4%	2.3%	2.7%
Overhead transmission line <sup>10</sup>	2.3%	3.3%	2.4%	2.3%	2.7%

Fixed operating & maintenance escalation factors for the power plant were evaluated by applying relevant O&M cost escalations weighted by the relevant O&M component items and is comprised of EGW WPI escalation rates, AUD/US exchange escalation rates and WPI construction escalation rates (refer footnote below).

The fixed operating & maintenance escalation factors for connection switchyard and overhead transmission line were evaluated on a similar basis by applying relevant escalation rates weighted by the relevant O&M components relevant to the switchyard and overhead transmission lines and is comprised of EGW WPI escalation rates, copper escalation rates and WPI construction escalation rates (refer footnote below).

<sup>8</sup> Based on 151.4 MW net output as stated in section 2.5 and is \$4.00/kW down from last year's value.

<sup>9</sup> The combined rate is assumed to be comprised of the following components: 70% of the WPI construction escalation rates, and 30% of the WPI EGW escalation rates. AUD/USD escalation is applied to the 30% WPI EGW that is subjected to exchange rate for materials & spares. GHD has assumed the various escalation rates with the quoted weightings to reflect the expected O&M escalation that includes labour, materials and fluctuation in exchange rate for imported spares/materials.

<sup>10</sup> The combined rate is assumed to be comprised of the following components: 40% of the WPI construction escalation rates, 40% of the WPI EGW escalation rates and 20% of the copper escalation rates. GHD has assumed the various escalation rates with the quoted weightings to reflect the expected O&M escalation that includes labour, materials and fluctuation in components that are made of copper.

## 4. Fixed Operating & Maintenance Costs

### 4.1 Overview of fixed operating & maintenance costs

Once the power plant configuration was defined, GHD used our internal O&M data bank to establish the fixed operating cost estimate using a bottom up approach. The fixed operating & maintenance (O&M) cost is comprised of the following items:

- Plant operator labour cost
- Corporate overhead for operating costs
- Regular and routine maintenance costs associated with OCGT substation, and balance of plant;
- Regular reporting on generator licence and environmental issues pertaining to emissions and compliance with EPA permit;
- Annual legal costs
- Travel
- Subcontractors
- Annual engineering reports/studies;
- Security
- Servicing and support for fire detection & protection system;
- Fixed O&M for associated overhead transmission line and connection at switchyard inclusive of:
  - Labour costs for routine maintenance;
  - Cost for machinery, plant and tool hire for routine maintenance;
  - Overhead corporate costs (management, administration & operations).

For all evaluation of the fixed O&M cost for the power station, GHD has applied a cost escalator that is based on the mid-point of the forecasts of the Reserve Bank of Australia (RBA).

### 4.2 Assumptions

The fixed O&M cost for the liquid fuelled OCGT power plant has been estimated by GHD on the following basis:

- The assumed power plant capacity factor is 2% pa;
- An annualised fixed O&M cost associated with each major component has been estimated for each 5-year period for up to 60 years;
- Fixed O&M costs were determined as at 1 October in year 3 of the reserve Capacity Cycle.
- Variable costs for the OCGT plant such as schedule maintenance have not been included in the fixed O&M costs;
- One shift for operators and maintenance crew has been assumed;

### 4.3 Fixed O&M Costs

The fixed O&M costs have been derived using GHD's O&M data bank for OCGT plants. Where applicable a cost escalator provided in Section 3 was used to establish the fixed cost estimate for 2018. The costs are provided in the table below.

**Table 9 Fixed O&M Costs**

O&M Cost Component	Fixed Cost Estimate (\$ pa)
Last year Plant Operator Labour was based on (1 x Plant Manager, 2 x Operators, 2 x Technical Assistants and 1 x Receptionist) The cost last year was \$628,928*. This year GHD has applied WPI escalation on last year's value ( $\$628,928^* \times 1.015^{11} = \$638,360$ ).	638,360
OCGT Substation (connection to tie line), has been escalated by 1.85% from last year's figure of \$243,456.	247,960
Rates are based on a site that is 17550 m2. The Landgate gross rental value (GRV) for a site of this size is \$438,700 (which is the same value as last year and is equivalent to a weekly rental of \$8,436/wk or \$25/m2 per annum). The Bunbury local Council increased their fee multiplier from \$0.09087 to \$0.09351 and therefore this year's fees are GRV x \$0.09351 which results in Council rates of \$41,020 for this year.	41,020
Market Fee – AEMO fee for 2017/18 was based on \$0.918/MWh. This year AEMO fees are based on \$0.791/MWh. Therefore fees are based on a generation of 26,525 MWh ( $151.4 \text{ MW} \times 8760 \text{ hrs} \times 2\% = 26,525 \text{ MWh}$ ) which results in an annual fee of \$20,980	20,980
Balance of Plant (BOP) (service of pumps, water plant, fire system, etc., using a contract of 0.12% of capital for BOP Mechanical and Electrical services	147,020
Consent (EPA annual Charges emission testing) This year's figure is based on previous data for this. A range of \$30,000 to 45,000 is considered a reasonable fee for this service. GHD has assumed a last year's charges and added escalation (CPI) resulting in a fee of \$38,290 ( $\$37,500^* \times 1.021$ ).	38,290
Legal - There are years when legal costs are negligible and some year's, depending on the number of legal disputations, where this cost could be as high as \$40,000. GHD assumed last year's legal cost and added escalation (CPI) resulting in a legal fee for this year of \$31,240 ( $\$30,600^* \times 1.021$ ).	31,240
Corporate Overhead (apply 30% based on items such as superannuation contributions, workcover contributions, contribution to corporate office lease, cost for office staff in the corporate office, ongoing training of staff, employee insurance). GHD assumed last year's overhead and added escalation based on this year's WPI ( $\$188,678 \times 1.015^{11} = \$191,510$ ).	191,510
Travel (allow 10 domestic flights/accommodation at \$1230** each plus 2 International flights/accommodation at \$8180** each (Because there are occasions when Siemens may conduct workshops or training courses overseas GHD has allowed for 2 x international flights. This allowance could also be extended to overseas conferences that would be relevant to OCGT plant.	28,660

<sup>11</sup> WPI (actual): [https://www.treasury.wa.gov.au/Treasury/Economic\\_Data/Economic\\_Forecasts/](https://www.treasury.wa.gov.au/Treasury/Economic_Data/Economic_Forecasts/)

O&M Cost Component	Fixed Cost Estimate (\$ pa)
Subcontractors (Based on a more competitive environment among subcontractors since last year GHD deems that there would be an increase of 0.5% (over last year's cost of \$298,620*) for services by Subcontractors. Therefore a cost of \$300,110 is used for this year's value for subcontractor fees	300,110
Engineering Support - Similarly as for the case of Subcontractors GHD has applied a 0.5% increase to Engineering services (on last year's cost estimate of \$58,150*).	58,440
This year security has been increased by escalation. Last year's cost for security was \$120,000*. This year GHD has applied a CPI escalation resulting in an increase security cost (\$120,000* x 1.021=\$122,520).	122,520
Last year's electrical cost (including control & instrumentation) was based on 8 hours/week for a service provider to check and report on the operation of electrical, instrumentation and controls equipment at a rate of \$2000*/week. This year GHD has applied a CPI escalation taking the weekly rate up to \$2,045/week. The total cost will therefore be \$106,340 pa)	106,340
Similarly as per last year for fire detection and protection systems, GHD has made an allowance of 2 hours /week to check and report on the status of the fire detection and protection system. Based on a weekly rate of \$820/week the annual cost will be \$42,640)	42,640
<b>Total</b>	<b>2,015,090</b>

\*Last year's value.

\*\*Value increased by CPI from last year's value.

The total fixed O&M cost estimate has increased by \$27,582 from last year's report. The reasons for this increase are provided in the following table:

**Table 10 Fixed O&M Costs Summary Table**

O&M Cost Component	Variation from last year's results (\$ pa)	Comments
Plant Operator Labour.	+\$9,432	This year GHD has continued with the allocated number of staff, staff type and salaries for a typical OCGT plant and has added an escalation for this year's cost.
OCGT Substation (connection to tie line)	+\$4,504	An escalation has been applied this year on last year's value.
Rates	+\$1,160	This year's increase is due to the fact that last year's multiplier used by the Council has increased from \$0.09087 to \$0.09351. This resulted in a higher figure than last year.
Market Fee	-\$3,370	This year the AEMO fee rate was \$0.791 compared with last year's rate of \$0.918/MWh. This resulted in a reduction of last year's market fees.
Balance of Plant	+\$3,254	This year, the BOP estimate has increased over last year's value due to the higher plant capital cost.

O&M Cost Component	Variation from last year's results (\$ pa)	Comments
Consent (EPA annual Charges emission testing)	+\$790	This is an increase on last year's figure and is based upon last year's charge for this service plus an escalation.
Legal	+\$640	This year there is an increase on last year's legal fee as this year's fee is based last year's fee plus an escalation.
Corporate Overhead	+\$2,832	GHD retained corporate overhead based on 30% of the value of salaries. This year's value is an increase over last year's value due to escalation.
Travel	+\$660	This value has increased over last year's travel allowance due to escalation.
Subcontractors	+\$1,490	This value has increased over last year's value by 0.5%. This is due mainly to stronger demand for subcontractors.
Engineering Support	+\$290	Similarly as for the subcontractor services, the value for engineering support increased by 0.5% over last year's value.
Security	+\$2,520	This value has increased over last year's security cost due to escalation.
Electrical (including control & instrumentation)	+\$2,340	This year's cost estimate is based on 8 hours/w eek at \$2,045/w eek.to carry out these services. This is an increase over last year by a factor for escalation.
Fire detection and Protection Systems	+\$1,040	This year's cost estimate is based on 2 hours/w eek at \$820/w eek.to carry out these services (an increase if \$20/w eek from the rate used last year).
<b>Total Variation</b>	<b>+\$27,582</b>	

Five yearly aggregate fixed O&M costs for the power plant are provided in Table 11 below.

**Table 11 Fixed O&M cost for OCGT Power Plant (\$2018)**

Five Yearly Intervals	Fixed O&M Costs (\$)
1 to 5 Years	10,075,450
6 to 10 Years	10,075,450
11 to 15 Years	10,075,450
16 to 20 Years	10,075,450
21 to 25 Years	10,075,450
26 to 30 Years	10,075,450
31 to 35 Years	10,075,450
36 to 40 Years	10,075,450

Five Yearly Intervals	Fixed O&M Costs (\$)
41 to 45 Years	10,075,450
46 to 50 Years	10,075,450
51 to 55 Years	10,075,450
56 to 60 Years	10,075,450
<b>1 to 60 Years</b>	<b>120,905,400</b>

#### 4.4 Connection Switchyard and overhead transmission line

The fixed O&M costs have been calculated from the isolator on the high voltage side of the generator transformer.

The transmission line is assumed to be a single circuit 330 kV construction with 2 conductors per phase. The assumed power factor is 0.8 and for the 160 MW plant the line can facilitate the transport of up to 200 MVA.

A bottom up approach has been used to estimate the fixed O&M cost of switchyard and transmission line asset based on evaluating an annual charge for the connection infrastructure that assumes the substation and a 2 km HV connecting line to the tie-in point. This is then compared with last year's estimate.

Maintenance cost for these type of assets occur irregularly and therefore GHD has assessed the costs before producing an annualised fixed cost.

The fixed O&M cost estimate is inclusive of:

- Labour cost for routine maintenance
- Overheads (management, administration, operations, etc.)
- Hire cost of machinery and equipment to support routine maintenance

##### 4.4.1 Assumptions

The following key assumptions apply to the switchyard and transmission line O&M fixed cost estimates:

- The annualised fixed O&M cost does not allow for replacement of defective asset items over the life of the assets
- Insurance and tax costs are not included in the annualised fixed O&M costs
- Depreciation of assets has not been included in the normalised O&M fixed costs

#### 4.4.2 Switchyard Fixed O&M Costs

The fixed O&M cost over the asset lifetime for the switchyard was evaluated using a bottom up approach. Our estimate for this cost remains the same as last year's (\$75,268). However an escalation has been applied over this cost resulting in this year's cost increasing to \$76,400 pa in current dollars. This is an increase of \$1,732 pa over the value used in last year's report.

Table 12 shows the fixed O&M costs presented in five yearly periods over the lifetime of the switchyard assets.

**Table 12 Five yearly aggregate fixed O&M costs for switchyard assets**

Five Yearly Intervals	Fixed O&M Costs (\$)
1 to 5 Years	382,000
6 to 10 Years	382,000
11 to 15 Years	382,000
16 to 20 Years	382,000
21 to 25 Years	382,000
26 to 30 Years	382,000
31 to 35 Years	382,000
36 to 40 Years	382,000
41 to 45 Years	382,000
46 to 50 Years	382,000
51 to 55 Years	382,000
56 to 60 Years	382,000
<b>1 to 60 Years</b>	<b>4,584,000</b>

The increase in cost of \$1,732 pa was due to the addition of escalation on last year's fixed O&M cost for the switchyard. GHD assumed that routine maintenance would take an equivalent annual period of one week and would require the hire of scissor lift and forklift, as well as requiring project management, planning and organising by management and operations staff. This of course will change from year to year depending on what is required but essentially this cost is representative of a normalised spend over the period of the assets lifetime.

#### 4.4.3 Transmission line Fixed O&M Costs

Based on last year's fixed O&M cost GHD has added an escalation and therefore this year's fixed O&M cost for the transmission line is \$4,770 pa in current dollars. This cost represents an increase of \$104 pa over the value used in last year's report.

Table 13 shows the fixed O&M costs presented in five yearly periods over the lifetime of the transmission line asset.

**Table 13 Five yearly aggregate fixed O&M costs for transmission line asset**

Five Yearly Intervals	Fixed O&M Costs (\$)
1 to 5 Years	23,850
6 to 10 Years	23,850
11 to 15 Years	23,850
16 to 20 Years	23,850
21 to 25 Years	23,850
26 to 30 Years	23,850
31 to 35 Years	23,850
36 to 40 Years	23,850
41 to 45 Years	23,850
46 to 50 Years	23,850
51 to 55 Years	23,850
56 to 60 Years	23,850
<b>1 to 60 Years</b>	<b>286,200</b>

The increase in cost of \$104 pa for transmission line fixed O&M is due to escalation. GHD assumed that the work would be organised by management and operations staff and that the inspection would be carried out over a 2 day period and require the hire of scissor lift, as well as requiring planning and project management. The fixed O&M cost will change from year to year depending on the O&M required but essentially this cost is representative of a normalised spend over the period of the assets lifetime).

# 5. Fixed Fuel Costs

## 5.1 Overview of fixed fuel cost estimate

The fixed fuel cost component is associated with the cost for an onsite liquid fuel (diesel) storage and supply facility for the 160 MW OCGT power plant. The storage facility has sufficient capacity for 24 hours of operation on diesel fuel. The fixed fuel cost however will be based on having the storage facility filled to have sufficient capacity for the power plant to operate for 14 hours.

## 5.2 Assumptions

- Key assumptions for the fixed fuel cost used in GHD's report prepared in 2011<sup>12</sup>, and as specified in section 2.6 of the market procedure, were used for the fixed fuel cost for the 160 MW power plant which includes:
  - A fuel tank of 1,000 tonnes (nominal) capacity including foundations and spillage bund suitable for 14 hours' operation.
  - Facilities to receive fuel from road tankers.
  - All associated pipework, pumping and control equipment.
- Land is available for use and all appropriate permits and approvals for both the power station and the use of liquid fuel have been received;
- The basis of the estimate for fuel storage and handling assets is based on GHD's report mentioned in the first dot point;
- The fuel facility concept design would be reasonably typical for storage and handling of diesel fuel for service to an open-cycle gas turbine power station.
- The facility battery limits start from the loading bay and manifold for receipt of fuel from road tankers through to storage tank, diesel transfer pumps, diesel filtration and ends at a tie-in point on the fuel transfer pipe to the gas turbine, not further than 100 m and upstream from the turbine fuel train limits.
- The facility design complies within AS 1940 and includes for spillage bund containment and fire protection accordingly;

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<sup>12</sup> GHD Report Titled "Review of fixed fuel cost for maximum reserve capacity price in the wholesale electricity market", dated November 2011

### 5.3 Estimated Fixed Fuel Cost

#### Fuel facility cost

Table 14 below provides a breakdown of our estimate for the liquid fuel storage and handling facility for the 160 MW OCGT.

**Table 14 Cost breakdown for the diesel storage & handling facility**

No.	Item Description	A\$
1	Fuel Storage Tank – fabrication and construction of roofed vertical tank, externally coated, process nozzles, access manholes and concrete ring foundation, Spillage bund of concrete wall and floor, Stairways and access platforms, Instrumentation for level and temperature measurement, Geotechnical investigation, hydrostatic testing and cathodic protection.	1,611,500
2	Fuel Supply Loading Manifolds (two sets) – Loading manifolds including valves and coupling, Loading pumps and motors, Piping and electrical works.	53,950
3	Road Tanker Loading Bay of sealed road surface	128,270
4	Fuel transfer mainline piping (from pumps to the gas turbines including valves)	101,800
5	Fuel Transfer Pumping (duty & standby) Two fuel pump runs each with motor, filters & oil separators Flow meters, Piping and basic instrumentation, including floating suction header in tank, Concrete foundation and bunded plant area.	445,880
6	Oily Water Treatment System Sump pump, Oil separator unit, Piping and electrical, Concrete foundation and bunded plant area.	74,310
7	Site preparation, civil and early works	2,229,420
8	Perimeter fencing (cyclone wire mesh)	39,700
9	Fire protection (including hose reels and fire extinguishers)	36,650
10	Lighting	25,450

No.	Item Description	A\$
11	Mobilisation and De-mobilisation	88,570
12	Engineering, procurement and construction management (12%)**	580,260
13	Contractor risk, insurance and profit (15%)**	725,330
14	Spares and consumables	77,370
A	Sub-total for facility installation	6,218,460***
B	Base fuel storage of 633.8 m <sup>3</sup> (536.2 tonne) @ A\$0.7556/litre	478,900
	<b>TOTAL</b>	<b>\$6,697,360</b>

\*Estimate values have had 2018 CPI applied to last year's estimates (and rounded off) unless otherwise stated.

\*\*Based on % stated for the total of items 1 through to 11.

\*\*\* Approximately 2% up from \$6,108,000 (2017).

### Cost of fuel

The reference cost for diesel was obtained from the Jacobs report for AEMO titled "Energy Price Limits for the Wholesale Electricity Market in Western Australia", dated 8 June 2018. The wholesale price quoted in the report for distillate was \$17.88/GJ<sup>13</sup> (i.e. \$0.6896/litre, ex terminal price less excise and GST). A transport cost was evaluated to be approximately \$0.066/litre (based on a 24 tonne tanker load at \$1340/load from Freight Metrics Website<sup>14</sup>). This results in a delivered price of \$0.7556/litre.

Based on the above, the delivered cost for distillate is 75.56 cents/litre. This is a 4.86 cent/litre increase from last year's report. The increase in price is due to increased oil prices since last year's report.

The estimated gross HHV heat rate for the 160 MW OCGT operating at the specified site conditions is 11,363 kJ/kWh (10,669 kJ/kWh \* 1.0651 (HHV/LHV ratio)). The hourly fuel consumption would therefore be 1,747,629 MJ (for 153.8 MW gross output) which, based on a HHV for distillate of 45.6 MJ/kg (45,600 MJ/Tonne), represents a fuel consumption of 38.3 tonnes of distillate/hour. For 14 hours of operation at full load the amount of fuel required is estimated to be 536.2 tonnes of distillate or 633,806<sup>15</sup> litres of distillate.

The estimated cost for the first fill capacity (lasting 14 hours of operation at full load) is \$478,900<sup>16</sup>. This figure is approximately \$21,700 higher than last year's figure. This difference is due to the increase in fuel cost since last year.

<sup>13</sup> Based on a calorific value of 38.57 MJ/L

<sup>14</sup> <http://www.freightmetrics.com.au/FuelLevyCalculator/tabid/114/Default.aspx>

<sup>15</sup> Based on density of Diesel of 846 kg/m<sup>3</sup>

<sup>16</sup> Last year's fuel cost was \$457,192.

## 6. Margin M Costs

### 6.1 Overview of margin M costs

The allowance for the M factor includes:

- a. legal costs associated with the design and construction of the power station.
- b. financing costs associated with equity raising.
- c. insurance costs associated with the project development phase;
- d. approval costs including environmental consultancies and approvals, and local, state and federal licensing, planning and approval costs;
- e. other costs reasonably incurred in the design and management of the power station construction; and
- f. contingency costs.

The following sub-section provide an overview of the cost estimate that make up the M factor.

### 6.2 Derivation of M factor in 2018

#### Legal Costs

The legal cost estimated in 2017 was \$2,024,700. This figure is approximately 1.7% of the 2017 reported capital cost applicable for a 160 MW OCGT power plant.

GHD has maintained the bottom up approach used last year to determine the Legal cost and has updated the table below based on this year's reported capital cost. The evaluation for legal costs are shown in the following table.

**Table 15 Legal Costs**

Description	GHD's % Estimate on Project Costs (based on previous projects)	GHD's Estimate (A\$)
Support for contract conditions for specifications, tender analysis, and negotiations	0.60	735,100
Legal content for diesel fuel supply contract	0.12	147,000
Legal support for PPA/Capacity/offtake contract	0.40	490,050
Legal support for financing/loan procurement	0.10	122,500
Legal support for grid connection agreement	0.12	147,000
Legal support for contracts during construction phase	0.35	428,800
<b>Total</b>		<b>2,070,450</b>

Based on our assessment, in the table above for a 160 MW OCGT plant, our estimate for legal cost is \$2,070,450 which is slightly higher than last year's cost for legal (due to this year's higher capital cost for the 160 MW unit).

## Financing costs

The financing cost comprise of cost to raise capital and also setting up the project vehicle for financing during the construction phase. Last year assessment involved a bottom up approach to evaluate the financing cost which is comprised of a Senior debt loan and a Subordinate loan. Last year's financing cost was evaluated to be \$2,790,257.

Based on an equity to debt ratio of 20%/80% and a senior debt of 60% (of the total project loan –  $(0.8 * ((122,517,100 + 6,697,360)*0.6))) = 62,022,941$ ) and a subordinate debt of 40% (of the total project loan -  $(0.8 * ((122,517,100 + 6,697,360)*0.4))) = 41,348,627$ ), GHD's estimate for loan fees based on the loan amount (@ for a borrowing of 80% of the full project cost) is as follows;

**Table 16 Finance Cost**

Loan Fee	% fee for loan	Amount A\$
Senior loan	2.50%	1,550,574
Subordinate loan	3.15%	1,302,482
<b>Total</b>		<b>2,853,055</b>

\*Note the % split and magnitude for Senior and Sub-ordinate loans were derived from a previous project and is indicative of a project of this capacity.

Based on our assessment, in the table above for a 160 MW OCGT plant, our estimate for financing cost is \$2,853,055 and is slightly higher than last year's cost for financing. The reason for this difference is due to the fact this year's analysis for financing cost was based on a slightly higher capital cost for the 160 MW generic unit.

## Insurance cost

The cost for insurance assumes a number of risks that may occur during the construction phase of the power plant. An OCGT of this technology is relatively simple technology compared with other power plant technologies and therefore would attract a premium commensurate with the level of risks for this technology.

Insurance for a plant of this nature generally covers the following key risks:

- Loss due to fire and irreparable damage of the major plant components; and,
- Loss of income of the power plant due to lengthy delays during the construction phase;

A loss of the key power plant component rendering it to be written off is generally about 0.5 to 0.7% of the capital cost for the project. It is understood that the capital outlay during construction will ramp up during construction to the full project value until after the plant is commissioned, tested and handed over to the owner. However, insurance is based on the value of the commitment since total loss may occur toward the end of construction when the owner has paid over at least 90% of the commitment. Insurance premiums take into consideration the payment schedule during construction and therefore will initially be based on the commitment or asset value insured by the owner. Similarly, as was done last year, GHD has used a figure mid-way between 0.5% and 0.7% and therefore the insurance cost is estimated to be \$735,100.

Loss of income due to delayed construction is not always a risk that power plant owners insure against, and since loss of income is very subjective between insurance companies and can usually be recovered by the owner through liquidated damages. Therefore, as was the case in last year's assessment, the estimate for insurance premium for delayed construction risk is not included as part of the insurance cost for this assessment.

## Permitting & Approvals cost

The basis of this costing assumes that the proposed power station will be constructed on land which is appropriately zoned under the relevant local government planning scheme and that the site does not contain any significant environmental constraints that would require formal assessment by the WA Environmental Protection Authority under Part 4 of the *Environmental Protection Act 1986 (EP Act)*.

Therefore, the power station will require a Works Approval and Licence under Part 5 of the EP Act and development approval under the relevant local government planning scheme.

### *Works Approval*

A Works Approval issued by the Department of Environmental Regulation (DER) under the Environmental Protection Regulations 1987 will be required to allow construction of the power station.

Environmental assessment by the DER will focus on air and noise emissions. We have assumed that the site will contain remnant vegetation and consequently a biological survey will be required to support a Clearing Permit, but will not require heritage clearance (given the nature of its zoning).

The Works Approval will need to provide the following information:

- General specifications of the main pieces of plant
- Proposed facility layout
- Standard emissions
- Typical operating conditions
- Storage of hazardous goods
- Details of any liquid runoff
- Fuel source and estimated consumption
- Proposed mitigation measures for any emissions, as well as any surface water runoff.

Indicative costs are based on last year's assessment with an increase in cost due to current hourly rates:

• Prepare and submit Works Approval	\$21,010
• Air and noise modelling	\$21,010
• Biological survey	\$21,010
• Clearing Permit	\$10,510
• Application fee (est.)	\$64,725

## *Development Approval*

The proposed facility will require development approval under the local government planning scheme.

The Development Application will need to include:

- Appropriate application fee
- Details of the use proposed for the land or buildings
- Submission of three sets of plans consisting of:
  - site plan
  - elevations and sections of any building proposed to be erected or altered and of any building intended to be retained
  - floor plan
  - landscape plan
  - drainage plan.

Plans will need to include:

- Street names, lot number(s), north point and the dimensions/contours of the site
- The location and proposed use of any existing buildings to be retained and the location and use of buildings proposed to be erected
- The existing and proposed means of access for pedestrians and vehicles
- The location, number, dimensions and layout of all car parking spaces to be provided
- The location and dimensions of any area proposed to be provided for the loading and unloading of vehicles carrying goods or commodities and the means of access to and from those areas
- The location, dimensions and design of any landscaped or open storage areas
- Building materials, including specification of roof colours
- The location of on-site remnant vegetation, in particular mature trees
- Boundary fencing treatments
- The location of any underground services lines.

Indicative costs are based on last year's estimates with an increase in cost due to current hourly rates:

- |  |  |
|--|--|
| • Prepare landscape and drainage plans                                   | \$31,520   |
| • Prepare and submit Development Application (building details provided) | \$21,010 (assumes engineering and building details provided) |
| • Application fee (est.)   | \$41,720   |

## *Licence*

Once constructed a licence to operate will need to be obtained from the DER. The licence will document the type of emissions from the facility and specify the regular (annual) testing and reporting requirements.

Indicative costs are based on last year's estimates with an increase in cost due to current hourly rates:

- Prepare and submit Licence application \$15,760
- Annual licence fee \$5840
- Annual stack monitoring \$10,510
- Annual compliance report \$21,010

The estimated cost for Permitting and approvals cost is **\$285,635**.

### **Design & project management (Project Development)**

The project development cost is comprised of project management cost, owners cost, initial spares, site services, and start-up costs. Our analysis for these costs is outlined in detail in the sub-sections below.

#### ***Project management***

The project management services considered in this section pertains project development by the developer that includes all costs associated with the following:

- Concept/prefeasibility study
- Full feasibility
- Costs for the engagement of an Owners Engineer;
- Costs for the engagement of legal and financial services;
- Cost associated for the owner to provide a project team

#### ***Owners Engineer***

The owners engineer services consider the following costs:

- Front End Engineering Design (FEED) which includes all site related studies, specification, tendering, EPC Contractor selection and contract negotiations up to financial close;
- Construction management services to include, design drawing and document reviews, over-see construction activities, witness testing and commissioning activities and ensure that the O&M manuals and as-built drawings are correct.

Last year's methodology used to establish project management and owners engineering services was re-examined this year and was found to be sound and consistent with current practice.

The cost associated with project management and owners cost is therefore based on last year's assessment with consideration to the current applicable hourly rate and is provided in the following table.

**Table 17 Cost associated with project management and owners engineer services.**

Description	Cost (A\$)	
<b>Project Management</b>		
Concept/feasibility study	\$157,590	This is an average cost to produce a concept/feasibility study for an OCGT project. This normally takes 1 to 2 months to complete.
Full Feasibility Study	\$588,340	This is an average cost to produce a full feasibility study for an OCGT project. This normally takes 3 to 4 months to complete.
Engagement of Owners Engineer	\$220,625	This is an average cost to carry out a tender process to engage an owners engineer to represent the owner for the construction of the OCGT plant. This normally takes 2 to 3 months to complete.
Engagement of legal & financial services	\$304,675	This is the average cost to evaluate legal and financial groups to provide these support services for the OCGT plant. This normally takes 2 to 3 months to complete.
Cost associated for the owner to provide a project team	\$893,000	This is the cost associated for the owner to provide a team of staff to oversee the progress of the project from concept to commercial operation. This normally takes 2 to 3 years to complete.
<b>Owners Engineer</b>		
FEED & Contractor selection (tender process) up to Financial close	\$1,828,050	This is an average cost to produce a front end engineering design (FEED) and for an OCGT project and a tender process to establish an EPC contractor and the necessary contract for the construction of the OCGT plant
Construction management services	\$2,437,390	This is the average cost to carry out construction management services by an Owners engineer throughout the construction period up to and including testing & commissioning.
<b>Total</b>	<b>\$6,429,670</b>	

Based on the table above the cost associated with project management and owners engineering services is \$6,429,670 and is \$187,270 higher than last year's estimate of \$6,242,400. The reason for this difference is the increase in hourly rates over last year's assessment.

## Other costs

### Initial spares

As was the case in last year's assessment, it was assumed that a bare minimum of spares will be held by the power plant operators. GHD considers that spares will be held for scheduled maintenance such as hot gas path inspections and minor overhauls and thereafter replacement parts will be ordered on an as-needed basis.

The following table outlines areas of concern for the Siemens gas turbine and only those items marked "Wear" under the category "Findings" are likely to be held in stock at the power station.

**Table 18 Areas of Concern for Siemens V94.2 GT (SGT5-2000E)**

Item	Component	Findings	Measures
1	Compressor Blades	Corrosion & cracks	Replacement
2	Compressor Vanes	Cracks on Hooks	Replacement
3	Flame Tube Tile Holders	Wear	Replacement
4	Burner	Corrosion & cracks	Replacement
5	Seal Ring	Wear	Replacement
6	Casing	Cracks	Repair
7	Turbine Blades	Cracks/Degradation	Life extension for one further interval
8	Inner Casing	Oxidation	Repair and life extension for one further interval
9	Rotor Disk	Oxidation	Requalification and life extension for 100,000 EOH
10	BOP plant spares for wear (filters, gaskets, hoses, bolts, nuts, spare transfer pump, fuses, control cards, etc	Wear	Replacement

Source Life Extension for Siemens Gas Turbine<sup>17</sup>

The cost estimate for the parts marked "Wear" was estimated to be approximately \$511,250 in last year's assessment. This will of course differ from plant to plant depending on the adopted operator's maintenance strategy. For this year's assessment GHD has added applicable escalation since last year. Therefore, our estimate for initial spares is \$522,750.

### Site services

Last year's allowance for site services was \$152,250. GHD considers last year's estimate for site services to be reasonable (based on the site services required for this technology power plant). GHD's assessment for site services for this year is based on last year's estimate with an allowance for an increase in hourly rates for labour. Therefore, our estimate of \$156,820 is assumed to cater for the cost of site services for this year.

<sup>17</sup> Life Extension for Siemens Gas Turbine, Guido Lipiak, Susanne Bussmann, Power-Gen Europe 2006 30 May-1 June 2006, Cologne, Germany.

### Start-up costs

The start-up cost for the 160 MW OCGT power plant considers the cost for recruiting and training and employing staff during commercial operations as well as the cost of fuel and consumables used for testing and commissioning the plant.

The value used in last year's report was 1.5%. GHD considers this value to be reasonable as it was based on the output from GTPro. Therefore, based on using 1.5% of the capital value for the 160 MW OCGT plant, our estimate is \$1,837,760.

### Contingency

The contingency is an allowance for items that were not identified at the time of producing a cost estimate resulting from level of design available. The major cost for an OCGT power plant is the gas turbine package, which in this case is well defined by GTPro. Costs for gas turbines are updated annually and therefore GHD considers that the level of accuracy for the gas turbine is high.

In last year's report, a contingency of 5% was used which is consistent with previous year's and therefore for this year's report GHD maintains that a contingency of 5% is reasonable. Therefore, our estimate is \$6,125,855.

## 6.3 Overall M factor

The M factor for year 2018 is provided in Table 19 below.

**Table 19 Calculation of M factor for 2018**

Component of "M"	2017 Cost (\$)	2018 Cost (\$)	Difference (\$)
Legal Cost	2,024,700	2,070,450	45,750
Financing Cost	2,790,257	2,853,055	62,798
Insurance Cost	718,800	735,100	16,300
Permitting & Approvals Cost	278,240	285,635	7,395
Design & Project Management	6,242,400	6,429,670	187,270
<i>Other Costs</i>			
Initial Spares	511,250	522,750	11,500
Site services	152,250	156,820	4,570
Start-up cost	1,797,080	1,837,760	40,680
Contingency	5,990,260	6,125,855	135,595
<b>Total</b>	<b>20,505,237</b>	<b>21,017,095</b>	<b>511,858</b>

Following our assessment of the 2018 cost the overall M factor has increased by approximately \$511,858 due mainly to a change in increased hourly rates and higher capital cost for this year's 160 MW OCGT.

The overall M factor value is sensitive to a number of assumptions and styles of management from the specification of the plant to the operating and maintenance strategy adopted. However, the figure of \$21,017,095 is considered to be within the range expected for this factor.

GHD

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