

Review of the Vesting Contract Mid-term Capital Cost Update

for the period 1 January 2018 to 31 December 2018

Revised Report

2611312A-REP-005A



30 June 2017

Submitted to: Energy Market Authority
Submitted by: WSP | Parsons Brinckerhoff

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EXECUTIVE SUMMARY

WSP together with KPMG, has been engaged by Energy Market Authority (EMA) of Singapore to conduct a comprehensive review of the vesting price parameters set out in Section 2.3 of the published EMA's Procedures for Calculating the Components of the Vesting Contracts (Procedures)¹ for the period 1 January 2017 to 31 December 2018. The scope of the consultancy services consists of:

TASK 1:

1. Recommending the values of each parameter for items 6, and 11 to 23 to be used for setting the vesting price for the 2-year period, 1 January 2017 to 31 December 2018.
2. Recommending the values of each parameter for items 7 and 8 to be used for setting the vesting price for the 1-year period, 1 January 2017 to 31 December 2017.

The final report for Task 1 (2611312A-REP-004A) was completed in 2016 and referred to as the '2017-2018 review' in this report.

TASK 2:

Reviewing and recommending the values of each parameter for items 7 and 8 to be used for setting the vesting price for the 1-year period, 1 January 2018 to 31 December 2018. The review shall be conducted using the same methodology as that used for Task 1.

This report is for Task 2 of the consultancy services and also referred to as the '2017-2018 mid-term review'. The recommended values for items 7 and 8 are summarised in the following table.

Table 1 Summary of recommended updated parameters for 2017-2018 (mid-term) review

ITEM	DESCRIPTION	UNIT	2017-2018 MID-TERM REVIEW
7	Capital cost of the plant identified in item 6	US\$/kW	893.33
8	Land, infrastructure and development cost of the plant identified in item 6	S\$ million	155.56

¹ The Procedures is available at EMA website: https://www.ema.gov.sg/cmsmedia/Version%202%203%20-%20Vesting%20Contract%20Procedures_updated.pdf Version 2.3, September 2015 has been used for this report.

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ABBREVIATIONS

ABBREVIATION	DESCRIPTION
CCGT	Combined Cycle Gas Turbine
CPI	Consumer Price Index
EMA	Energy Market Authority
EPC	Engineering, Procurement and Construction
GT	Gas Turbine
HRSG	Heat recovery steam generator
ISO	International Organization for Standardization
kW	kilo Watt
LRMC	Long Run Marginal Cost
MAS	Monetary Authority of Singapore
MW	Mega Watt
NEMS	National Electricity Market of Singapore
OEM	Original equipment manufacturer
WSP	WSP Consultancy Pte. Ltd.
PEACE	Plant Engineering And Construction Estimator
psm	Per square metre
SGD	Currency of Singapore
SPPG	Singapore Power Powergrid
USD	Currency of USA
WACC	Weighted average cost of capital

1 INTRODUCTION

1.1 TERMS OF REFERENCE

In January 2004, the Energy Market Authority (EMA) of Singapore implemented Vesting Contracts as a tool to mitigate the exercise of market power by commercial generation companies (Gencos) in the national electricity market of Singapore (NEMS). Under the Vesting Contracts, Gencos are committed to sell a specified quantity of electricity at a specified price. This removes the incentive for large Gencos to withhold generation capacity in the market. The price under the Vesting Contracts is approximated with the long run marginal cost ("LRMC") of a theoretical new generation entrant in the market, utilising the most economic generation technology in operation which contributes to more than 25% of total demand.

The parameters for setting the Vesting Contract price associated with these contracts are reviewed every two years. WSP, together with KPMG, was appointed by the EMA to review the technical parameters (items 6 to 8 and 11 to 16 in section 2.3 of the Vesting Contract Procedures) and financial parameters for setting of the vesting price for the period 1 January 2017 to 31 December 2018. The first task of this review was completed in 2016.

In the Vesting Price Procedures, there is a mid-term review for the capital cost components (items 7 and 8) to be applied to the second year of the review period. This second task forms the scope of review in this report.

1.2 FINANCIAL PARAMETERS

For the mid-term review, the financial parameters relevant to the calculation of the capital costs are shown in Table 2.

Table 2: Financial parameters applied to capital costs components determination

No.	PARAMETER	VALUE FOR 2017-2018 MID-TERM REVIEW	REMARKS
1	CPI	1.485%	Average year-on-year MAS core inflation index for March 2017 to May 2017 ²
2	Exchange rates	SGD/USD - 1.3994 SGD/EUR - 1.5147	Average of daily Bid/Ask rates for March to May 2017 ²
3	WACC	7.15% pre-tax, real	From 2017-2018 review; financial parameters report

1.3 DISCLAIMER

This report has been prepared for the benefit of EMA for the purposes of setting the vesting contract price for the 1-year period from 1 January 2018 to 31 December 2018. This report may not be relied upon by any other entity and may not be relied upon for any other purpose.

² This report is updated to base month of May 2017.

2 CAPITAL COST

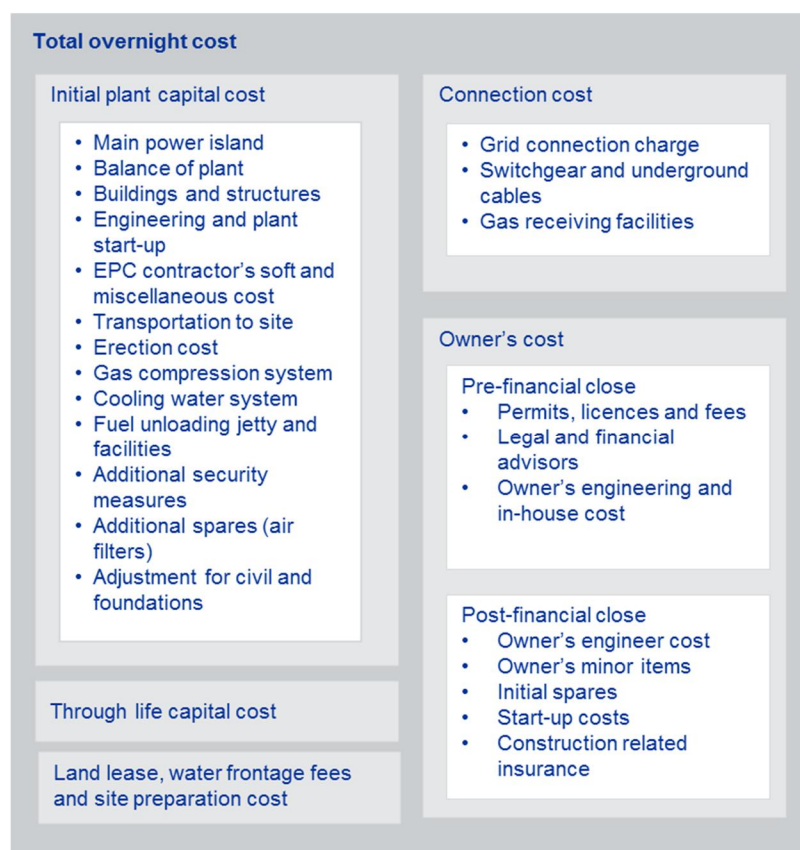
2.1 INTRODUCTION

This mid-term review follows the same methodology for deriving the capital cost of the power plant as employed in the 2017-2018 review.

The items considered in the capital cost of the power plant are listed below and in Figure 1. Details are further described in the subsequent sections.

- The main power island of the CCGT power plant in a single shaft configuration, each unit comprising of gas turbine generator, HRSG and steam turbine
- The balance of plant facility costs (ancillary buildings, water treatment and demineralisation plant, gas compression system, sea water intake/outfall structures, emergency fuel unloading jetty and storage tanks)
- Civil works for the plant, erection and assembly, detailed engineering and start-up costs, and contractor soft costs
- Additional spares and security measures³ as required by the authorities
- Discounted through life capital cost
- Land lease, water frontage and site preparation
- Grid connection facility and gas receiving facilities
- Owner's costs before and after achievement of Financial Close

Figure 1: Overview of capital cost considered in the review



³ The costs to implement the additional cyber security measures since the 2013-2014 review are accounted for in this review. Firewall with improved security features, splunk implementation, maintenance support for splunk, network and security devices, manpower resource, 1-way data flow diode, plant firewall, encryptors, antivirus software and ISO certification.

2.2 METHOD OF ASSESSMENT

The method of assessment used in this review is consistent with the previous reviews. The estimated capital cost of the new entrant power plant is assessed using the following approach:

1. The modelled two-unit single shaft “F” class CCGT built with shared common facilities in the 2017-2018 review is used to generate the initial capital cost information from the latest version of the PEACE software⁴ included with the GTPro software suite. The average of the PEACE output of the four machine types is taken and adjusted to the plant output considered in this review. The PEACE software has in-built current regional cost factors (labour, equipment, currency) to adjust the costs to be region specific to reflect the market condition. The PEACE cost generated is on an “overnight basis”.
2. Enquiries made to the OEMs for adjustments to the EPC price indication for constructing such a green field CCGT plant in Singapore since the previous year.
3. Assessment of recent CCGT power projects in the region and WSP in-house data.
4. Assessment of published price indicators: Power Capital Cost Index (PCCI) North America, European Power Capital Cost Index (EPCCI) and the widely used Gas Turbine World Handbook to gauge the change in price trends of power plants since the review. These are provided in Table 3 and Figure 2.
5. Cost of additional facilities and equipment required for the power plant that are not typically included in a turnkey project and captured by PEACE are computed using costs from the previous review adjusted by the BCA tender price index for construction components of civil/structural nature and the MAS core index for plant machinery and equipment. This method is consistent with the previous reviews. The indices are provided in Figure 3 and Figure 4.

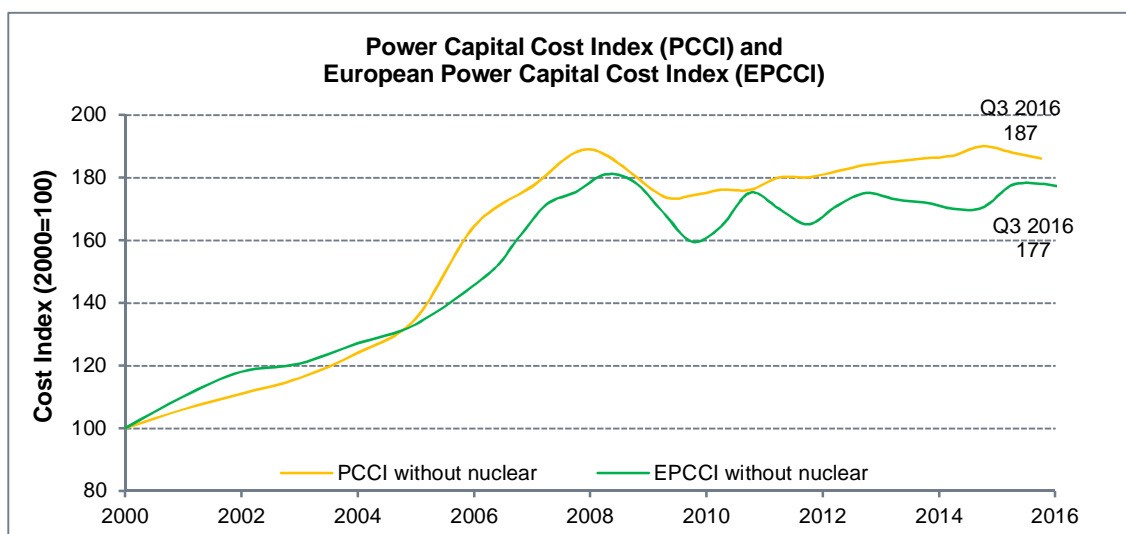
2.3 COST TRENDS AND ESCALATORS

Table 3: Gas Turbine World Handbook budget plant prices for CCGT units, USD/kW_{iso}

GAS TURBINE UNIT FOR A SINGLE SHAFT CCGT BLOCK	VOL. 26 2007-08	VOL. 27 2009	VOL. 28 2010	VOL. 29 2012	VOL. 30 2013	VOL. 31 2014-15	VOL. 32 2016-17
Frame 9FB	520	551	494	536	572	667	660
M701F	529	539	491	533	560	670	659
GT26	521	549	497	539	Not listed	675	667
SGT5-4000F	521	550	497	Not listed	Not listed	Not listed	Not listed

⁴ Version 26 with updates until 23 March 2017

Figure 2: Price trends of power plants (without nuclear): PCCI and EPCCI⁵



The price trends from GTW Handbook and PCCI and EPCCI show a declining CCGT prices in the global power market in the last year. The specific costs are not used in the review calculation as there is a time lag between the published data and actual market conditions.

Figure 3: BCA Tender Price Index, 2010 = 100

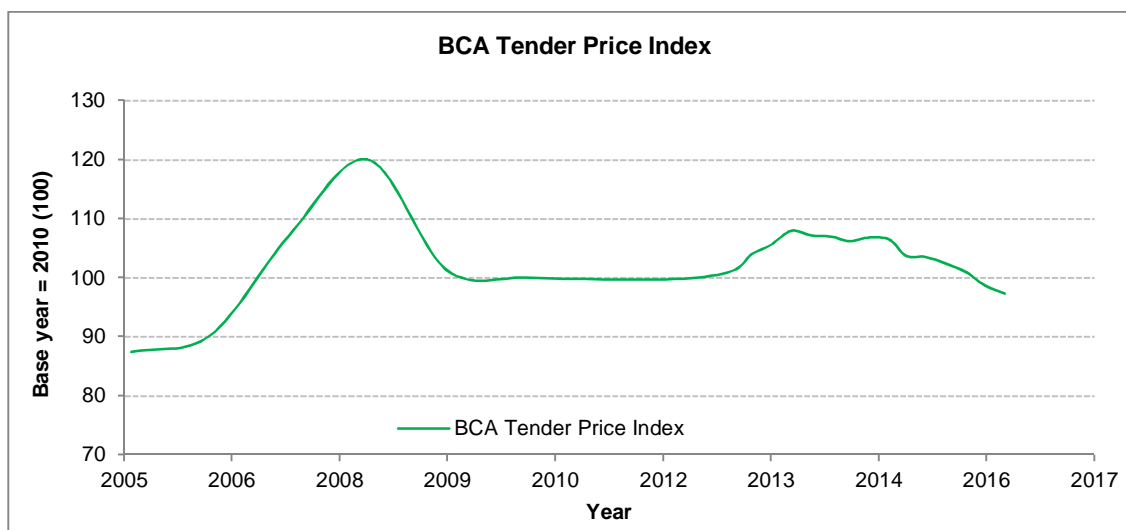


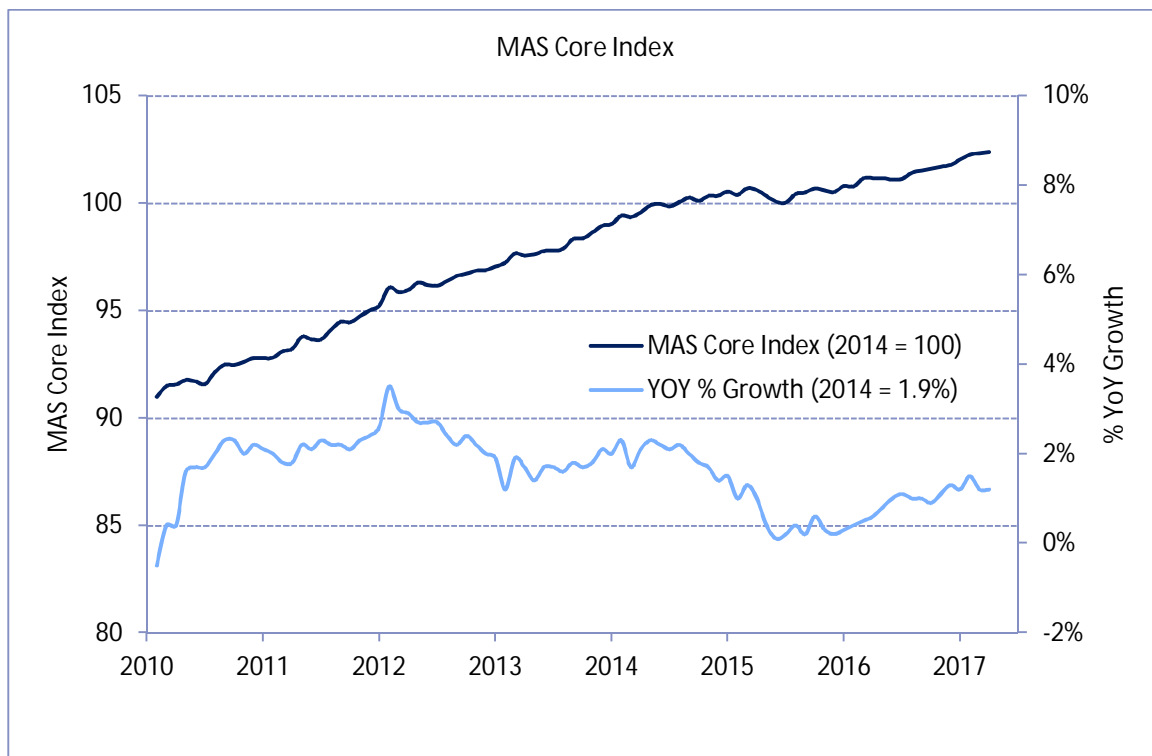
Table 4: Construction Material Market Prices (2010 - Q3 2016)

VARIABLES	UNIT	2012	2013	2014	2015	2016
Cement In Bulk (Ordinary Portland Cement)	S\$/ton	100.87	100.23	97.93	92.97	82.95
Steel Bars (16-32 mm High Tensile)	S\$/ton	887.13	766.9	653.9	501.4	500.52
Granite (20 mm Aggregate)	S\$/ton	21.26	20.61	22.45	19.71	15.43
Concreting Sand	S\$/ton	24.1	22.99	23.25	22.68	18.30

⁵ IHS Indexes. The PCCI and EPCCI track the costs of building coal, gas, wind and nuclear power plants, indexed to year 2000. Data excluding nuclear power plants are used.
<https://www.ih.com/info/cera/ihindexes/>

VARIABLES	UNIT	2012	2013	2014	2015	2016
Ready Mixed Concrete	S\$/m ³	110.23	106.85	111.15	99.47	85.01
BCA Tender Price Index (2010=100)	-	99.8	104.6	106.8	104.0	Q3 = 97.3

Figure 4: MAS Core Index, 2014 = 100 (2010 to 2017)



The apparent local construction costs have decreased since the previous review as reflected by the BCA Tender Price Index (Figure 3) and the construction material prices (Table 4). In the 2017-2018 review, the BCA Tender Price Index used was 101.0 for February 2016 and the latest available quarterly data in August 2016 is at 97.3. Thus, the adjustment factor applied to construction components of civil/structural nature is 0.96.

For plant machinery and equipment which are outside of the EPC contractor scope, the cost estimates have been escalated using the MAS core index which reflects the cost of goods in Singapore, excluding accommodation and private road transport. The previous index used in the 2017-2018 review was 101.14 (average of 3 months including base month, May 2016). The current value is 102.32 (average of 3 months including base month, May 2017). This represents an increase of 1.012.

2.4 RESULTS OF ANALYSIS

From the analysis of items 2 to 4 as listed in Section 2.2, the PEACE cost estimate of item 1 is adjusted to produce the initial plant capital cost as tabulated in Table 5.

The PEACE model provides the cost output in USD and compared with the previous review, there is a marginal increase in EPC contractor price of 0.2%. From our discussions with the OEMs, the market conditions remain largely unchanged from last year and this supports the PEACE cost results. With the effect of the stronger USD, which has appreciated approximately 3.8% to the Singapore Dollar (SGD), as per the base month of this review, the EPC contractor price in SGD reflects an overall 4% increase in the initial plant cost compared to the 2017-2018 review.

2.5 INITIAL PLANT CAPITAL COST

The initial plant capital cost includes the following modifications applied to a typical two-unit CCGT plant. This is done to reflect the design features required for a power plant in Singapore. Where plant equipment or infrastructure is shared between the two units, the costs are halved.

- Gas compression system (two trains per unit)
- Once-through cooling system with the civil costs added separately on a shared (two-unit) basis
- Dual fuel firing system for the gas turbines and fuel forwarding system from the tanks
- Fuel unloading jetty and associated facilities on a shared (two-unit) basis
- Fuel tanks with on-site storage capacity at not less than sixty days on a shared (two-unit) basis
- Civil costs are calculated on a two-unit station basis and then halved
- Building and structures costs are calculated for a two unit station and then halved
- Additional security measures as allowed in previous reviews and cyber security measures put in place since 2013-2014 review are included. See Footnote 3 for details.
- Additional inlet filter spares considering the requirements of the Transmission Code clause 9.2.5

The resulting initial plant cost for the plant (excluding external connections) is S\$507.771 million per unit as shown in Table 5. This cost is on an "overnight" basis⁶.

Table 5: Initial plant capital cost summary and compared with previous review (1 unit)

All figures in million Singapore dollars

No.	ITEM	2017-2018 (MID-TERM)	2017-2018
1	Specialized Equipment	248.810	242.377
2	Other Equipment	12.553	11.489
3	Civil	28.746	31.771
4	Mechanical	39.238	37.470
5	Electrical Assembly & Wiring	10.578	8.906
6	Buildings & Structures (shared except turbine hall)	8.324	5.617
7	Engineering & Plant Start-up	16.177	15.966
8	Contractor's Soft & Miscellaneous Costs	78.146	76.936
9	Transport	Included	Included
10	Gas compression system	10.586	11.597
11	Cooling water system	6.519	6.809
12	Fuel unloading jetty and facilities	7.784	8.130
13	Fuel tanks	26.725	22.814
14	Additional security measures and cyber security measures	2.929	2,886

⁶ Overnight basis does not include interest during construction.

No.	ITEM	2017-2018 (MID-TERM)	2017-2018
15	Air filters	0.152	0.150
16	Adjustment for civil/foundations	5.294	5.530
	Total initial plant cost excl. connection costs (1 unit) (numbers may not add up due to rounding)	502.560	488.448

The total initial plant cost is S\$502.560 million for one unit or S\$1.051 billion for two units.

2.6 THROUGH-LIFE CAPITAL COSTS

Additional capital costs are incurred through the project's life. Actual costs incurred vary considerably and are based on progressive assessments made of plant condition through the plant's life. The recommended estimates for this review are given in Table 6.

Table 6: Current review through-life capital costs compared with previous review (1 unit)

No.	ITEM	UNIT	2017-2018 (MID-TERM)	2017-2018
1	Distributed control system (DCS)			
	- Time to replacement:	EOH	150,000 or ~15 years	150,000 or ~15 years
	- Cost of replacement:	S\$ m S\$ m real	6.90 2.45 <i>(discounted equivalent at pre-tax real WACC of 7.15%)</i>	6.80 2.41 <i>(discounted equivalent at pre-tax real WACC of 7.15%)</i>
2	Gas turbine rotor			
	- Time to replacement:	EOH	150,000 or ~15 years 14.0 (US\$10 m)	150,000 or ~15 years 13.6 (US\$10 m)
	- Cost of replacement:	S\$ m S\$ m real	4.96 <i>(discounted equivalent at pre-tax real WACC of 7.15%)</i>	4.84 <i>(discounted equivalent at pre-tax real WACC of 7.15%)</i>
	Total through life capital cost (1 unit)	S\$ m	7.41	7.25

The cost of the DCS upgrade depends on the level of obsolescence of related items such as field instrumentation and associated wiring.

Towards the end of the notional technical life of the plant, if market studies indicate that the plant may still be economic, studies would be undertaken to evaluate extending the plant's life. The studies and the resulting costs and resulting life extensions are not included.

2.7 LAND AND SITE PREPARATION COST

The land and site preparation cost excludes (i) facility costs (ancillary buildings, demineralisation plant, sea water intake/outfall structures, constructing the jetty for emergency fuel unloading facility and gas receiving facilities) and (ii) emergency fuel facilities. These costs have been included under capital cost for the current review.

The site area for building the two units remains unchanged from the previous review at 12.5 Ha and a waterfront requirement of 200m. Based on data published by JTC Corporation's Land Rents and Prices, the land price for 30-year lease at Tuas View is between \$190 and \$238 psm and taking the midpoint value of S\$214 psm, the total land lease cost is S\$26.75 million. The published water frontage fees range from \$1,101 to \$1,652 per metre per year and using the midpoint annual cost at a pre-tax discount rate of 7.15% over 25 years; this gives an equivalent cost of \$3.16 million. Therefore, the total cost assuming mid-point land cost is S\$29.91 million.

For site preparation cost at the same site location as the previous review, the BCA tender price index have been applied to the previous review cost of S\$2.11 million which results in site preparation cost of S\$2.02 million.

The total land and site preparation costs are summarised and compared with the previous review in Table 7.

Table 7: Current review land and site preparation cost compared with previous review (2 units)

No.	REVIEW	UNIT	2017-2018 (MID-TERM)	2017-2018
1	Land cost for 30-year lease at Tuas View	S\$ m	26.75	31.75
2	Equivalent water frontage cost	S\$ m	3.16	3.68
3	Site preparation cost	S\$ m	2.02	2.11
	Total land and site preparation cost (2 units) <i>(numbers may not add up due to rounding)</i>	S\$ m	31.94	37.54

For the current review, the total land and site preparation costs is \$31.93 million for two units or S\$15.97 million per unit.

2.8 CONNECTION COST

The connection costs for electrical and gas connections to the electricity grid and gas network respectively are considered in this section.

2.8.1 ELECTRICAL CONNECTION COST

For the electrical connection cost, the components considered are shown in Figure 5 and itemised in Table 8.

The electrical connection configuration assumed in this review is consistent with the previous review where the 3 x 500 MVA arrangement is selected from the options of a 3 x 500 MVA or 2 x 1000 MVA connection. It is noted that the PacificLight and Sembcorp Cogen connections are using the 3 x 500 MVA configuration to achieve the "N-1" redundancy arrangement. The sizing of the 230kV GIS equipment, 230kV cables have been sized for export of the plant total net output at 24.7°C of 879.4 MW.

Figure 5: Assumed electrical connection configuration

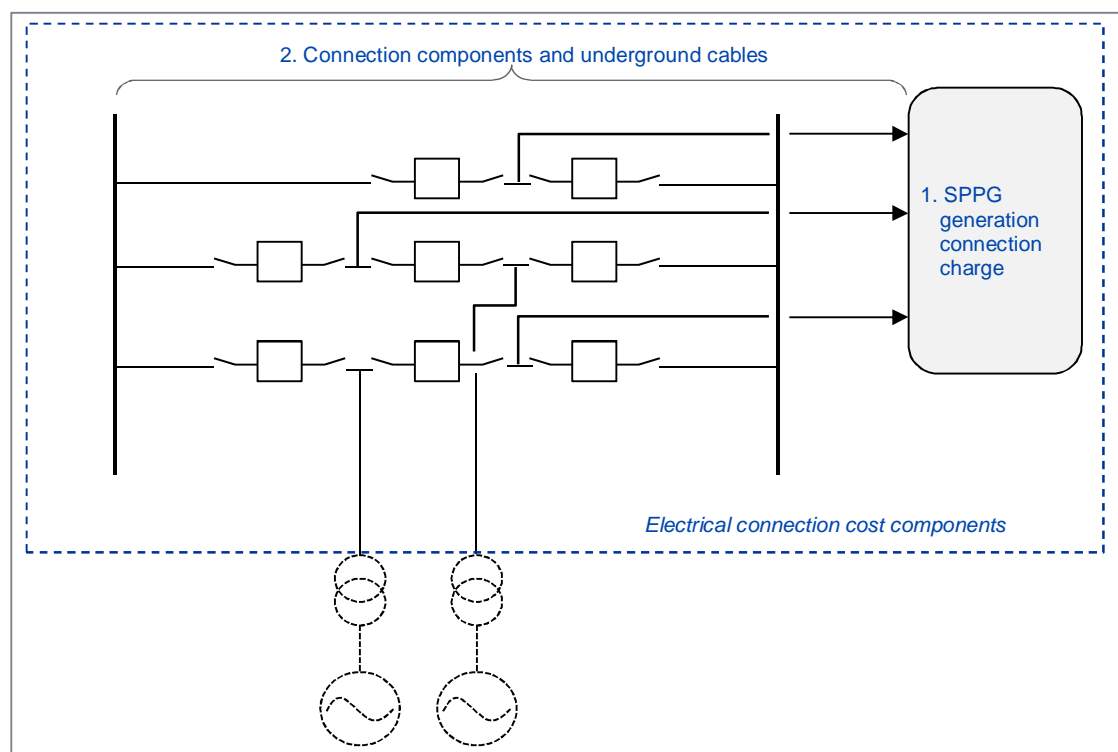


Table 8: Current review electrical connection costs compared with previous review (2 units)

No.	ITEM	UNIT	2017-2018 (MID-TERM)	2017-2018
1	Total SPPG generation connection charge	S\$ m	43.97	43.97
1a	- Plant output at 24.7°C	MW	879.4	879.4
1b	- Unit cost of SPPG generation connection charge	S\$/MW	50,000	50,000
2	230kV Switchgear GIS and underground cables - Includes switch house but excludes generator transformer which is included in power plant cost - 3 x 500 MVA circuits, 1km direct buried cables	S\$ m	34.49	34.06
Total electricity connection cost (2 units)		S\$ m	78.46	78.03

From Singapore Power PowerGrid (SPPG), the unit cost of the generation connection charge is at S\$50,000/MW and the total net plant capacity at 24.7°C is 879.4 MW (unchanged from previous review). This gives a total generation connection charge of S\$43.97 million. Using a bottom-up approach, the cost of the 230kV switchgear GIS and underground cables are estimated to be S\$34.49 million. The total electricity connection cost for the power plant is S\$78.46 million for two units and S\$39.23 million per unit.

2.8.2 GAS CONNECTION COST

Given the location of the new entrant plant is the same as the last review at Tuas View area and the gas requirements of the power plant, the gas connection cost is escalated from the previous review using MAS core inflation index and BCA tender price index for equipment/materials and

civil costs respectively. This gives a gas connection cost of S\$14.11 million for two units or S\$7.06 million per unit.

The total connection cost is S\$92.58 million for two units or S\$46.29 million per unit.

Table 9: Current review connection costs compared with previous review (1 unit)

No.	REVIEW	UNIT	2017-2018 (MID-TERM)	2017-2018
1	SPPG generation connection charge	S\$ m	21.99	21.99
2	230kV Switchgear GIS and underground cables	S\$ m	17.24	17.03
3	Gas connection cost	S\$ m	7.06	7.08
	Total connection cost (1 unit) <i>(numbers may not add up due to rounding)</i>	S\$ m	46.29	46.09
	Total connection cost (2 units)	S\$ m	92.58	92.18

2.9 OWNER'S COSTS AFTER FINANCIAL CLOSE

The Owner's costs incurred from Financial Close to the Commercial Operation Date of the plant are typically calculated as a percentage of the initial plant capital costs and connection costs. The allowances recommended are shown in Table 10.

Table 10: Current review Owner's cost after Financial Close compared with previous review (1 unit)

No.	ITEM	% OF INITIAL PLANT COST AND CONNECTION COST	2017-2018 (MID-TERM) (S\$ M)	2017-2018 (S\$ M)
1	Owner's engineer	3%	16.47	16.04
2	Owner's minor items	3%	16.47	16.04
3	Initial spares	2%	10.98	10.69
4	Start-up costs	2%	10.98	10.69
5	Construction related insurance, etc.	1%	5.49	5.35
	Total Owner's cost post Financial Close (1 unit) <i>(numbers may not add up due to rounding)</i>		60.37	58.80

The Owner's cost items considered after Financial Close are consistent with the previous reviews. Owner's engineering costs are the costs to the owner for in-house and external engineering and management services after financial close, including inspections and monitoring of the works, contract administration and supervision, project management and coordination between the EPC contractor, connection contractors and contractors providing minor services, witnessing of tests and management reporting.

Minor items include all the procurement costs to the owner outside of the primary plant EPC costs and the electricity and gas connections. This includes permits/licences/fees after financial close, connections of other services, office fit-outs and the like. This also reflects any site specific optimisation or cost requirements of the plant above those of a "generic" standard plant covered in Section 0.

Start-up costs include the cost to the owner of bringing the plant to commercial operation (the actual commissioning of the plant is within the EPC contractor's scope). The owner is typically responsible for fuels, water and consumables used during testing and commissioning, recruiting, training and holding staff prior to commercial operations commencing, and for establishing systems and procedures. The construction related insurance cost borne by the owner has also been considered in the owner's total cost after Financial Close.

The initial working capital, including initial working capital for liquid fuel inventory and for accounts receivable versus payable, are not included (these are an ongoing finance charge included in the fixed operating costs of the plant).

The total owner's cost after Financial Close is S\$60.39 million for one unit or S\$120.78 million for two units.

2.10 OWNER'S COSTS PRIOR TO FINANCIAL CLOSE

At the time of Financial Close, when the investment decision is being made, the costs accrued up to that time against the project are "sunk" and are sometimes not included in a new entrant cost estimate.

Nevertheless, the industry needs to fund the process of developing projects to bring a plant from initial conception up to financial closure. If these are to be added, the costs can be highly variable. The allowances should include both in-house and external costs to the owner/developer from concept onwards including all studies, approvals, negotiations, preparation of specifications, finance arranging, legal, due diligence processes with financiers etc. These would typically be over a 3 to 5 year period leading up to financial close. An example of typical allowances based on percentages of the EPC cost is shown in Table 11.

Table 11: Current review Owner's cost pre Financial Close compared with previous review (1 unit)

No.	ITEM	% OF INITIAL PLANT COST AND CONNECTION COST	2017-2018 (MID-TERM) (\$ M)	2017-2018 (\$ M)
1	Permits, licenses, fees	2%	10.98	10.69
2	Legal and financial advice and costs	2%	10.98	10.69
3	Owner's engineering and in-house costs	2%	10.98	10.69
	Total Owner's cost pre-Financial Close (1 unit) (numbers may not add up due to rounding)		32.93	32.07

Permits, licences and fees primarily consist of gaining the environmental and planning consents for the plant.

Legal and financial advice is required for establishing the project vehicle, documenting agreements, preparing financial models and information memoranda for equity and debt sourcing, management approvals and due diligence processes.

Owner's engineering and in-house costs prior to financial closure include the costs of conceptual and preliminary designs and studies (such as optimisation studies), specifying the plant, tendering and negotiating the EPC plant contract, negotiating connection agreements, attending on the feasibility assessment and due diligence processes, management reporting and business case preparation, etc.

Project development on a project financed basis sometimes incurs extra transaction costs, such as swaptions for foreign exchange cover or for forward interest rate cover. These are highly project specific and not always necessary. No extra allowance is included.

3 SUMMARY OF CAPITAL COST PARAMETERS

The calculation of the specific capital costs in USD/kW applied in item 7 of the vesting contract parameters are given in Table 12. Table 13 shows the calculation of the land, infrastructure connection and development costs included in item 8 of the vesting contract parameters.

Table 12: Calculation of item 7 of vesting contract parameters

ITEM	REVIEW	UNIT	2017-2018 (MID-TERM)
5	Exchange Rate (\$US per \$Sing)		1.3994
6	Economic capacity of the most economic technology in operation in Singapore	MW	407.92 (from 2017-2018 review)
	Initial plant capital cost	S\$ million	502.56
	Through-life capital cost	S\$ million	7.41
	Total plant capital cost	S\$ million	509.97
7	Capital cost of the plant identified in item 6	US\$/kW	893.33

Table 13: Calculation of item 8 of vesting contract parameters

ITEM	REVIEW	UNIT	2017-2018 (MID-TERM)
	Land and site preparation cost	S\$ million	15.97
	Electrical connection cost	S\$ million	39.23
	Gas connection cost	S\$ million	7.06
	Owner's costs after Financial Close	S\$ million	60.37
	Owner's costs prior to Financial Close	S\$ million	32.93
8	Land, infrastructure and development cost of the plant identified in item 6	S\$ million	155.56

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