SINCLAIR KNIGHT MERZ
SKM

Independent Market Operator

IMO
Wholesale Electricity Market

Review of the Maximum Reserve Capacity Price 2008 – Non Power Station Elements

FINAL REPORT

- 10 October 2008

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1. Introduction

As a part of the Government of Western Australia's ongoing commitment to the Wholesale Electricity Market within the South West Interconnected System, the Government of Western Australia has setup 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 to mid 2008 value:

- 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;
- Capital cost (procurement, installation and commissioning, excluding land cost) of a 330kV three breaker mesh switchyard configured in a breaker and a half arrangement that facilitates the connection of the above mentioned power station to an existing transmission line;
- Fixed Operating & Maintenance costs of this switchyard. The cost shall be in 5 year periods covering 1 to 50 years;
- Capital cost (procurement, installation and commissioning, including shallow land easement cost) of a 2km long 330kV overhead single circuit lattice steel tower transmission line that connects the power station and the switchyard, whereby the switchyard is located in the vicinity of an existing 330kV transmission line. The capital cost will also easement acquisition costs
- Fixed Operating & Maintenance costs of this overhead transmission line. The cost shall be in 5 year periods covering 1 to 60 years;
- Ensure the switchyard and the transmission line arrangements comply with the requirements of Western Power's Technical Rules; and
- Legal, approval, environmental, financing and design 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 explain the scope of this project in detail and is attached in Appendix A.

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

2. Executive Summary – Non Power Station Elements

SKM estimates the capital cost of building a new switchyard and connecting it to a nearby 330kV transmission line to be AU$ 9.82 million in 2008 figures.

The capital cost of building a new 2km long 330kV single circuit transmission line from the power station to the switchyard is estimated to be AU$ 2.10 million in 2008 figures.

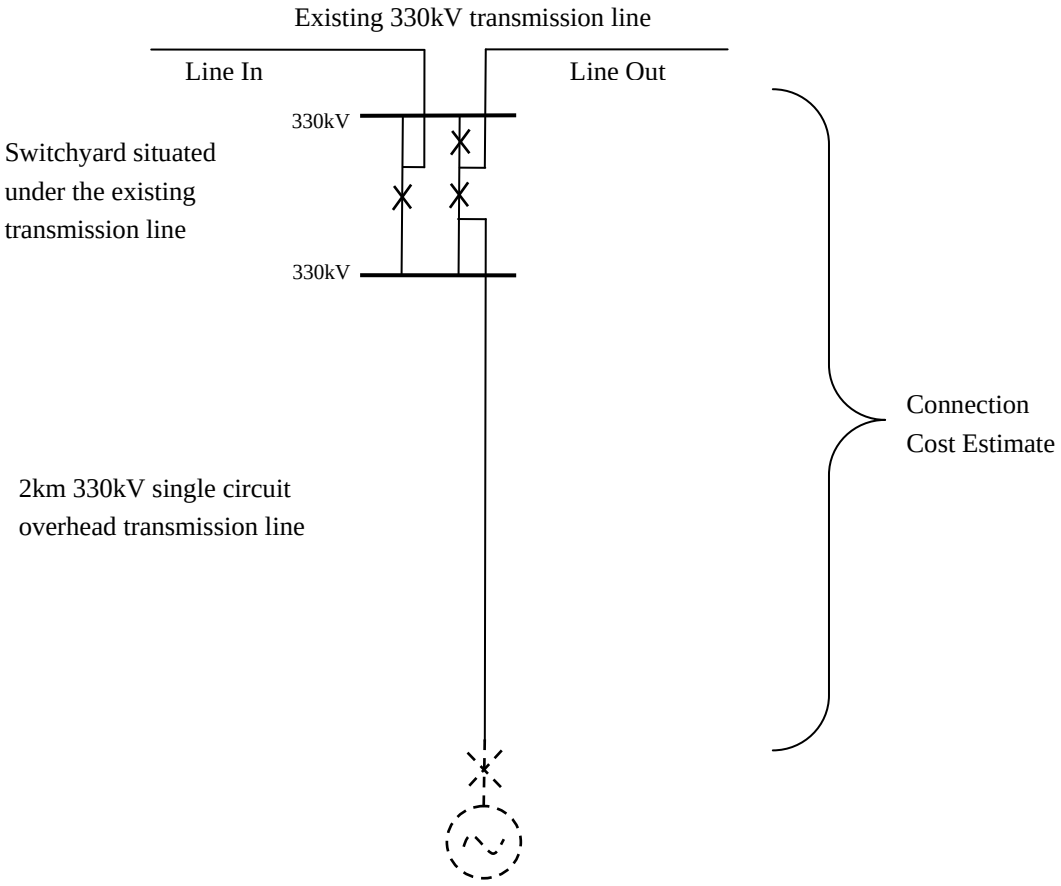
The capital cost to acquire the land easement around the 2 km long transmission line is estimated to be AU$ 5.08 million in 2008 figures.

SKM estimates the average annual operating & maintenance costs over the asset lifetime for the switchyard and the transmission line are AU$ 163.5K and AU$ 7K respectively.

3. Switchyard and Overhead Transmission Line Connection Capital Costs

3.1 General Issues and Assumptions

The output from the power station will be transmitted by a 2km long 330kV single circuit steel lattice tower transmission line to the existing transmission line. The connecting point to the existing transmission line will be a three breaker mesh switchyard configured in a breaker and a half arrangement. This arrangement is shown in Figure 3-1.

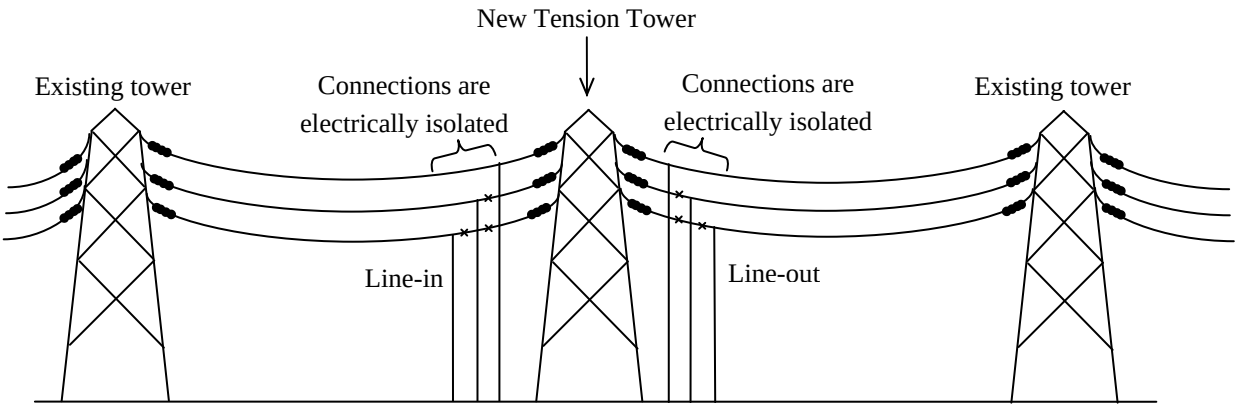


- **Figure 3-1 Overall arrangement**

The switchyard consists of two 1.5 breaker diameters. The first diameter has one centre bay and two spare (empty) feeder bays and is connected to the existing transmission line. The second diameter has one feeder bay, one centre bay and one spare (empty) feeder bay and is connected to

the generator and the existing transmission line. A general arrangement and single line diagram for this switchyard can be seen in Appendix E. This switchyard will be located under the existing transmission line.

It is assumed that the existing transmission line will not require modification to allow for this connection with the exception of one new tension tower located at the switchyard to allow the point of connection. SKM has considered a single tension tower configuration, with the new tension tower being positioned between two existing towers to allow for '*Christmas tree connection*' as shown in Figure 3-2. Costs associated with any staging works have not been considered.



- **Figure 3-2 Elevation of connection point into the existing transmission line**

The 160MW OCGT can deliver up to 180MW output that is transmitted by the 3 phase overhead conductors at 330kV. One "Orange" conductor per phase has a suitable ampere rating for this purpose. All connection costs have been calculated from the isolator on the high voltage side of the generator transformer and therefore do not include any of the costs associated with the generator transformer and switchgear.

The switchyard located under the existing transmission line considers a flat land in a rural setting with minimum or no vegetation and no unforeseen environmental or civil costs associated with the development. The 2km long transmission line connecting the power station to the switchyard considers 50% flat - 50% undulating land, 50% rural - 50% urban conditions, no gas pipeline crossing, allowance for one road crossing per km, minimum or no vegetation requiring very little clearing, and with no unforeseen environmental or civil costs associated with the development.

The main advantage of this arrangement is the flexibility for future development of the power station. Additional generation capacity can be easily transferred to the existing network by

connecting to the spare feeder bay. Additional one and a half breaker diameters can also be easily added in the switchyard alongside the proposed diameters.

3.2 Switchyard Capital Costs

The capital costs for the 3 breaker mesh switchyard configured in a breaker and a half arrangement has been estimated at $9,817,679 in mid 2008 dollar value. This estimate includes civil, infrastructure, all primary and secondary plants & equipments, a connection tension tower located within the switchyard, EPCM, and an adjustment factor for higher contractor cost in South Western region of Western Australia. It is assumed that OPGW is installed in the existing and new transmission lines; hence the cost estimate includes OPGW retrofits and two terminal ends. The cost estimate does not include the cost of land. Refer Appendix C for the detailed switchyard cost estimate.

3.3 Transmission Line Capital Costs

The capital cost for a 2km long 330kV single circuit, lattice steel tower, with one "Orange" conductor per phase and OPGW is estimated at $2,101,176 in mid 2008 dollar value. This estimate is based on 400m of span length and includes EPCM and an adjustment factor for higher contractor cost in South Western region of Western Australia. As the line is only 2km in length, a 100% allowance for the short length factor has been applied to the line cost based on SKM's recent experience on similar projects (note SKM's standard unit rates for transmission lines are based on a reference asset where the transmission line is constructed on a 100km length). Refer Appendix D for the detailed transmission line cost estimate.

The land easement for this transmission line is assumed to be 50m wide along the 2km route. The cost to acquire the needed easement land is estimated approximately at $5,082,000[1] in mid 2008 dollar value.

3.4 Compliance to Technical Rules for 330kV Switchyard and Transmission Line

The existing Western Power Technical Rules sets out the Transmission and Distribution System Planning Criteria for the SWIS network. Clause 2.5.2.3 states

[1] The land easement cost estimate is based on the average selling price of land at Collie, Bridgetown, Boddington and Manjimup. These regions are located nearer to the existing 330kV transmission line in the SWIS area. However, the size of the land is typically large and does not represent the narrow corridor required for an easement. The cost estimate does not take into account the specific details and requirements of each property over which the easement will be required. Additionally the cost valuation, negotiation, surveys and legal costs are not included in the land easement cost estimate.

"The N-1-1 criterion applies to those sub-networks of transmission system where the occurrence of a credible contingency during planned maintenance of another transmission element would otherwise result in the loss of supply to a large number of consumers. Sub-network of the transmission system that are designed to the N-1-1 criterion include all 330kV lines, substation and power stations"

The complete section containing the clause above is shown in Appendix B.

Clause 2.5.2.3 states that sub-networks are required to meet N-1-1 criterion. This means that the network will be required to withstand a forced outage of a transmission or generating element while another element are out of service due to maintenance without causing loss of supply to customers.

The proposed connections only meet N-1 security criteria when considered in isolation from the network. This is less than the requirements set out in Clause 2.5.2.3. However this may not be the case when the complete network is considered to provide alternative solutions to meet this planning requirement. It should be noted that new network connections would not be treated in isolation and any new connections would need to go through Western Power's planning process to ensure that the requirements under the technical rules can be met.

3.5 Connection Works Cost Escalation

The connection work cost escalation indices is developed by using SKM's internal Capex Cost Escalation Model. The Model has been used extensively in developing cost escalation index for a number of Transmission and Distribution Network Service Providers throughout Australia. The SKM cost escalation methodology has also been accepted by the AER in revenue proposals submitted by these utilities.

The Model draws upon 2006 SKM strategic procurement study which surveyed the network project capital expenditure of nine (9) TNSPs and DNSPs throughout Australia. Procurement specialists and equipment suppliers/manufactures were also brought into the process to ascertain the weighting of underlying cost drivers that influenced the final cost of each plant and equipment item. These cost drivers were identified through the projects undertaken by the TNSPs and DNSPs.

Historical and forecast movements of these underlying cost drivers, from various sources as listed in Sections 3.6 and 3.7, are then used to populate the Model. This allows for suitable escalation indices that are specific for electricity utility industry to be developed. These cost drivers are periodically updated in the Model.

The Capex Cost Escalation Model have been progressively refined since its first introduction. The enhancements have been undertaken by various means, including:

- Reviewing and updating supplier and contractor costs during subsequent asset valuation assignments;
- Obtaining updated budget price information from suppliers and contractors for individual plant, equipment and projects; and
- Other external project costs for non-utility clients that are project managed by SKM;

The EPCM cost element is applied in the form of 15% and 20% cost uplift on all other costs for switchyard and transmission line projects respectively. Hence EPCM is also represented in 2008 dollar term.

3.6 Switchyard Capital Cost Escalation

For the switchyard capital cost escalation, the following data types have been drawn on:

- **Table 3-1 Switchyard Capital Costs Escalation Data Sources**

Source	Cost Drivers	Used for
ABARE, IMF, LME, World Bank, Wachovia, Brent, CRUspi, Consensus Economic Energy & Metal Monitor	Aluminium, Copper, Iron Ore, Oil, Steel	Equipments, P&C, Misc Materials, Structure
ABS, SKM, Treasury, The Construction Forecasting Council, Econtech Labour Cost Forecasts	CPI, General labour, Utility Labour, Civil Works	Installation, Erection, Commissioning, Foundation, Civil, Structure
ETA Union, Econtech Cost Forecasts	Site Labour	Installation, Erection, Commissioning
SKM	Switchgear, Transformers	Equipments

These indices have been compounded for each element in proportion to the ratio of the make up costs to which the indices are applicable. The switchyard capital cost consist the following cost elements:

- Switchgear
- Structure
- Foundation
- Civil
- P&C
- Erection
- Commissioning
- Other

The composite 2007 to 2008 capital cost escalation index determined for the switchyard materials and the labour mentioned in the previous section is 0% and 5.7% respectively. It was noted that escalation in the 330kV switchgear market was immaterial due to a combination of fierce competition between a few major manufacturers and cost savings due to technological advancements.

3.7 Transmission Line Capital Cost Escalation

For the transmission line capital cost escalation, the following data types have been drawn on:

Table 3-2 Transmission Line Capital Costs Escalation Data Sources

Source	Cost Drivers	Used for
ABARE, IMF, LME, World Bank, Wachovia, CRUspi, Consensus Economics Energy & Metals Monitor	Aluminium, Copper, Iron Ore, Oil, Steel	Conductor, Earthwire, Towers, Misc. Materials, Structure
ABS, SKM, Treasury, The Construction Forecasting Council. Econtech Labour Cost Forecasts	CPI, WPI, General labour, Utility Labour, Civil Works	Civil, Labour, Insulators, Fittings, Foundation
ETA Union, Econtech Cost Forecasts	Site Labour	Survey, Clearing & Access
SKM	Al Conductor	Al Conductor

These indices have been applied to capital cost and compounded in proportion to the relative mix for the different cost make up elements as follow:

- Conductor
- Earth wire
- Tower
- Insulators
- Fittings
- Foundations
- Labour

The composite 2007 to 2008 capital cost escalation index determined for the transmission line materials and the labour mentioned in the previous section is 3.8% and 5.7% respectively.

4. Switchyard and Overhead Transmission Line Operation and Maintenance Costs

4.1 Options considered

Sinclair Knight Merz has developed the operation and maintenance costs for the transmission connection on an asset class basis. This has been achieved by using the unit costs developed in Section 3 of this report and applying a variable percentage value for O&M over the life of the assets. The percentage value used allows for the following:

- Salaries / wages of personnel,
- Public Utilities (water, electricity, telephone),
- Maintenance of equipment, and
- Depreciation of equipment

Sinclair Knight Merz has assumed that the average life of the 330kV switchyard assets is 50 years and the 330kV transmission line is 60 years respectively. It should be noted that annual insurance costs and tax have been omitted from the O&M costs as these cost components will be dependent on the ownership arrangement.

4.2 Switchyard Operational & Maintenance Costs

Table 4-1 shows the operation and maintenance costs over the life of the switchyard assets. The average annual O&M costs over the asset lifetime for the switchyard is $163,500. The switchyard O&M costs are averages with a potential range of ±10%.

- **Table 4-1 O&M costs for option 1**

Period	5 years Cumulative Switchyard O&M Costs (AU$, 2008)
1 to 5 years	$ 411,543
6 to 10 years	$ 472,330
11 to 15 years	$ 542,096
16 to 20 years	$ 622,167
21 to 25 years	$ 714,065
26 to 30 years	$ 819,536
31 to 35 years	$ 940,586
36 to 40 years	$ 1,079,516
41 to 45 years	$ 1,238,967
46 to 50 years	$ 1,421,970

4.3 Transmission line Operational & Maintenance Costs

Table 4-2 shows the operation and maintenance costs over the life of the transmission line assets. The average annual O&M costs over the asset lifetime for the transmission line are $6,943. The transmission line O&M costs are averages with a potential range of ±10%.

- **Table 4-2 O&M costs for option 2**

Period	5 years Cumulative Transmission Line O&M Costs (AU$, 2008)
1 to 5 years	$ 12,496
6 to 10 years	$ 14,674
11 to 15 years	$ 17,232
16 to 20 years	$ 20,235
21 to 25 years	$ 23,762
26 to 30 years	$ 27,904
31 to 35 years	$ 32,767
36 to 40 years	$ 38,478
41 to 45 years	$ 45,185
46 to 50 years	$ 53,060
51 to 55 years	$ 62,309
56 to 60 years	$ 73,169

4.4 Switchyard O&M Cost Escalation

The O&M cost of the switchyard is taken as a percentage multiplier[2] of the switchyard capital cost. Hence the escalation applied for the switchyard O&M cost is identical to that applied to its capital cost.

4.5 Transmission Line O&M Cost Escalation

The O&M cost of the transmission line is taken as a percentage multiplier[3] of the transmission line capital cost. Hence the escalation applied for the transmission line O&M cost is identical to that applied to its capital cost.

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[2] This multiplier has been determined from substation O&M data gathered over a number of years by SKM and is periodically validated against known substation O&M costs. The multiplier varies in an increasing and approximate exponential manner with equipment age.

[3] This multiplier has been determined from overhead transmission line O&M data gathered over a number of years by SKM and is periodically validated against known overhead transmission line O&M costs. The multiplier varies in an increasing and approximate exponential manner with asset age.

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

Appendix B Western Power's Technical Rule, Clause 2.5.2.3 N-1-1 Criterion

2.5.2.3 N-1-1 Criterion

(a) The N-1-1 Criterion applies to those sub-networks of the *transmission system* where the occurrence of a *credible contingency* during planned maintenance of another *transmission element* would otherwise result in the loss of *supply* to a large number of *Consumers*. Sub-networks of the *transmission system* that are designed to the N-1-1 criterion include:

(1) all 330 kV lines, *substations* and *power stations*;

(2) all 132 kV *terminal stations* in the Perth metropolitan area, and Muja *power station* 132 kV *substation*;

(3) all 132 kV *transmission lines* that *supply* a sub-system of the *transmission system* comprising more than 5 *zone substations* with total *peak load* exceeding 400 MVA; and

(4) all power stations whose total rated export to the *transmission system* exceeds 600 MW.

(b) The range of operating conditions that are allowed for when planning a part of the *transmission system* to meet the N-1-1 criterion is set out in Table 2.9.

Table 2.9 Transmission system operating conditions allowed for by the N-1-1 criterion

Maintenance *Outages* and Contingencies
transmission line maintenance and unplanned *transmission line outage*
transformer maintenance and unplanned *transformer outage*
transformer maintenance and unplanned *transmission line outage*
busbar maintenance and unplanned *transmission line outage*
busbar maintenance and unplanned *transformer outage*
circuit breaker maintenance and unplanned *transmission line outage*
circuit breaker maintenance and unplanned *transformer outage*
circuit breaker maintenance and unplanned *busbar outage*
transmission line maintenance and unplanned *transformer outage*

(c) Under the N-1-1 criterion, each sub-network must be capable of withstanding the coincident planned and unplanned *outages* of *transmission elements* listed in Table 2.9 at up to 80% of the expected *transmission system peak load*. In determining whether the N-1-1 criteria have been met, the *Network Service Provider* may assume that, during the planned *outage*, *generation* has been rescheduled to mitigate the effect of the subsequent unplanned *outage*.

(d) Following the unplanned *outage* of the *transmission element*, the *power system* must continue to operate in accordance with the performance standards specified in clause 2.2, provided the *transmission system load* remains below 80% of the expected *peak load*.

Appendix C Switchyard Capital Costs

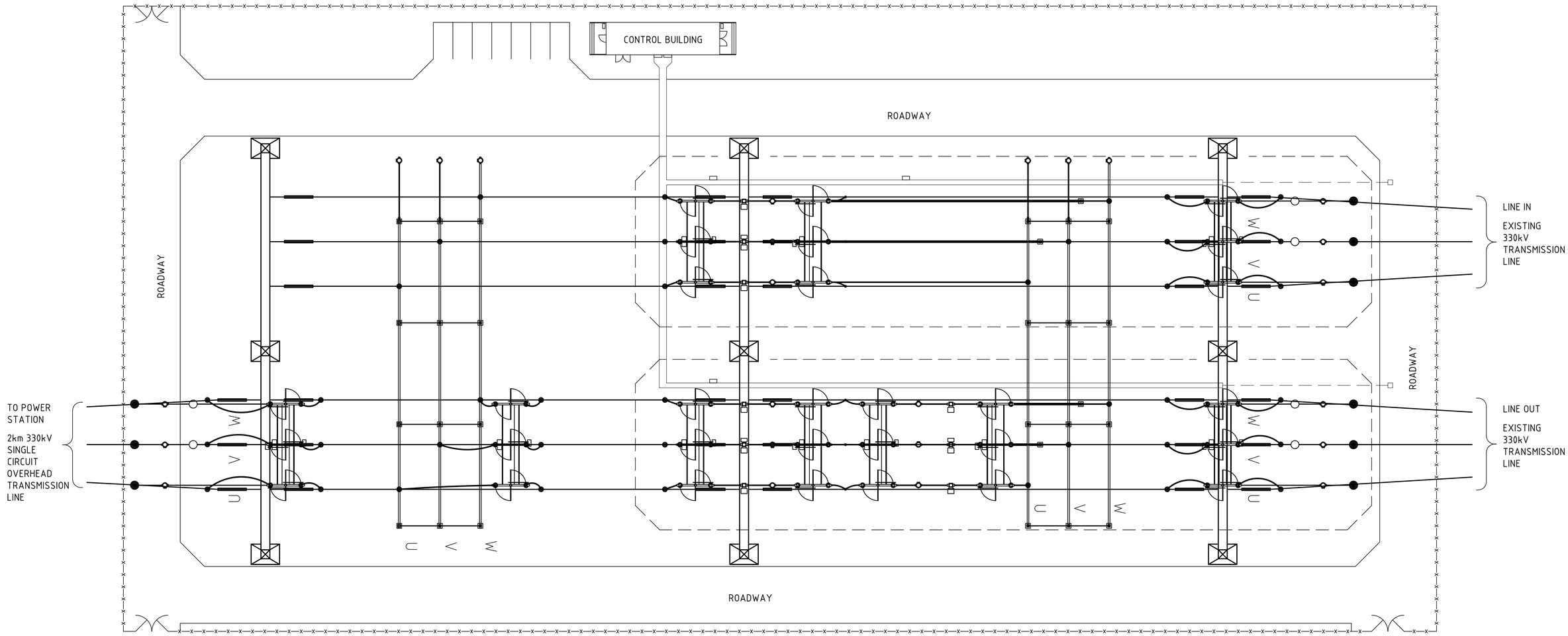
Asset Description / Component	Cost Estimate (AU$, 2008)
330kV 3 breaker mesh switching station configured in a breaker & a half arrangement (i.e. One 1.5 diameter with 2XCBs + One 1.5 diameter with 1XCB). Allowance for a connection tower	
330kV Switchyard Establishment	$ 3,251,200
Switchbays - 330kV	$ 3,473,500
Metering, Security	$ 221,600
Communications Terminal equipment	$ 932,000
Connection Point - New Tension Tower	$ 238,000
	$ 8,116,300
EPCM: 15%	$ 1,217,445
Contractor facilities and mobilisation (7.5% of EPCM)	$ 91,308
Western Australia Factor (on EPCM & mobilization): 30%	$ 392,626
Total Switchyard with Connection Tower Cost (including all factors)	**$ 9,817,679**

Appendix D Transmission Line Capital Costs

Asset Description / Component	Cost Estimate (AU$, 2008)
2km of 330kV Non Cyclonic Lattice Steel Tower, Single Circuit, 1 X Orange per phase, OPGW, 2 tension + 3 suspension towers	
Clearing	$ 46,500
Structure	$ 598,400
Insulators and Fittings	$ 22,900
Phase and Earth conductor	$ 166,000
	$ 833,800
Short Line Length Factor (since only 2km): 100%	$ 833,800
	$ 1,667,600
EPCM: 20%	$ 333,520
Western Australia Factor (on EPCM): 30%	$ 100,056
Transmission Line Total Estimate (including all factors)	**$ 2,101,176**
Transmission Line Easement Acquisition Estimate	**$ 5,082,000**
Total Transmission Line and Easement Acquisition Estimate	**$ 7,183,176**

Appendix E Drawings

HA01128-E-001	3 breaker mesh in breaker & half configuration general arrangement
HA01128-E-002	3 breaker mesh in breaker & half configuration single line diagram



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CLIENT APPROVAL

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CLIENT	INDEPENDANT MARKET OPERATOR (WA)		
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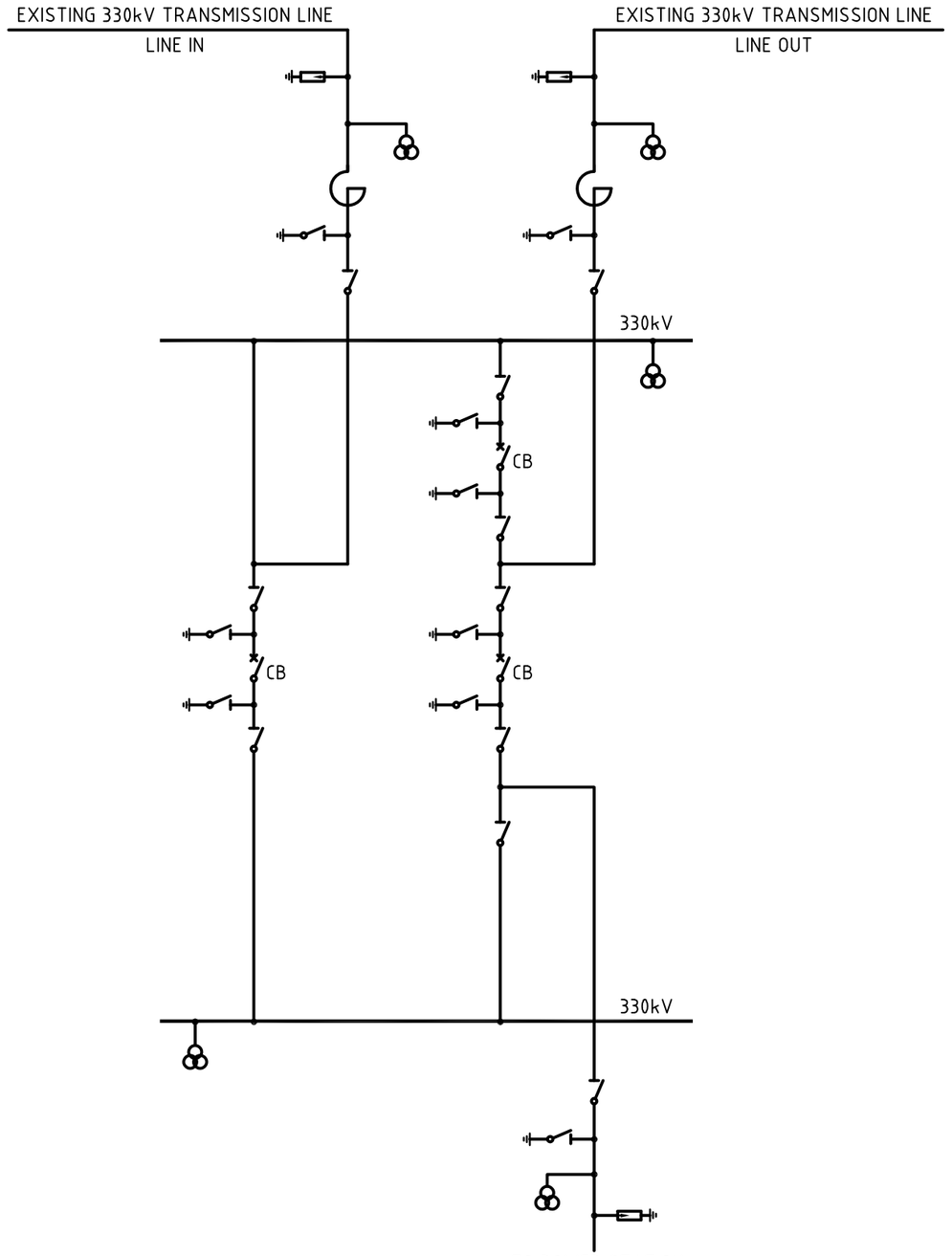
DRAWN PC	DRAFTING CHECK PC	REVIEWED PROJECT MANAGER PRA	APPROVED PROJECT DIRECTOR
DESIGNED RD	DESIGN REVIEW PRA		

TITLE	3 BREAKER MESH IN BREAKER & HALF CONFIGURATION GENERAL ARRANGEMENT		
SCALE NTS	PROJECT No HA01128	DRAWING No HA01128-E-001	AMDT A



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DESIGNED RD	DESIGN REVIEW RPA		

TITLE: 3 BREAKER MESH IN BREAKER AND HALF CONFIGURATION SINGLE LINE DIAGRAM

SCALE	PROJECT No	DRAWING No	AMDT
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