SOUTH AUSTRALIAN ENERGY TRANSFORMATION

FUNCTIONAL TRANSMISSION LINE SPECIFICATIONS

Date: Wednesday 22 August 2018

Distribution: Public

1. Introduction

This note summarises the approach used to develop transmission line cost estimates for the interconnector options considered as part of the South Australian Energy Transformation (SAET) Regulatory Test for Transmission (RIT-T) assessment being undertaken by ElectraNet, including details of the functional specification of the line options.

Further information is available in the Project Assessment Draft Report (PADR)[1], published on 29 June 2018, and accompanying Basis of Estimate report[2].

2. Approach to transmission line cost estimates

ElectraNet commissioned expert consultants ETSE Consulting to develop high level specifications for line component of the potential interconnector solutions – namely:

(i) double circuit 275 kV AC;

(ii) double circuit 330 kV AC; and

(iii) 400 kV HVDC.

These high level specifications were discussed and agreed with the relevant Jurisdictional Planning Bodies (JPBs) - namely Powerlink, TransGrid and AEMO - for the proposed interconnector options between South Australia and respective eastern states.

These high level specifications are attached to this note and cover the primary design voltages and route options considered in the course of the assessment.

High level estimates (indicative prices) were then sought from reputable Australian companies with proven experience and capabilities for building transmission lines.

Conceptual cost estimates were also obtained for each of the route options from the respective JPBs.

In order to derive an appropriate unit cost rate that captures the prevailing construction market price for the key transmission line options of 400 kV HVDC, 330 kV AC double circuit and the 275 kV AC double circuit lines across the various route options considered,

[1] ElectraNet, SA Energy Transformation RIT-T – Project Assessment Draft Report, 29 June 2018.

[2] https://www.electranet.com.au/wp-content/uploads/projects/2016/11/SAET-RIT-T-Basis-of-Estimate-for-PADR.pdf

Monte Carlo (i.e. probabilistic) simulations of potential cost outcomes were then conducted using the vendor costs and conceptual cost estimates from JPBs.

From this a cost rate on a ”per kilometre” basis was derived on a 50% probability of exceedance (P50) basis to provide the basis of the overall transmission line cost estimates for the various route options considered.

The Monte Carlo simulation approach and use of P50 estimates has been endorsed by the JPBs. The unit cost estimates derived have been published in the Basis of Estimate report.

These ”per kilometre” cost rates were then used by ElectraNet to determine the total line construction cost for each option based on the distance of the relevant transmission line and design voltage involved.

These transmission line construction costs comprise the bulk of the cost of each of the interconnector options. Additional cost elements included in the final cost estimates included substations, converter stations, project delivery costs, special purpose equipment and land and easement costs. The basis of these cost components is set out in the Basis of Estimate report.

ATTACHMENTS

- Transmission line parameters: Tungkillo - Horsham 275kV (SA - Victoria Interconnector)
- Transmission line parameters: Davenport - Bulli Creek 400kV HVDC (SA - Queensland Interconnector)
- Transmission line parameters: Robertstown- Buronga-Wagga 330kV (SA-NSW Interconnector

Transmission Line Parameters

Tungkillo - Horsham 275kV

EC14171; SA Energy Transformation Project

Rev-1.1

14171-EDR-002

(SA - Victoria Interconnector)

A. General		
a.1	Transmission Line Name	Tungkillo to Horsham transmission line
a.2	Nominal System Voltage (kV)	275
a.3	No of Circuit	2
a.4	Rating per Circuit (MVA)	700
a.5	Route Length- approx (km)	350
a.6	Easement width (m)	50
a.7	Conductor clearance to ground (m)	7.5 metres as required by AS/NZS 7000:2016
a.8	Clearance over highway/road crossings	Compliant to high load transport corridor requirements, national highway clearance requirements and state road/highway clearance requirements as applicable.
a.9	Clearance over railway crossings	Compliant to ARTC requirements and state railway clearance requirements as applicable.
a.10	Clearance buffer	+500mm
B. Line Reliability		
b.1	Security Level (AS/NZS 7000:2016)	III
b.2	Design Life (yrs)	100
b.3	Wind Zone (AS/NZS 7000:2016)	II and III
C. Electrical Parameter		
c.1	System Highest Voltage (kV)	300
c.2	Audible Noise Limit	Compliant to Environment Protection Act (SA) and Environment Protection Act (VIC)
c.3	Radio interference limit	Compliant to AS/NZS 2344
c.4	Corona Surface Gradient (kV/cm)	14.1kV/cm middle phase when line operates at 300kV.
c.5	Target Surge Impedence Loading	262MW
c.6	Transposition Requirement	The line between Tungkillo and Horsham is to be transposed into three equal sections.
D. Insulation Coordination Parameters		
d.1	Lightning Impulse withstand Voltage (kV)	1050
d.2	Switching Surges	3.0 per unit
d.3	Backflashover rate	Each circuit to have less than 0.5 outages per 100 kilometres per year
d.4	Shielding Failure Flashover Rate	Each circuit to have less than 0.1 outages per 100 kilometres per year
d.5	Recommended Shielding Angle (degrees)	Nominal 0-5 degrees. Two overhead shielding wires are required
d.6	Pollution Level	Medium pollution classification of AS 4436 - 1996
d.7	Minimum Required Creepage Length (mm)	6000mm
d.9	Required Footing Resistance- typical (ohm)	Design resistance less than 10 ohms at majority of structures
E.Clearances		
e.1	Power frequency clearance (mm)	900
e.2	Switching surge clearance	Clearances to withstand a 3.0per unit switching surge
e.3	Lightning impulse clearance (mm)	2200
e.4	Maintenance approach clearance (mm)	Compliant to AS/NZS 7000-2016 and AS 5804
e.5	Live line working clearances (mm)	2100mm auto reclose on, 1600mm auto reclose off.
e.6	Helicopter clearances	3700mm MHAD auto reclose on, 3200mm MHAD auto reclose off
e.7	External clearances- Tower top geometry	As per AS/NZS 7000:2016
e.8	Insulator swing- serviceability	Nominal 25 degrees for lightning clearances. Clearances for different operating condition shall be maintained as per AS/NZS 7000:2016.
e.9	Insulator swing- ultimate	Nominal 60 degrees for power frequency clearances. Clearances for different operating condition shall be maintained as per AS/NZS 7000:2016.
F. Structure Top Geometry		
f.1	Phase Spacing (mm)	6900
f.2	Phase Projection from structure (mm)	crossarm lengths to meet clearance requirements
f.3	Phase Configuration	Vertical
f.4	Top phase to Earthwire spacing (mm)	6700mm approximately. minimum 3400mm beteween top cross arm and earthwire and 3300mm approximate length of suspension insulator string.
G.Conductor and earthwire		
g.1	Conductor Type/ Name	ACSR 54/7/3.25 Orange- Twin
g.2	Maximum Operating Temperature (degrees C)	100
g.3	Corrosion protection- phase conductor	The steel core shall be greased as per AS3607-1989
g.4	Vibration Control	Stock Bridge type Vibration Damper
g.5	Subconductor Spacing (mm)	380

g.6	Subconductor Spacer Type	Rigid spacers
g.7	Shielding wires	2X OPGW with 72 fibres 16.4mm diameter, minimum strand size 3.0mm (equivalent to AFL Specification DNO-8029)
g.8	Corrosion protection-Shielding Wire	Fully greased
g.9	Vibration control for Shielding Wires	Stock Bridge type Vibration Damper
H.Insulator Assembly		
h.1	Insulator Type	Toughened Glass Alternate option- Composite longrod
h.2	Corona Ring	Grading rings not required on strain assemblies Corona rings as supplied by insulator manufacturer are required to protect composite insulators.
h.3	Sag link and extended fittings (strain assembly)	Yes
h.4	Live line Maintenance	Yes
h.5	Indicative total length	approximately 3300mm for suspension assemblies
i.Structure		
i.1	Structure Type	Self supporting lattice tower Alternate steel monopole for environmentally sensitive locations
i.2	Structure Family	Suspension (0-2) Angle/Stop (0-15) Angle (15-30) Angle (30-60) Angle >60 and Termainal Transposition
i.3	Footing Types	Bored Pier Mass Footing Raft Footing Pile Foundation Alternate Foundation types

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Date; 2017/05/19

Transmission Line Parameters

Davenport - Bulli Creek 400kV HVDC **(SA - Queensland Interconnector)**

EC14171; SA Energy Transformation Project

Rev-3.0 -Issued for Pricing

Parameters are based on a preliminary assessment and are subject to detailed design studies

A. General		
a.1	Tranmission Line Name	Davenport - Bulli Creek
a.2	Nominal System DC Voltage (kV)	400kV HVDC
a.3	No of Poles	2
a.4	Rating per Pole (MW)	500
a.5	Route Length- approx (km)	1,420
a.6	Easement width (m)	60
a.7	Conductor clearance to ground (m)	9.0 metres is minimum required by AS/NZS 7000:2016 though E-field considerations may require additional clearance. Therefore, **11.0 m** is allowed for the preliminary cost model.
a.8	Clearance over highway/road crossings	Compliant with high load transport corridor requirements, national highway clearance requirements and state road/highway clearance requirements as applicable.
a.9	Clearance over railway crossings	Compliant to ARTC requirements and state railway clearance requirements as applicable.
a.10	Clearance buffer	+ 1000mm
B. Line Reliability		
b.1	Security Level (AS/NZS 7000:2016)	III
b.2	Wind Return Period	2000 yrs
b.3	Wind Zone (AS/NZS 1170.2 :2011)	Region A, both Synoptic and Convective downdraft shall be considered as per AS/NZS 7000:2016 (Wind Zone II and III)
C. Electrical Parameter		
c.1	Transmission line Highest DC Voltage (kV)	420
c.2	Audible Noise Limit	Compliant to Environment Protection Act (SA) and Environmental Protection Legislation (Qld)
c.3	Radio interference limit	Compliant to AS/NZS 2344 as applicable to HVDC
c.4	Corona Surface Gradient (kV/cm)	22-24kV/cm when line operates at 420kV.
c.5	Transposition Requirement	Not applicable
D. Insulation Coordination Parameters		
d.1	Lightning Impulse withstand Voltage (kV)	1300
d.2	Switching Surges	1.8 per unit
d.3	Backflashover rate	Each pole to have less than 0.5 outages per 100 kilometres per year
d.4	Shielding Failure Flashover Rate	Each pole to have less than 0.1 outages per 100 kilometres per year
d.5	Recommended Shielding Angle (degrees)	Two overhead shielding wires are required with shielding angle of approximately 15-20 degrees
d.6	Pollution Level	Light to medium pollution classification of 30-40mm/kV (DC)
d.7	Minimum Required Creepage Length (mm)	12,600
d.9	Required Footing Resistance- typical (ohm)	Design resistance less than 10 ohms at majority of structures
E.Clearances		
e.1	Steady State Withstand clearance (mm)	1000
e.2	Switching surge clearance	Switching surge clearance is not expected to dominate tower geometry
e.3	Lightning impulse clearance (mm)	3100
e.4	Maintenance approach clearance (mm)	Compliant to AS/NZS 7000:2016 and AS 5804 as applicable to HVDC lines
e.5	Live line working clearances (mm)	2800mm
e.6	Helicopter clearances	2400mm MHAD
e.7	External clearances	As per AS/NZS 7000:2016 as applicable to HVDC
e.8	Insulator swing- serviceability	Nominal 25 degrees for lightning clearances. Clearances for different operating conditions shall be maintained as per AS/NZS 70000:2016
e.9	Insulator swing- ultimate	Nominal 60 degrees for power frequency clearances. Clearances for different operating conditions shall be maintained as per AS/NZS 7000:2016
F. Structure Top Geometry		
f.1	Pole to pole spacing (mm)	13400
f.2	Pole projection from structure (mm)	crossarm lengths to meet clearance requirements
f.3	Pole Configuration	Horizontal
f.4	Pole to earthwire spacing (mm)	8500mm approximately. (minimum 3000mm beteween top cross arm and earthwire and 5500mm minimum exepcted length of suspension insulator string.
G.Conductor and earthwire		
g.1	Conductor Type/ Name	Two alternate Proposed; ACSR Lapwing 45/4.78+7/3.18- Twin ACSR Chukar 84/3.70 + 19/2.22 - Twin
g.2	Maximum Operating Temperature (degrees C)	100

g.3	Corrosion protection- phase conductor	The ACSR conductor steel core to be greased as per AS3607-1989
g.4	Vibration Control	Stock Bridge type Vibration Damper
g.5	Subconductor Spacing (mm)	460
g.6	Subconductor Spacer Type	Rigid spacers
g.7	Shielding wires	2X OPGW with 72 fibres 16.4mm diameter, minimum strand size 3.0mm (equivalent to AFL Specification DNO-8029)
g.8	Corrosion protection-Shielding Wire	Fully greased
g.9	Vibration control for Shielding Wires	Stock Bridge type Vibration Damper
H.Insulator Assembly		
h.1	Insulator Type	Toughened glass type disc insulators suitable for HVDC lines Alternate option - Composite
h.2	Corona Ring	Grading rings are required on strain assemblies to protect hardware. Corona rings are required to protect composite insulators.
h.3	Sag link	Yes
h.4	Live line Maintenance	Yes
h.5	Indicative total length	approximately 5,000mm overall length for suspension assemblies
i.Structure		
i.1	Structure Type	Self supporting lattice tower Alternate Chainette structure for remote and non-agricultural land Alternate steel monopole for environmentally sensitive locations
i.2	Structure Family	Suspension (0-2) Angle/Stop (0-15) Angle (15-30) Angle (30-60) Angle >60 and Terminal
i.3	Footing Types	Bored Pier Mass Footing Raft Footing Pile Foundation Alternate Foundation types

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Transmission Line Paramaters

Robertstown- Buronga-Wagga 330kV
EC14171; SA Energy Transformation Project
Rev-1.1

14171-EDR-001
(SA-NSW Interconnector)

A. General		
a.1	Tranmission Line Name	Robertstown-Buronga-Wagga
a.2	Nominal System Voltage (kV)	330
a.3	No of Circuit	2
a.4	Rating per Circuit (MVA)	1000
a.5	Route Length- approx (km)	698
a.6	Easement width (m)	60
a.7	Conductor clearance to ground (m)	8.0 metres as required by AS/NZS 7000:2016
a.8	Clearance over highway/road crossings	Compliant to high load transport corridor requirements, national highway clearance requirements and state road/highway clearance requirements as applicable.
a.9	Clearance over railway crossings	Compliant to ARTC requirements and state railway clearance requirements as applicable.
a.10	Clearance buffer	+500mm
B. Line Reliability		
b.1	Security Level (AS/NZS 7000:2016)	III
b.2	Design Life (yrs)	100
b.3	Wind Zone (AS/NZS 7000:2016)	II and III
C. Electrical Parameter		
c.1	System Highest Voltage (kV)	362
c.2	Audible Noise Limit	Compliant to Environment Protection Act (SA) and Environment Protection Act (NSW)
c.3	Radio interference limit	Compliant to AS/NZS 2344
c.4	Corrona Surface Gradient (kV/cm)	15.9kV/cm middle phase when line operates at 362kV.
c.5	Target Surge Impedence Loading	390MW
c.6	Transposition Requirement	The line between Robertstown and Buronga is to be transposed into three equal sections. The line between Buronga and Darlington Point is also to be transposed in three equal sections
D. Insulation Coordination Parameters		
d.1	Lighting Impulse withstand Voltage (kV)	1175
d.2	Switching Surges	3.0 per unit
d.3	Backflashover rate	Each circuit to have less than 0.5 outages per 100 kilometres per year
d.4	Shielding Failure Flashover Rate	Each circuit to have less than 0.1 outages per 100 kilometres per year
d.5	Recommended Shielding Angle (degrees)	0 degrees. Two overhead shielding wires are required
d.6	Pollution Level	Medium pollution classification of AS 4436 - 1996
d.7	Minimum Requied Creepage Length (mm)	7240mm
d.9	Required Footing Resistance- typical (ohm)	Design resistance less than 10 ohms at majority of structures
E.Clearances		
e.1	Power frequency clearance (mm)	1100
e.2	Switching surge clearance	Clearances to withstand a 3.0per unit switching surge
e.3	Lightening impulse clearance (mm)	2600
e.4	Phase to phase clearance (mm)	7500mm
e.5	Maintenance approach clearance (mm)	Compliant to AS/NZS 7000;2016 and AS 5804
e.6	Live line working clearances (mm)	2700mm auto reclose on, 1900mm auto reclose off.
e.7	Helicopter clearances	4750mm MHAD auto reclose on, 3020mm MHAD auto reclose off
e.8	External clearances-tower top geomentry	As per AS/NZS 7000:2016
e.9	Insulator swing- serviceability	Nominal 25 degrees for lightning clearances. Clearances for different operating condition shall be maintained as per AS/NZS 7000:2016.
e.10	Insulator swing- ultimate	Nominal 60 degrees for power frequency clearances. Clearances for different operating condition shall be maintained as per AS/NZS 7000:2016.
F. Structure Top Geometry		
f.1	Phase Spacing (mm)	7500
f.2	Phase Projection from structure (mm)	crossarm lengths to meet clearance requirements
f.3	Phase Configuration	Vertical
f.4	Top phase to Earthwire spacing (mm)	7000mm approximately. (minimum 3500mm beteween top cross arm and earthwire and 3500mm minimum exepcted length of suspension insulator string.
G.Conductor and earthwire		
g.1	Conductor Type/ Name	ACSR 54/7/3.5 Olive- Twin
g.2	Maximum Operating Temperature (degrees C)	100
g.3	Corrosion protection- phase conductor	The steel core shall be greased as per AS3607-1989
g.4	Vibration Control	Stock Bridge type Vibration Damper

g.5	Subconductor Spacing (mm)	380
g.6	Subconductor Spacer Type	Rigid spacers
g.7	Shielding wires	2X OPGW with 72 fibres 16.4mm diameter, minimum strand size 3.0mm (equivalent to AFL Specification DNO-8029)
g.8	Corrosion protection-Shieldign Wire	Fully greased
g.9	Vibration control for Shielding Wires	Stock Bridge type Vibration Damper
H.Insulator Assembly		
h.1	Insulator Type	Standard Profile Toughened Glass Alternate option- Composite
h.2	Corona Ring	Grading rings are required on strain assemblies to protect hardware. Corona rings are required to protect composite insulators.
h.3	Sag link and extended fittings (strain assembly)	Yes
h.4	Live line Maintenance	Yes
h.5	Indicative total length	approximately 3500mm for suspension assemblies
i.Structure		
i.1	Structure Type	Self supporting lattice tower Alternate steel monopole for difficult locations
i.2	Structure Family	Suspension (0-2) Angle/Stop (0-15) Angle (15-30) Angle (30-60) Angle >60 and Termainal Transposition
i.3	Footing Types	Bored Pier Mass Footing Raft Footing Pile Foundation Alternate Foundation types

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