PROPOSED NEW LARGE NETWORK ASSET

ADELAIDE CENTRAL REGION

SOUTH AUSTRALIA

FINAL REPORT

ElectraNet Pty Ltd
(ABN 41 094 482 416)

10 July 2009

Important Information and Disclaimer

This final report has been prepared for the purposes of clause 5.6.6 of the National Electricity Rules. It may be used by Registered Participants and interested parties only for the purposes of the consultation process under that clause. This final report should not be used or relied on for any other purposes. The contents of this final report may differ from the contents of the preceding application notice.

This final report contains analysis based on estimates prepared by, and assumptions made by, ElectraNet and ETSA Utilities. The document has also been prepared using information, including cost information, provided by a number of third parties. The cost estimates used to evaluate the options described are based on the best information available to ElectraNet and ETSA Utilities at the time of preparing the report and should not be taken as necessarily reflecting the actual costs of later implementing an option.

The final report contains the results of financial modelling and economic analysis undertaken by ElectraNet and ETSA Utilities. It contains assumptions regarding, among other things, economic growth and load forecasts that may or may not prove to be correct.

While care was taken in preparation of the information in this final report, and it is provided in good faith, neither ElectraNet nor ETSA Utilities warrant the accuracy of the contents of this final report, and so far as the law allows accept no responsibility or liability for any loss or damage that may be incurred by any person acting in reliance on this final report or assumptions drawn from it.

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Preface

On 10 January 2008, ElectraNet published an Application Notice on its website that proposed the establishment of a new substation on the outskirts of Adelaide's central business district (a new large transmission network asset) that would increase the reliability of supply to the Adelaide Central region to the level specified in the July 2008 Electricity Transmission Code (ETC). The closing date for submissions on the Application Notice was 27 February 2008.

A single submission was received from the Electricity Supply Industry Planning Council (ESIPC), which did not materially alter ElectraNet's proposed augmentation. This submission is summarised in Section 6 of this Final Report, in accordance with clause 5.6.6(h) of the National Electricity Rules. ElectraNet's response to that submission is also described in that section. The content and structure of this report has been significantly altered to address the issues raised by the ESIPC.

This report is the Final Report issued in accordance with the requirements of clause 5.6.6(h) of the National Electricity Rules for the reinforcement of the Adelaide Central Region of South Australia.

Executive Summary

As a licensed Transmission Network Service Provider (TNSP), ElectraNet is required to meet the supply reliability standards specified in the South Australian Electricity Transmission Code (ETC).

In the most recent version of the ETC (July 2008), the supply reliability requirement for the main commercial centre of Adelaide has been increased. As a consequence, ElectraNet is required to establish a new substation to the west of King William Street that is capable of independently supplying the Adelaide Central region, in the event that supply from the existing East Terrace substation is not available. Furthermore, Adelaide Central supply must be uninterrupted should any single transformer or transmission line supplying that region fail. Additionally the 275kV supply to the new substation must be from a source independent of the one which presently supplies East Terrace substation.

To meet that requirement, ElectraNet will establish a 275/66kV substation, comprising one 300MV.A transformer, at Lot 500, 1 Richmond Road, Keswick, known as City West substation. Supply to that substation will be provided by a single 275kV underground cable from the Torrens Island (TIPS) 275kV switchyard, 18 kilometres to the north-west of the new substation and essentially following a corridor along Port Road. ETSA Utilities will provide the 66kV connection from the new substation to the Adelaide Central 66kV network at Whitmore Square substation and will upgrade the existing 66kV network to manage the increased capacity. The cost to ElectraNet for this augmentation is estimated to be $216.5m, with the cost for ETSA Utilities' portion of the work estimated to be $65m.

The proposed substation and underground cable development is the result of applying an economic assessment to a range of options, which considered different substation sites, transmission line corridors including both overhead line and underground cable options and 66kV connections to the Adelaide Central distribution network.

The site for the new substation is ideally located to also provide future additional 275/66kV injection into ETSA Utilities' southern and western suburbs 66kV networks. ElectraNet and ETSA Utilities have identified that the Richmond Road site will provide a cost-efficient means of also facilitating the committed 'SIM II' augmentation, which involves ElectraNet installing a single 300MV.A 275/66kV transformer dedicated to supplying the northern portion of the southern metropolitan 66kV network, with ETSA Utilities again providing the 66kV infrastructure to connect into its existing southern suburbs network at Keswick substation and ensuring that the 66kV network is capable of supporting the increased capacity.

The installation of the 'SIM II' transformer and associated switchgear will be undertaken in conjunction with construction of the City West substation. While of necessity the 'SIM II' project has been incorporated into the economic assessment of options presented in this report, the costs of this project are excluded from the overall cost of the Adelaide Central augmentation. The estimated ElectraNet and ETSA Utilities costs for the 'SIM II' works are $24m and $41m, respectively.

Although not specifically considered as part of the evaluation criteria, the site at Richmond Road offers the additional advantage of providing a potential option for connecting the South Australian Government's proposed railway electrification.

The City West substation will be commissioned and commercially available by 31 December 2011, in accordance with the requirements of the July 2008 ETC.

1. Introduction

Changes to the South Australian Electricity Transmission Code (ETC) that came into effect on 1 July 2008 have increased the level of electricity supply reliability that ElectraNet must provide for Adelaide's central business district.

Changes included the introduction of a new load category, Category 6, for the 'Adelaide Central' region including the central business district. The new load category introduces a higher level of reliability for the main commercial and business district of Adelaide than is provided for the surrounding semi-residential and residential areas.

Adelaide Central has been defined in the July 2008 ETC as *"that area east of West Terrace, north of South Terrace, west of East Terrace, and south of the River Torrens"*. ElectraNet is required to provide N-1 transformer and N-1 transmission line capacity into Adelaide Central for at least 100% of agreed maximum demand (AMD) on a continuous basis by means of independent and diverse transmission substations.

ElectraNet is required to construct a new substation located west of King William Street and to have this commissioned and commercially available by 31 December 2011. ETSA Utilities must facilitate connection of that new supply point to its existing 66kV network. The ETC also states that ElectraNet must have sufficient transformer capacity available such that the new reliability standards continue to be met in the event of failure of either one of the two 275/66kV transformers that would then be supplying that Adelaide Central region.

In accordance with clause 5.6.6 of the National Electricity Rules (NER or Rules), this final report must set out the matters detailed in clause 5.6.6(c) of the NER and summarise the submissions received from interested parties, and ElectraNet's and/or ETSA Utilities' response to each submission. In accordance with clause 5.6.6(c), the final report must contain the following:

(1) a detailed description of:

> *(i)   the proposed asset;*

> *(ii)   the reasons for proposing to establish the asset (including, where applicable, the actual or potential constraint or inability to meet the network performance requirements set out in schedule 5.1 or relevant legislation or regulations of a participating jurisdiction, including load forecasts and all assumptions used); and*

> *(iii) all other reasonable network and non-network alternatives to address the identified constraint or inability to meet the network performance requirements identified in clause 5.6.6(c)(1)(ii). These alternatives include, but are not limited to, interconnectors, generation options, demand side options, market network service options and options involving other transmission and distribution networks;*

(2) all relevant technical details concerning the proposed asset;

(3) the construction timetable and commissioning date for the asset;

(4) an analysis of the ranking of the proposed asset and all reasonable alternatives as referred to in clause 5.6.6(c)(1)(iii). This ranking must be undertaken by the applicant in accordance with the principles contained in the regulatory test;

(5) an augmentation technical report prepared by the Inter-regional Planning Committee in accordance with clause 5.6.3(j) but only if:

(i) the asset is reasonably likely to have a material inter-network impact; and

(ii) the applicant has not received consent to proceed with such construction from all Transmission Network Service Providers whose transmission networks are materially affected by the asset; and

(6) a detailed analysis of why the applicant considers that the asset satisfies the regulatory test and, where the applicant considers that the asset satisfies the regulatory test as a reliability augmentation, analysis of why the applicant considers that the asset is a reliability augmentation.

This final report provides the required information and analysis set out above including:

- more details of the relevant ETC reliability standard that is the driver for the proposed new large transmission network asset (a reliability augmentation);

- details of the public consultation undertaken jointly by ElectraNet and ETSA Utilities; and

- the analysis and economic assessment of feasible transmission and distribution network options in accordance with the Regulatory Test.

The option that ElectraNet and ETSA Utilities are jointly recommending minimises the present value (PV) of the costs to Registered Participants in the National Electricity Market (NEM) while meeting the reliability standards in the NER, the July 2008 ETC, and the Electricity Distribution Code (EDC).

Of added benefit, the site for the new substation is ideally located to also provide additional 275/66kV injection into ETSA Utilities' southern and western suburbs 66kV networks, thus ensuring maximum asset utilisation through the sharing of common infrastructure.

2. Background: Electricity Supply System

2.1 Geographic Area

Adelaide's CBD and the north eastern suburbs were grouped together and defined as a Category 5 load in the previous version (July 2003) of the ETC. That combined load is presently supplied by the Dry Creek East, East Terrace, Magill and Northfield group of connection points, and includes the Adelaide CBD, North Adelaide, and the suburbs of Linden Park, Burnside, Kent Town, Norwood, Magill, Campbelltown, Prospect, Northfield, Ingle Farm, Modbury, Golden Grove, Tea Tree Gully, and Holden Hill, among others. The geographic area is shown in Figure 1.

The July 2008 ETC divides this load area into two regions with one being the new Adelaide Central region. The new Adelaide Central region has been assigned a new, increased level of reliability, referred to as Category 6. The remaining portion of the existing Category 5 load area retains its previous categorisation. The geographical bounds of the previous Category 5 load that has become the new Category 6 load region are shown in Figure 2.

Figure 1: Approximate geographic boundary of the Category 5 load area as defined in the previous July 2003 ETC

Figure 2: The Adelaide Central region as defined in the July 2008 ETC

2.2 Existing Supply Arrangements

Primary supply to the CBD and the north eastern suburbs is presently provided by ElectraNet's East Terrace, Magill, Dry Creek East and Northfield 275/66 kV substations. ETSA Utilities' interconnected 66 kV sub-transmission system then reticulates electricity throughout the region via numerous 66/11kV, 66/33kV and 33/11kV substations.

East Terrace, Magill, Dry Creek East and Northfield substations were previously grouped together to form a single group of connection points under the July 2003 ETC and classified as a Category 5 load. This classification meant that ElectraNet was required to have sufficient transmission line and transformer capacity installed to be able to continuously supply the total forecast load of that region with any single item of transmission plant out of service (N-1), and to supply all of the CBD and a given percentage of the remaining load with two independent items of transmission plant out of service (N-2). Under this standard, ElectraNet, with reliance on ETSA Utilities' interconnected 66kV network, had sufficient transmission infrastructure installed to meet its obligations for some time into the future.

The overall arrangement of the near Metropolitan 275 kV transmission system is shown in Figure 3, and the configuration of ETSA Utilities' 66 kV and 33 kV distribution networks is shown in Figure 4.

2.3 Committed Network Developments

There are no committed network developments and neither ElectraNet nor ETSA Utilities are aware of any development proposal that would impact on the requirement to establish the proposed new large transmission network asset.

2.4 Existing and committed generation facilities and demand side management

The July 2008 ETC sets out a clear requirement for a new large transmission network asset to meet the increased reliability standard for the Adelaide Central region, which excludes consideration of non-network options such as generation options and demand side options in this particular case.
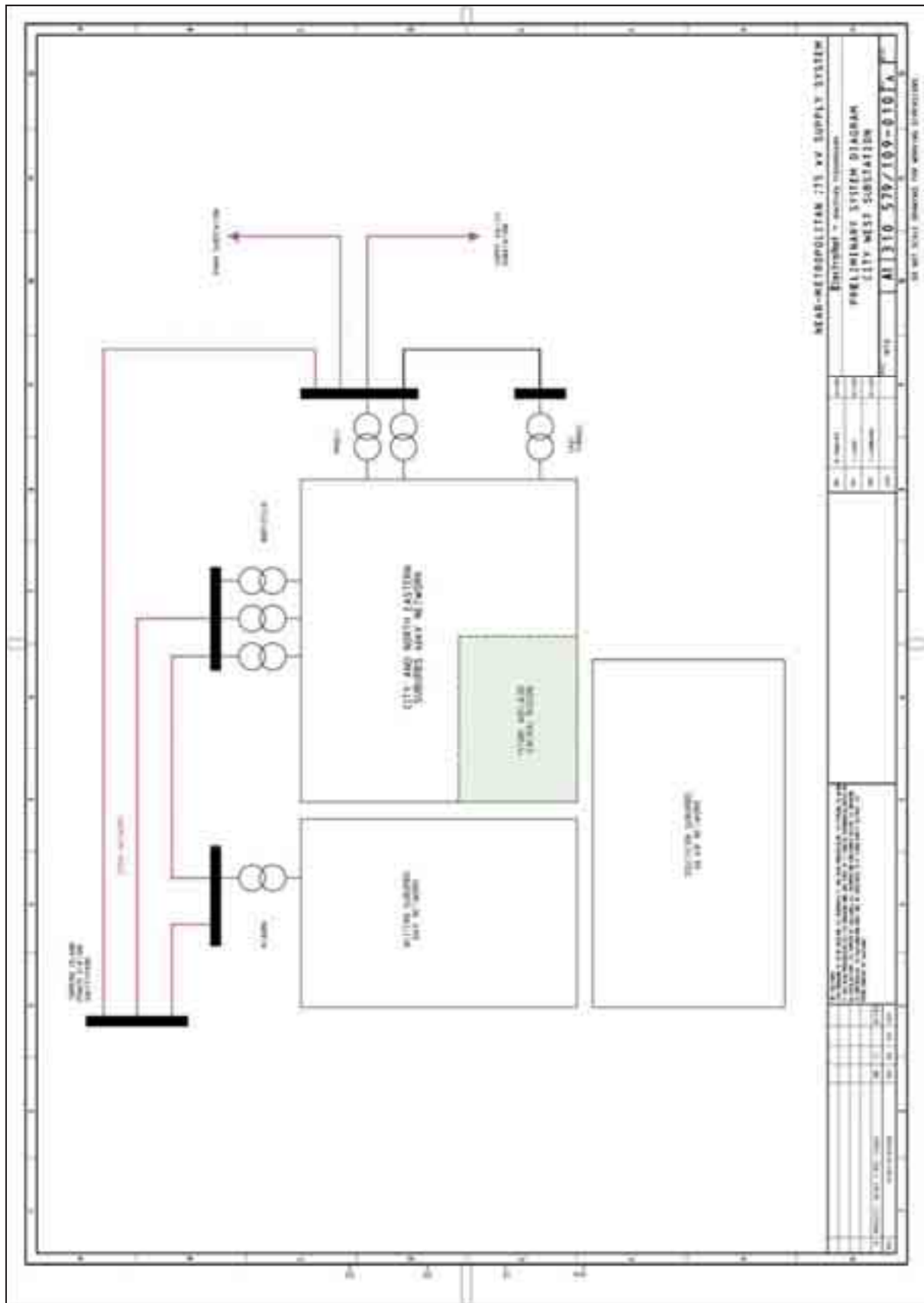
Figure 3: Near-metropolitan 275kV supply system

Figure 4: Existing arrangement of ETSA Utilities' 66 kV network for the north eastern suburbs and Adelaide Central load areas

3.   Background: Electricity Demand

3.1   Overview

The demand forecasts that underpin the recommendations of this final report are consistent with the ten-year demand and energy forecasts published in ElectraNet's 2008 Annual Planning Review and the ESIPC's 2008 Annual Planning Report.

Ten-year electricity demand forecasts are determined by ETSA Utilities with input from customers for each connection point to ElectraNet's transmission system. Those forecasts take account of demand-side management programmes that are either presently in place or foreseen by ETSA Utilities, as well as embedded generation, each of which may have the effect of reducing the forecast demand to be supplied via a particular transmission connection point.

3.2   Demand forecast

Demand growth is dependent on numerous variables, including economic growth, housing and commercial development, industrial growth, spot-load increases that occur in response to local requirements, and environmental conditions (predominantly weather conditions). In the case of the Adelaide Central region, much of the load comprises office and commercial tenancy, with a significant component of that load attributable to air-conditioning and heating of those premises. However, in recent years developers have increasingly introduced high density apartment-style accommodation to the region.

The combined demand forecast for the Adelaide CBD and north eastern suburbs for the coming 10-year period has been determined by ETSA Utilities together with a forecast for the newly-defined Adelaide Central region. Both of these forecasts are shown in Table 1.   The forecast summer peak demand is based on medium economic growth, hot weather, a 10% probability of exceedance, and excludes transmission losses and generator auxiliary loads.

Connection Point		07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18
CBD and North-Eastern suburbs	MW	755	772	790	807	825	844	862	882	901	921	942
	MV.A	771	788	806	823	842	861	889	909	829	949	981
Adelaide Central	MW	221	226	231	236	241	247	252	257	263	269	275
	MV.A	221	226	231	238	243	249	255	260	268	274	281

Table 1: Forecast summer peak demand for both the Adelaide CBD and north eastern suburbs region, and the "Adelaide Central" load region (medium economic growth)

3.3   Pattern of Use

Peak demand in the Adelaide Central region is experienced during the 'office hours' of a working weekday in summer, and is driven by high temperatures and the resulting high air conditioning loads, the increasing reliance on computers and associated hardware, as well as the growing density of offices and urban living.

As can be seen in Figure 5, summer weekday electricity demand in the Adelaide Central region remains high throughout the day, with a significant drop in demand during evening and night-time hours. Electricity demand during the weekends falls away markedly due to the closure of many offices.
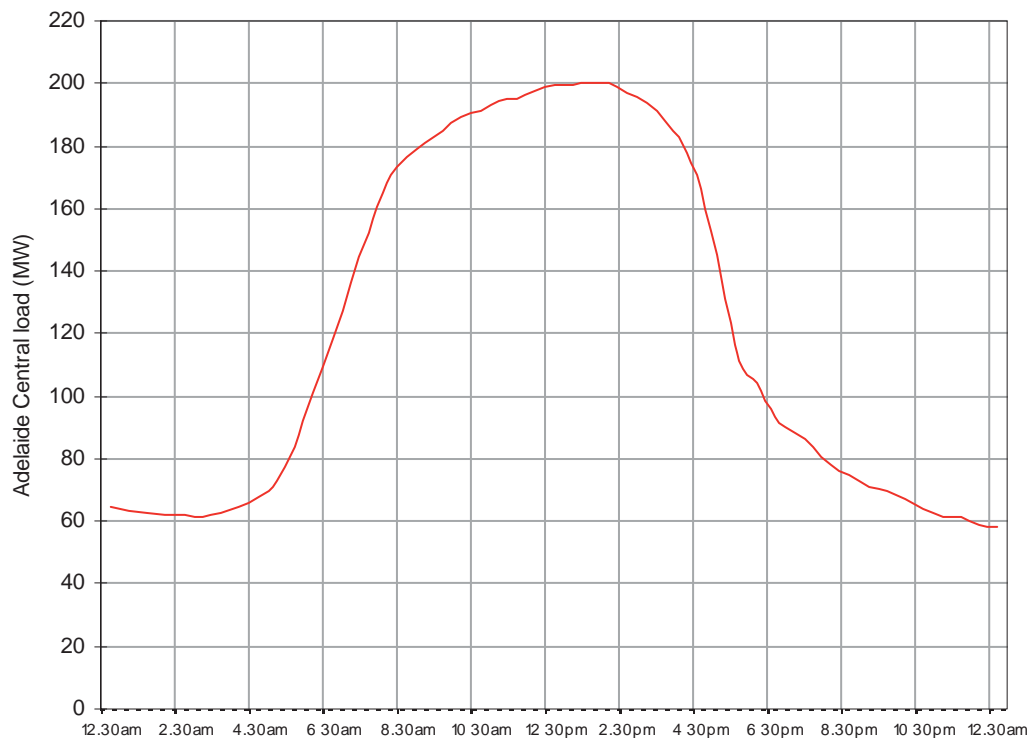

Figure 5: Adelaide Central Daily Load Curve – peak summer day
Monday, 5 February 2007

4. Adelaide Central Service Obligations

As a TNSP operating in the South Australian jurisdiction of the NEM, ElectraNet is bound by the service obligations of the NER and the ETC. Similarly, ETSA Utilities, as a Distribution Network Service Provider (DNSP), is bound by the service obligations of the NER and the Electricity Distribution Code (EDC).

4.1 National Electricity Rules

The network planning and development obligations on TNSPs in the NER are not the principal driver for the proposed new large network asset to reinforce the Adelaide Central region.

4.2 South Australian Electricity Transmission Code

The principal driver for the proposed new large network asset, as mentioned previously in this report, is the reliability standard in the July 2008 ETC that specifically requires ElectraNet, by 31 December 2011, to provide N-1 transmission line and N-1 transformer capacity into Adelaide Central for at least 100% of agreed maximum demand. This capacity must be provided on a continuous basis by means of independent and diverse transmission substations.

Extracts of the relevant service standards contained in the ETC are provided below.

Clause 2.1 Quality of supply and system reliability

2.1.1 Quality of supply

A transmission entity shall use its best endeavours to plan, develop and operate the transmission network to meet the standards imposed by the National Electricity Rules in relation to the quality of transmission services such that there will be no requirements to shed load to achieve these standards under normal and reasonably foreseeable operating conditions.

2.1.2 System reliability

A transmission entity shall use its best endeavours to plan, develop and operate the transmission system so as to meet the standards imposed by the National Electricity Rules in relation to transmission network reliability such that there will be minimal requirements to shed load under normal and reasonably foreseeable operating conditions.

The ETC also assigns reliability standards for each connection (exit) point or group of connection points within the transmission network and thereby imposes specific requirements on ElectraNet for planning and developing its transmission network. The ETC also includes additional obligations with regard to response times, spares holdings, and reporting requirements.

The following provides a more detailed summary of ElectraNet's service obligations for the Adelaide Central region based on the ETC requirements that became effective as of 1 July 2008 (refer Clause 2.10 of the July 2008 ETC).

Until 31st December 2011, ElectraNet must…

- not contract for an amount of agreed maximum demand greater than 100% of installed transmission line or equivalent transformer capacity; and

- provide transmission line capacity and equivalent transformer capacity for at least 100% of agreed maximum demand.

After 31st December 2011, ElectraNet must…

- provide N-1 transmission line and transformer capacity into Adelaide Central for at least 100% of agreed maximum demand; and

- provide that transmission line and transformer capacity "on a continuous basis by means of independent and diverse transmission substations (which must be commissioned and commercially available), one of which must be located west of King William Street";

- use its best endeavours to restore contracted transmission line capacity within 4 hours of an interruption; and

- in the event of a transformer failure, use its best endeavours to repair the installed transformer or install a replacement transformer as soon as possible so as to minimise the likelihood of an interruption as a result of the failure of the other transformer also supplying the Adelaide Central region.

In addition, after 31st December 2011, ElectraNet must…

- in the event that agreed maximum demand into Adelaide Central exceeds the line capacity or transformer capacity standards specified above, use its best endeavours to ensure that the line capacity or transformer capacity into Adelaide Central meets the required standards in 12 months, and in any case, within 3 years.

The July 2008 ETC can be viewed in its entirety at the following website:

http://www.escosa.sa.gov.au/webdata/resources/files/060906-R-ElecTransCodeET05.pdf

5. Projected Network Limitations

Prior to publication of the July 2008 ETC, ElectraNet identified the need for additional transformer capacity into the CBD and north-eastern suburbs regions. That additional transformer capacity would ensure that the level of supply reliability to the region would be maintained in the event of failure of the existing East Terrace 275/66kV transformer, in accordance with the standards in the July 2003 ETC.

However, ElectraNet subsequently examined the possibility of cyclically rating the East Terrace transformer. Following further investigation, it has been confirmed that the transformer can be loaded to 270MV.A under emergency conditions, rather than the 225MV.A nameplate limit that had previously been applied[1]. The increased transformer rating had the effect of deferring the need for reinforcement of the CBD and north-eastern suburbs regions for several years to 2016/17, but only under the now-superseded July 2003 ETC reliability standards.

As has been discussed, the projected network limitation results from the introduction of a higher reliability standard for the Adelaide Central region as set out in the July 2008 ETC. This standard requires ElectraNet to provide continuous N-1 transmission line capacity and continuous N-1 equivalent transformer capacity into Adelaide Central of at least 100% of agreed maximum demand by means of independent and diverse transmission substations, one of which must be located west of King William Street, with commissioning and commercial availability by 31 December 2011.

Consequently, the augmentation recommended in this report is a "reliability augmentation" as defined by the NER and has been assessed using the Regulatory Test for reliability augmentations, as promulgated by the AER.

6. Submissions to the Application Notice

In accordance with clause 5.6.6(h) of the National Electricity Rules, ElectraNet and ETSA Utilities have jointly considered the single submission received from the ESIPC in response to the Application Notice that preceded this final report.

That submission raised issues associated with technical content, level of detail provided and the cost of overhead line compared to underground cable for the 275kV supply.

In response to the ESIPC submission, a joint workshop was held with ESIPC, ETSA Utilities and ElectraNet to address the issues raised and to agree the additional content now included in this report.

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[1] The revised rating is based on an ambient temperature of 45°C, a hot-spot temperature of 130°C, and an overload period of eight hours. Those revised inputs give the transformer summer normal and emergency cyclic ratings of 250MV.A and 270MV.A ratings respectively.

7.   Options Considered

The following key parameters were identified as critical to the design of the required new large transmission network asset:

- Future transmission network development requirements;

- The ultimate layout or composition of the substation;

- The availability of suitably sized land on which to establish a new substation of the required capacity that would also meet the geographical location requirements of the ETC;

- The scope of works required to connect the new substation into its existing ETSA Utilities Adelaide Central 66kV network;

- The selection of Air Insulated Switchgear (AIS), Gas insulated Switchgear (GIS) or Hybrid substation technology;

- The source from which the new substation would derive its 275kV supply;

- The size of the transformer(s) that would be needed to provide the required transformer capacity;

- The route and composition (overhead/ underground) of the 275kV supply to the new substation; and

- The capacity of the 275kV supply.

Upon closer examination it was evident that complex interdependencies existed between the various considerations, with the effect that identifying the most cost-effective and technically sound solution that satisfied the Regulatory Test would require extensive investigation of each parameter, followed by an assessment of options for the overall integrated solution.

The result of ElectraNet's assessment of options regarding site selection, the source of supply for the new substation and the route and composition (overhead/ underground) of the new 275kV supply, are discussed in the following three sections of this report. Section 7.4 summarises the results of PV analysis comparing the twelve overall solution options resulting from combinations of those variables.

Chapter 8 addresses the technical details which underpin the design selections for the options analysis and ranking of options as described above, including:

- The future network development context for the project;

- 275/66 kV transformer capacity;

- capacity or rating of the new 275 kV transmission line;

- the ultimate layout or composition of the new City West substation;

- selection of substation technology;

- scope of works for the selected option; and

- design of 66kV connections to the new substation.

Section 8.9 demonstrates how the recommended option meets the required service obligations for the Adelaide Central region over the study period.

7.1 Transmission substation site selection

The following broad requirements and constraints were identified for substation site selection:

- The site had to be to the West of King William Street, as per the ETC;

- The approximate overall size would be determined by current and future expansion requirements, and could be different depending on where the site was located (inner city versus outskirts). This implies that certain sites may require the acquisition of additional sites at a later stage (but still within the planning period) to achieve the same ultimate solution;

- Large portions of the city West of King William street are zoned for residential or commercial use, which effectively excludes any potential development of this nature;

- Potential for EPA design restrictions which are aimed at limiting fire and pollution risks in the city precinct;

- City development planning, noise abatement and traffic management issues that would inflate the costs of construction; and

- The limited availability of land, particularly considering the short timeframe required (to ensure timely delivery of projects, ElectraNet normally takes a strategic view of land acquisition and secures its availability up to 15 years ahead of project commencement).

A four-tiered study methodology was adopted for the identification of potential sites. This methodology entailed:

- Commercial market search through use of a commercial real estate agency;

- In-house identification of sites through aerial imagery analysis and site visits;

- Direct approach to businesses, councils and rail authorities; and

- Advertisement placed in newspapers for potential sellers to make submissions.

This approach led to the identification of nineteen potential sites and provided a high level of confidence that the market was adequately covered. The locations of these sites are shown in Figure 6.

A Multi Criteria Analysis (MCA) was conducted to compare and evaluate the nineteen potential sites with input from both ElectraNet and ETSA Utilities. The following MUST criteria were defined for the overall project and sites were assessed against these for initial short listing:

- Must be available for purchase on the current market;

- The site must not jeopardise crown development support from Government Agencies;

- Location must meet the requirements of the ETC;

- Site must be large enough to support the substation development; and

- Delivery of project by December 2011 must be achievable.

Further assessment criteria were developed which addressed issues such as:

- Cost to procure the site;

- Complexity of substation design technology required to utilise the site;

- Site impacts on construction costs;

- Suitability of location for connection to the existing ETSA Utilities 66kV network;

- Proximity to residential and commercial buildings, infrastructure and access;

- The risk profile associated with the site;

- Likelihood of acceptance of site location, size and associated risks by key stakeholders;

- Development Approval considerations; and

- Strategic benefits offered by that location for future network developments (e.g. re-enforcement of other supply zones).

At the completion of the MCA, three sites were short listed and further analysis and estimates were carried out on those sites. The three sites, shown in Figure 7, were:

- Richmond Road, lot 500, 23 000 m^2

- Whitmore Square, 2 000 m^2

- Morphett St/ North Terrace (Rail Yard), 4 850 m^2

ElectraNet proceeded to confirm the availability and cost of each of the three sites, and conducted high-level estimates to determine the relative cost of constructing an appropriately designed substation of identical capacity at each location (for instance, consideration of whether the substation had to be multi-story or single-story, what facades would be required, land-contamination constraints, and so on).

The results of site comparison are presented below by way of the percentage difference in total capital cost of the options when compared with the least-cost option. As can be seen from those results, the site at Richmond Road proved comprehensively to be the least-cost option when the cost of constructing a technically identical substation and establishing the supporting infrastructure required for each of the sites was included.

- City West – Richmond Road (area 20,000m²) - cost factor 100%

- Inner City – Whitmore Square (area 2,000m²) - comparable cost factor 130%

- City north-west – Morphett St / North Tce (area 4,900 m²) - comparable cost factor 133%

All three of the above site options are included in the economic assessment of options included in this report.

However, the Richmond Road site was also the only site which was commercially available at that time and offered the following advantages:

- The site is located close to the city, with good road access for construction traffic, emergency services and transportation of plant, particularly large power transformers;

- Located in an Industrial area, the site does not have the constraints normally associated with residential zoning;

- The site has limited visibility from both main roads and secondary streets and screening can be readily achieved;

- An independent valuation of the site confirmed that the cost was market competitive;

- The site has potentially less environmental, heritage, community, political and planning issues associated with it than any of the other sites;

- The site offers strategic value in providing an ideal location for additional connection points into the Southern and Western Suburbs supply areas and the physical location of such new 66kV connections would eliminate progressively worsening voltage and overload issues on the 66kV networks; and

- Although not specifically considered as part of the evaluation criteria, the site offers a potential option for providing a connection point to the South Australian Government's proposed railway electrification.

As final confirmation of the suitability of the site of the new substation, ESCOSA was approached to seek its opinion on the location, specifically in light of the requirements specified in the 1 July 2008 ETC. ESCOSA was supportive of the site, confirming that it complied with the locational requirements as stated in the ETC. ElectraNet has secured the land to ensure that the new large transmission network asset can be established by the required 31 December 2011 practical completion date.

Figure 6: Potential substation sites following initial high-level site identification process

The site is large enough to enable ElectraNet to construct an economically efficient substation with options for future expandability when needed. At the time of publication of this final report, and after detailed assessment of all viable layout options, the Richmond Road site continues to be the least cost option of the options considered.

Figure 7: Three short-listed potential substation sites

7.2   Transmission Supply Options

Four technically feasible 275 kV supply sources were available for the new substation. They were:

- Torrens Island (TIPS) switchyard, to the north-west;

- Kilburn, to the north;

- Happy Valley, to the south; and

- Magill, to the east.

These four alternatives, including indicative 275kV transmission line corridors, are shown in Figure 8.

Analysis of the four alternatives revealed that supplying City West from either Happy Valley or Magill substations would not only involve the costs of establishing the 275kV transmission line connection between Happy Valley or Magill, and the new substation, but also substantial reinforcement of the transmission network 'behind' those two substations. This would add to the project cost in the order of $48m for Happy Valley (turning the TIPS-Magill 275kV line in-and-out of Para substation, and constructing an additional circuit between Cherry Gardens and Happy Valley), and $62m for Magill (to increase the rating of the Para to Magill line, which would involve a considerable amount of rebuild).

The additional 'deep network' augmentation costs resulted in the overall transmission cost estimates of the Happy Valley and Magill options rising to more than 130% and 120% of that of the lowest cost option, respectively. In addition to the considerably higher cost of these options, they would both also rely on supply via a transmission network that traverses high bushfire-risk terrain, thereby further increasing the risk to the security of supply to the new substation. Due to their substantially higher cost and inherent reliability risk, no further detailed analysis of these two options was undertaken. However, both options are included in the economic assessment of options included later in this report. .

The Kilburn option was then examined in more detail. Kilburn and Northfield substations are supplied from TIPS via a TIPS-Kilburn-Northfield-TIPS 275kV loop. The rating of each of those lines is 674MV.A, and the Kilburn 275kV bus, that forms part of that loop, is rated at 1600A, or 760MV.A.

Consequently, the maximum combined load of Northfield, Kilburn, and the load on the transmission line or cable to City West substation, must be limited to 674MV.A. This maximum load level would be realised in 2015/16, and would then necessitate the up-rating of those lines to a higher rating. The increased rating would be achieved by stringing a second conductor per phase in each line segment. The additional mechanical loading that the second conductor would place on the line structures would mean that a significant number of those structures would have to be replaced. The estimated cost of this work is $21m.

Shortly after rebuilding the lines, the Kilburn 275kV bus would become the limiting element in the loop, and would require the rebuilding of a substantial portion of Kilburn substation, at an estimated cost of $35m.

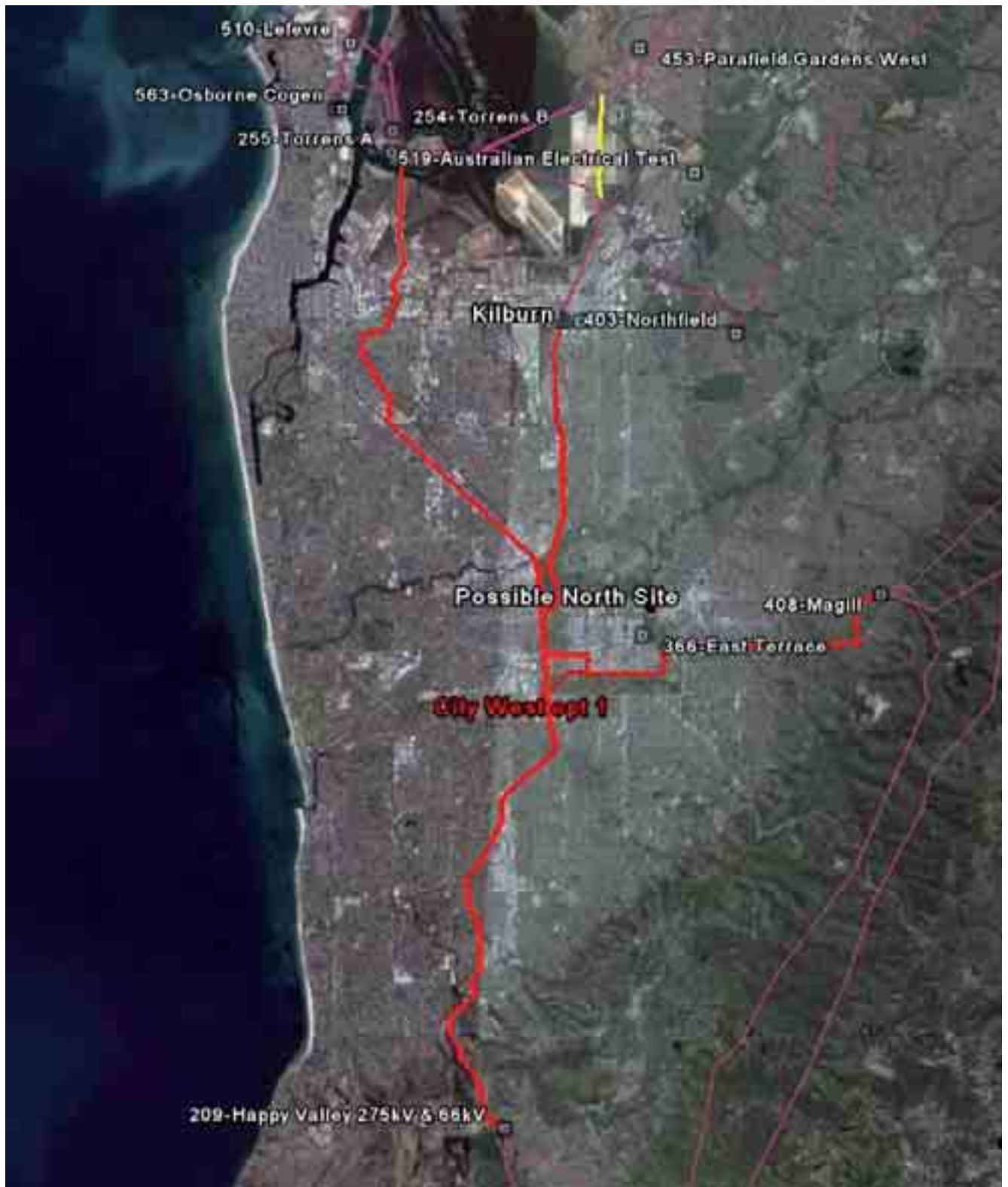The TIPS supply option was subjected to further detailed investigation.

Figure 8: Potential 275kV supply sources for the new substation.

7.3   275kV supply between TIPS and City West substation

Supply from TIPS switchyard was considered in greater detail, and seven supply options, using four corridors, were identified (as shown in Figure 9). The seven options were derived from a combination of different line corridors and different technologies; namely overhead lines using pole and tower structures, underground cables and a combination of these different technologies.

All of these options are considered to be technically viable but have varying risk profiles and project timing impacts related to the Development Approval Process and, therefore, the ability to meet the mandated completion date of 31 December 2011.

For this reason, ElectraNet's option assessment included both a cost and qualitative assessment.

External stakeholders were given the opportunity to contribute to options analysis, including local government, State Government agencies and selected potentially affected parties.

The seven options are:

- A – All underground cable mainly following Port Road

- B – Overhead and underground mainly following Port Road

- C – All overhead along Port Road

- D – Overhead and underground via Kapara Road

- E – All overhead via Kapara Road

- F – Overhead and underground via Barker Inlet and Churchill Road

- G – Overhead and underground via Kilburn and Churchill Road

Figure 9: Seven potential 275kV line corridors from the point of supply to the new substation.

Cost Assessment

A key factor in the cost assessment of options is the generally higher cost associated with underground cable versus overhead line construction.

Table 2a shows calculated cost ratios comparing the raw construction costs associated with the different types of construction. For example, a single or double circuit underground cable is estimated to cost three to four times the equivalent tower line in the metropolitan environment under consideration[2].

Technology	Comparative Cost Ratio[3]
Single circuit tower line	1.0
Single circuit pole line	1.1
Double circuit tower line	1.5
Double circuit pole line	1.5
Single circuit underground cable	3.2
Double circuit underground cable	5.5

Table 2a: Comparative raw costs of overhead and underground construction

However, there are other costs that need to be considered in addition to the raw construction costs that impact on these cost relativities, including:

- Acquisition costs for easements and/or property as required;

- The under grounding of the low voltage power lines where required;

- Reactive compensation equipment to offset the high capacitance associated with cable installations;

- Construction risk allowances to capture the different risks associated with the different technologies;

- Various substation entry configurations at City West substation relating to either an overhead or underground transmission line; and

- Remote end work (line and telecommunications) associated with each of the options.

Each of the above cost elements vary between the options considered.

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[2] Note that this ratio would be much higher in other settings such as within a rural environment where longer span lengths are possible and less strain towers are required for overhead construction.

[3] Cost ratios are based on detailed cost estimates of a 10km length of line in the relevant metropolitan environment and unit rates consistent with good electricity industry practice.

In particular, the acquisition of easements and in some cases the under grounding of low voltage powerlines add significantly to the cost of overhead construction options relative to using underground cable.

The easement and land acquisition cost estimates were based on the following assumptions:

- Road reserves have no compensation costs, but an allowance was made for administrative costs;

- Private land (industrial and commercial) cost estimates were based on recent sales values for the locality;

- Private residential land cost estimates were based on Real Estate Institute of South Australia data (averaging median house price for locality);

- An allowance of $25/m^2 for administrative costs associated with public lands (i.e. wetlands, Park lands and the Port Road median); and

- A transition yard (a point where an overhead line switches over to an underground cable) of approximately 40m x 60m is required for overhead options.

A present value (PV) analysis of the seven options was undertaken within the context of future network developments over the study period. These future network developments, which are discussed in Section 8.1, are common to all options considered with the exception of an additional reinforcement of the 275kV supply to the Adelaide Central region that is forecast to be required by 2025/26.

Consequently, the cost assessment of the seven options includes:

- all overhead line sections constructed as double circuit; and

- a second cable circuit to be installed in 2025/26 for cable options.

Cost estimates for the cable options include the purchase of spare parts and equipment (not currently held by ElectraNet) to minimise supply restoration times in the event of cable failure, as required by the ETC (refer to Section 4.2).

The PV analysis shows that Option A satisfies the Regulatory Test with the lowest PV outcome and Option F the next lowest (refer to Figure 10).

Option A involves an approximately 17km all underground cable solution generally following Port Road, while Option F involves approximately 18km of partially overhead line and partially underground cable construction following the Barker Inlet, wetlands and Churchill Road (refer to Figure 9). Option F assumes overhead construction from TIPS to a transition station in the vicinity of the Islington Railyards and underground cable from this point to City West.

Tables 2b and 2c provide a high level breakdown of the initial and future capital costs associated with Options A and F.

Cost Component	Option A	Option F	Comments
Overhead line (pole/lattice)	0	27	Line construction costs including environmental compliance and mitigation, relocation of services, traffic management etc.
Underground cable	111	73	Cable construction costs including environmental compliance and mitigation, relocation of services, traffic management etc.
Reactor	5	5	One reactor required in both cases for reactive compensation
Transition Station	0	3	Land acquisition, design and construction costs
Telecommunications	4	4	Buried optical fibre and OPGW (for Option F overhead line section)
Remote end work	14	17	For Option A primarily remote end substation works. Option F includes additional line termination works.
Contractor design and management	13	13	Contractor design and management costs.
Easements and property acquisitions	6	36	Easement compensation and property acquisitions
Total[4]	152	179	

Table 2b: Comparison of Option A and F initial capital cost estimates[5]

Cost Component	Option A	Option F	Comments
Underground line (Cable)	110	75	Cable construction costs including environmental compliance and mitigation, relocation of services, traffic management etc. Option F has less cable length.
Reactor	10	10	Two reactors required in both cases for reactive compensation
Telecommunications	1	1	Telecommunications panels at either end
Remote end work	5	0	Connection of new cable
Contractor design and management	13	9	Contractor design and management costs
Easements and property acquisitions	6	4	Easement compensation and property acquisitions
Total[4]	146	99	

Table 2c: Comparison of Option A and F future capital cost estimates (2025/26)[5]

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[4]   Numbers may not add due to rounding.

[5]   Note that capital costs are for the line component of the project only and exclude some costs that are common to all options (for example project management costs). Costs are expressed in $2007/08.

PV analysis of the seven line route options between Torrens Island and City West shows that Option A, an all underground cable solution mainly following Port Road, is the preferred option by a clear margin.

When key input assumptions are tested, this outcome is robust to all sensitivities conducted, including discount rate, operating and maintenance costs and demand growth.

Further detailed cost sensitivity analysis of Option A and its closest rival Option F, which specifically focuses on the key cost differentiating factors between the options, indicates that Option A remains the least cost outcome in all realistic scenarios considered.

The results of this analysis demonstrate the robustness of the PV assessment supporting Option A as the lowest cost option in accordance with the Regulatory Test.

Qualitative Assessment

To ensure an objective and robust qualitative evaluation process, assessment criteria were established. Each of the seven options were then evaluated against these criteria, and assigned a score based on the extent to which each option met the objectives of the assessment criteria.

The assessment criteria developed are shown in table 2d including a brief description of each one.

The qualitative assessment resulted in Option A being the preferred option. Comparative scores are indicated in Figure 10.

The robustness of the qualitative assessment was tested by assigning varying weightings to the criteria. Under all realistic weighting scenarios, Option A was clearly demonstrated to be the preferred option.

Criterion group	Objectives	Assessment criteria
Engineering	Minimise design risk Ease of construction Short duration to implement Minimise system strategic risk value Maximise safety Simplicity of operation and maintenance	Performance as a result of environmental impacts Constructability Construction program timeframe Repair time of severe failures
Asset strategy	Minimise design risk Maximise strategic value/ flexibility of the route/ site location Minimise whole-of-life cost	Supply to City West substation Minimise cost of second circuit Electrical losses Reactive support Increased Kilburn substation capacity Reduce TIPS reliance Inner metropolitan injection points

Criterion group	Objectives	Assessment criteria
		Existing infrastructure modifications
		Asset life
		Line crossings
Planning	Ease of planning approvals	Land use zoning — compatibility of proposal with local government Development Plan/s, zone objectives and policies
		Compatibility with sensitive sites/areas
		Obtaining development approval and minimise planning process risk/s
		Timeframe for approval process
		Corporate Governance
Environment	Minimise environmental impact	Area of native vegetation to be cleared
		Area of protected native vegetation to be cleared
		Number of rare or threatened species known to occur within proximity of the alignment
		Number of watercourses crossed, wetlands and flood zones
		Acid sulphate soils
Social and heritage	Minimise community/ media/ political impact	Residential areas traversed
		High amenity areas traversed – visual impact
	Minimise whole-of-life cost	Potential Electromagnetic Fields
		Construction impacts (noise, traffic, etc.)
		Number of roads and railway crossings
		Potential impact to Aboriginal and European heritage
		Property Acquisition community effect
		Effect on community/media

Table 2d: Route selection qualitative assessment criteria

Overall Outcome

The results of the cost and qualitative assessment of the seven options between TIPS and the City West substation site are graphically presented in Figure 10. Option A (TIPS – City West via underground cable) was assessed as being the preferred option because it has the:

- Lowest PV cost;

- Lowest initial capital cost;

- Best score in the qualitative (non-cost) assessment; and

- Least risk of development approval delays (obtaining timely development approval is critical for achieving the mandated completion date of 31 December 2011).
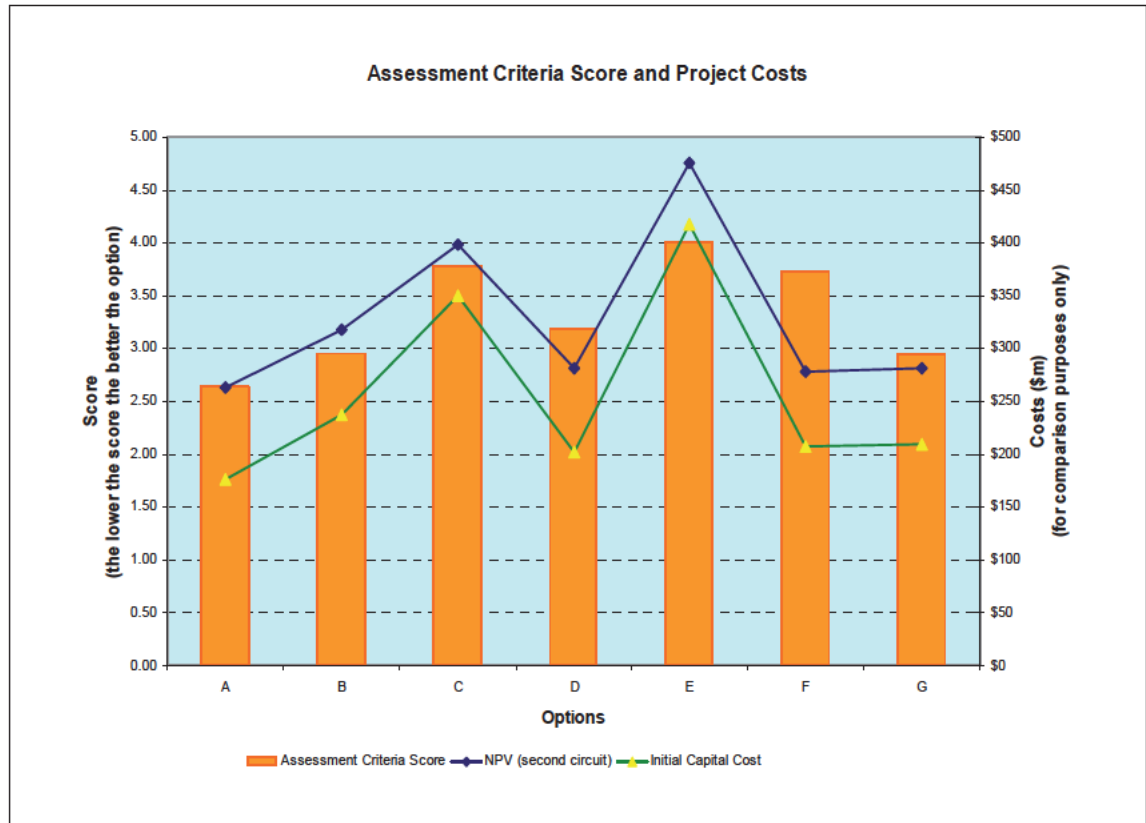
Figure 10: Options comparison for Torrens Island to City West 275kV supply

7.4   Site and Supply Source options comparison

This section of the report summarises the results of PV analysis comparing combinations of the four 275kV point-of-supply options and three substation site location options that will each individually address the augmentation requirements.

The twelve combinations of options have been grouped by the source of 275kV supply. Those options are:

- Option 1 – Supply to the new substation from TIPS 275kV switchyard;

- Option 2 – Supply to the new substation via a Kilburn by-pass arrangement out of TIPS;

- Option 3 – Supply to the new substation from Happy Valley; and

- Option 4 – Supply to the new substation from Magill.

The four options can each be further expanded into three sub-options depending on the location of the new substation that will be established, as was discussed in Section 7.1. Although the site at Richmond Road has now been purchased by ElectraNet, all three short-listed sites that were identified in Section 7.1 have been revisited in this section of the report to demonstrate conclusively that the decision to purchase the Richmond Road site was consistent with the overall least cost option.

Combinations of the four points of 275kV supply and three substation sites results in a total of twelve possible options for meeting the increased ETC reliability standards.

Siting the substation at either Whitmore Square or the Rail Yards rather than at Richmond Road would result in increases in the costs of the 275kV and 66kV connections due to route variations, as well as the major additional cost of ElectraNet's substation establishment. The Whitmore Square site option would also incur the additional cost of purchasing a further site on which to establish the southern and western suburbs 275/66kV supply points, as well as providing 275kV supply to that new connection. These additional costs must be considered in the options analysis in order that the three sites are compared on a like for like basis.

The size of land that was assumed for the additional injection point under these scenarios was 50m x 50m (2,500m^2), and it was further assumed that the site would be located at or near the current Richmond Road site.

Studies indicate that in about 2025/26, under the most severe contingency condition for the TIPS-City West cable; specifically, an outage of the Magill-East Terrace 275kV cable at time of peak load, the load on the TIPS-City West cable will exceed the cable's short term emergency rating. At about that same time, the loading on the ACR transformer at City West will exceed the transformer's emergency rating for that same contingency.

Accordingly, in 2025/26 it is proposed that a second ACR transformer be installed at City West and the 275kV cable between TIPS and City West be duplicated. Although these augmentations are strictly outside of the 15-year financial analysis period, their costs will be significant, and so have been included in the financial analysis to ensure that the findings and subsequent recommendations are robust and transparent.

The following three tables compare the cost of establishing the new substation at each of the three sites, and supplying that new substation from the four 275kV supply points identified. The transmission and distribution costs in these tables are inclusive of both line and substation establishment/ augmentation costs in each case (i.e. for either the transmission or distribution component, depending on which is relevant). The costs include the costs of future augmentations required of those options during the 15-year period of the analysis in order that all options are technically 'equivalent' at the end of that period. The fourth table then summarises the net present cost of the twelve options.

The financial analysis substantiating the results displayed in the tables is discussed further in Sections 9 to 11 of this report with detailed results provided in Appendix A.

It should be noted that for the transmission costs only the underlining differentiating costs (i.e. those costs not common to all options) have been used in the analysis. Excluding costs common to all options from the analysis (for simplicity) does not impact on the outcomes of the Regulatory Test assessment, which is based on the relative present value costs of the various options. As such, costs provided in the tables are not representative of actual implementation costs. Similarly, in those instances where future augmentations are common to all options; for example, the second transformer at East Terrace substation; the costs of those augmentations have been omitted. The costs associated with establishing both the 'SIM II' and western suburbs connection points have been included in the analysis because their establishment requires markedly different degrees of augmentation, and consequently cost, depending on where the substation is located.

Present value comparison of options ($m)

Table 3: Richmond Road substation site

Item	TIPS supply	Kilburn supply	Happy Valley supply	Magill supply	Comment / clarification
Transmission	162.2	198.3	213.6	197.2	Includes site purchase, substation establishment, 275kV connection, transformer and infrastructure for ACR connection, excludes S M II plant costs
Distr bution	106.0	106.0	106.0	106.0	Includes 66kV connection from new substation to ACR and associated ACR 66kV augmentation, and also includes SIM II 66kV network augmentation
Subtotal - Initial cost	268.2	304.3	319.6	303.2	
2019: Hindley Street substation rebuild	54.2	54.2	54.2	54.2	Excludes 66kV cable between Hindley Street and East Terrace substations since that cost is common to all options
2022/23: Western suburbs	46.0	46.0	46.0	46.0	Includes transformer and associated plant and equipment at Richmond Road, and 66kV connection to western suburbs network
2023/24: SIM III	59.0	59.0	59.0	59.0	Includes transformer and associated plant and equipment at Richmond Road, and 66kV connection to southern suburbs network
2025/26: 2nd cable and 2nd ACR transformer	91.0	91.0	91.0	91.0	Includes second ACR transformer at Richmond Road and second T PS-Richmond Road cable
PV	321.5	362.1	373.5	357.0	

Table 4: Whitmore Square substation site

Item	TIPS supply	Kilburn supply	Happy Valley supply	Magill supply	Comment / clarification
Transmission	206.6	242.7	269.3	231.6	Includes substation establishment, 275kV connection, plus land purchase for SIM II new connection and 275kV connection to that SIM II site
Distr bution	69.5	69.5	69.5	69.5	Includes 66kV connection from new substation to ACR and associated ACR 66kV augmentation, and also includes the cost for associated S M II 66kV augmentation from the separate connection point
Subtotal - Initial cost	276.1	312.2	338.9	301.1	
2019: Hindley Street substation rebuild	54.2	54.2	54.2	54.2	Excludes 66kV cable between Hindley Street and East Terrace substations since that cost is common to all options
2022/23: Western suburbs	51.4	51.4	51.4	51.4	Includes site purchase, 275kV supply, substation establishment, and 66kV connection to western suburbs 66kV network
2023/24: SIM III	59.0	59.0	59.0	59.0	Includes second transformer at S M II site and 66kV augmentation
2025/26: 2nd cable and 2nd ACR transformer	93.6	72.5	102.3	85.9	Includes second ACR transformer at Whitmore Square and duplication of 275kV supply
PV	330.8	365.9	394.8	355.5	

Table 5: Rail Yards substation site

Item	TIPS supply	Kilburn supply	Happy Valley supply	Magill supply	Comment / clarification
Transmission	160.9	197.0	241.0	196.9	Includes site purchase, substation establishment, 275kV connection, transformer and infrastructure for ACR connection, excludes SIM II plant costs
Distr bution	157.5	157.5	157.5	157.5	Includes 66kV connection from new substation to ACR and associated ACR 66kV augmentation, and Hindley Street substation rebuild, and also includes SIM II 66kV network augmentation
Subtotal - Initial cost	318.4	354.5	398.5	354.4	
2022/23: Western suburbs	89.0	89.0	89.0	89.0	Includes site purchase, 275kV supply, substation establishment, and 66kV connection to western suburbs 66kV network
2023/24: SIM III	98.0	98.0	98.0	98.0	Includes second transformer at SIM II site and 66kV augmentation
2025/26: 2nd cable and 2nd ACR transformer	78.7	57.6	107.4	79.7	Includes second ACR transformer at Rail Yards and duplication of 275kV supply
PV	375.1	410.3	458.0	411.6	

Substation site	Option 1: TIPS supply	Option 2: Kilburn supply	Option 3: Happy Valley supply	Option 4: Magill supply
Richmond Road	**321.5**	362.1	373.5	357.0
Whitmore Square	330.8	365.9	394.8	355.5
Railway Yards	375.1	410.3	458.0	411.6

Table 6: Summary of Present Value comparison

The results summarised in the above table demonstrate that the option being recommended jointly by ElectraNet and ETSA Utilities satisfies the Regulatory Test by providing the least present value solution to market participants, and ultimately, South Australian electricity consumers.

8. Technical Details

8.1 Future Network Development

In selecting the appropriate equipment ratings for City West substation and transmission line, due consideration was given to future development needs of the network, as depicted in Figure 11.

Figure 11: Network Integration Diagram showing initial and future planned network augmentations

The relevant network developments, relating to the Adelaide Central, Southern Suburbs and Western Suburbs regions are summarised in the table below together with the relevant constraints and contingencies that drive these development needs.

Year	Constraint/requirement	Contingency	Mitigation Option
2011/12	New ETC obligation for Adelaide Central region		Commissioning of City West substation with 275kV line to TIPS and one 275/66kV transformer for the ACR
	Happy Valley or Magill 275/66kV transformers and some main 66kV line capacity	Outage of a 275/66kV transformer at Happy Valley or Magill substation or an outage of some 66kV lines	Installing the second 275/66kV transformer at City West substation for the Southern suburbs
2016/17	N-1 transformer capacity for Adelaide Central region	Outage of City West 275/66kV transformer for ACR	Installation of second 275/66kV transformer at East Terrace substation
2018/19	Morphett Vale East-Cherry Gardens 275kV line capacity	Outage of Happy Valley-Cherry Gardens 275kV line	Not considered as negligible impact on the City West development
2022/23	Torrens Island 275/66kV transformer capacity	Outage of Kilburn 275/66kV transformer	Commissioning of third 275/66kV transformer at City West substation for the Western suburbs
	Happy Valley-Cherry Gardens 275kV line capacity	Outage of Morphett Vale East-Cherry Gardens 275kV line	Not considered as negligible impact on the City West development
2023/24	275/66kV transformer capacity at Happy Valley substation	Outage of City West 275/66kV transformer for southern suburbs	Installation of fourth 275/66kV transformer at City West substation (the second 275/66kV transformer for the Southern suburbs)
2023/24	275/66kV transformer capacity at Morphett Vale East substation	Outage of a 275/66kV transformer at Morphett Vale East substation	Third 275/66kV transformer at Morphett Vale East substation
2025/26	City West 275kV cable and 275/66kV transformer capacity for ACR	Outage of Magill-East Terrace 275kV cable	Installation of second 275kV line for City West from TIPS and fifth 275/66kV transformer at City West substation (the second 275/66kV transformer for the ACR)

The future network developments described above are common to all options considered with the exception of the further reinforcement of the 275kV supply to the Adelaide Central region that is forecast to be required by 2025/26.

Those developments that impact on the required capacity of the 275kV transmission line between TIPS and City West and the ultimate composition or layout of the City West substation are discussed in more detail in Sections 8.3 and 8.4 respectively.

8.2   City West Transformer Capacity

The peak demand in the Adelaide Central region is forecast to be 244MV.A during the summer of 2011/12 in which the new substation is required to be commissioned and commercially available. That demand is presently supplied by East Terrace substation, which comprises one 225MV.A transformer that can be cyclically loaded to 270MV.A, and which is supported in that role by the interconnecting 66kV ties to ETSA Utilities' neighbouring 66kV networks. As demand increases in both the Adelaide Central and neighbouring regions, the ability of those 66kV interconnections to support East Terrace substation will diminish. Furthermore, ETSA Utilities is under no obligation to maintain those 66kV ties to its neighbouring networks.

With consideration for the above, should ElectraNet install one of its current standard sized transformers of 225MVA at the City West substation, N-1 transformer capacity would be exceeded within five years of its establishment, and the installation of a second transformer would then be required (refer Figure 12).

Given that the additional cost to purchase the next standard size transformer (300MV.A, with an emergency cyclic rating of 360MV.A) is of the order of $1m (compared with a total purchase price of $5m), ElectraNet has determined that it is more cost-effective to purchase the larger transformers. That decision is supported by least-cost present value comparison.
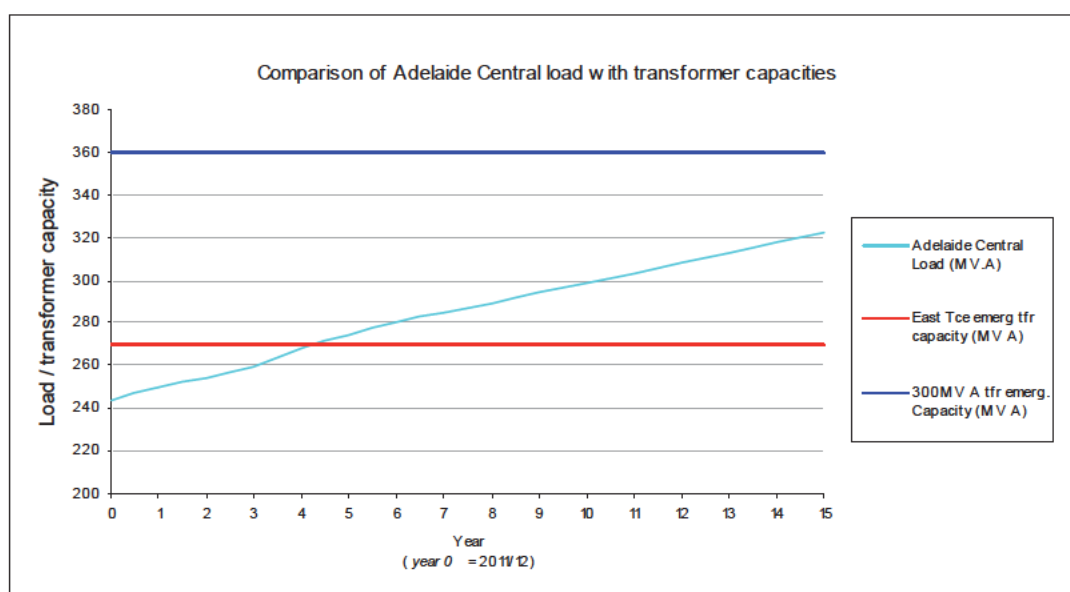
Figure 12: Adelaide Central load forecast compared with transformer capacity

8.3   Capacity of the 275kV Connection to the City West Substation

Based on the future development needs of the metropolitan network, as discussed in section 8.1, the capacity selection for the supply cable had to establish the most economical solution to address those developments.

The load on the 275kV TIPS to City West connection will comprise a combination of electrical loads representative of the Adelaide Central, Southern Inner Metropolitan,

and Western Suburbs regions. Each of those areas has a daily load profile that is unique to that particular area, and is influenced by the pattern of electricity usage.

In order to determine the required capacity of the 275kV cable, a load-flow model was created that represented the new City West substation in 2022/23. The summer of 2022/23 was selected because it represents the first peak demand period in which the Western Suburbs transformer would be in-service at City West. At that stage City West would comprise three 300MV.A transformers; one dedicated to supplying the Adelaide Central region, one to supplying SIM II, and the third transformer dedicated to supplying the Western Suburbs. Using that model, the proportion, and consequently the magnitude, of the total load on the cable that is attributable to each of those regions was able to be determined.

The individual demand profile for each of the three load areas was then obtained for the most recent 'peak-load' day (Monday, 17 March 2008). The three sets of half-hourly demand readings for that day were each separately converted to percentages of their individual maximum values during that 24-hour period. The magnitude of the demand supplied to each of the three individual areas, as determined above, was then assigned as the peak, or '100%', demand value for that particular area, thereby enabling the 24-hour MW demand profile for each of the three load components of the cable to be determined.

The three components of the load on the cable for each particular half-hour of the 24-hour period was added to produce the load profile that the cable will be expected to carry under normal operating conditions on a peak demand day during the summer of 2022/23.

The results of the above analysis, both for the week encompassing the peak load day, and the peak load day itself, are displayed in Figures 13 and 14.

The most severe single contingency condition for that part of the network – an outage of the Magill-East Terrace 275kV cable - was then modelled, and the above process repeated.

The three individual components of the resulting demand profiles were then scaled for progressive years in accordance with the demand forecast published by ETSA Utilities in April 2008. The loads were again summed on a half-hourly basis for the 24-hour period, and the resulting loading on the 275kV connection determined for progressive years[6] (refer figures 15 and 16). The results of the analysis so described culminated in the following two loading levels on the 275kV connection in 2027, around the time when a second 275kV supply to the new substation will be established and a second ACR transformer installed:

- 645MV.A (power factor 0.98) – normal operating conditions

- 750MV.A (power factor 0.98) – contingency operating conditions (Magill-East Terrace 275kV cable out of service)

In addition to the magnitude of the load, the expected duration of a contingency is of critical importance in the selection of the cable rating. As was discussed earlier in this section, it has been determined that the cable will be loaded to 750MV.A under contingency operating conditions in about 2027. The contingency that will cause the cable to load to that level is the failure of the Magill-East Terrace 275kV cable.

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[6]   Allowance was also made in ETSA's forecast for the Government-backed desalination plant planned for Port Stanvac, with completion scheduled for 2012. The desalination plant will be supplied from the southern suburbs network.

Should the 8-kilometre Magill-East Terrace cable fail, repair of that cable can be expected to run into weeks, rather than days.

In determining the cable rating, four cable rating parameters are considered; continuous rating, continuous cyclic rating, emergency cyclic rating and emergency rating. Continuous cyclic rating implies that the cable can be loaded to that rating on a daily basis provided the load curve is of cyclic nature and provides sufficient cooling period for the cable over a set period of time. The emergency cyclic rating is similar to the cyclic rating, except that the cable can only be loaded to this value for a maximum of three consecutive days. The emergency rating is an eight hour cable rating. The nature of the daily cycles of the loads which will be supplied by this cable is such that the continuous cyclic rating can be utilised for dealing with contingency situations. To ensure the cable will be of sufficient rating to cope with the contingency conditions described earlier, a cable with continuous cyclic rating of 750 MV.A was selected. This cable will have an emergency cyclic rating of 900 MV.A, and an emergency rating of 1080 MV.A.

ElectraNet investigated the option of installing two sets of cables of lesser rating each, to achieve the same ultimate overall rating, and provide increased operational flexibility and increased system security. This option was included in the Expression-of-Interest issued to cable suppliers as an alternative solution. An assessment of the submissions received clearly indicated that the lesser rated double circuit option is significantly more expensive than the single, high rating cable option. This cost differential excluded the cost of the additional switchgear required to achieve the establishment of a second circuit.

Should a single 450MV.A cable be installed initially in preference to the 750MV.A cable, the second 450MV.A cable would have to be installed, albeit approximately five years later, to match the capacity that the larger cable would provide. Taking that into consideration, financial analysis demonstrates that a 750MV.A cable provides the present value least-cost solution of these two options. Given the relatively small incremental increase in initial cost, and when considered in the context of the significant overall cost of purchasing and installing the cable, ElectraNet is satisfied that its decision is both prudent and one that represents good electricity industry practice. The additional cost of the larger cable does not alter the ranking of the options as determined by application of the Regulatory Test[7].

Consideration was also given to the use of a lesser rated cable to be installed in the initial stage of the project, i.e. a cable with a continuous cyclic rating of 600 MV.A. This option would result in the second circuit being installed at an earlier stage in the future, but not at the same time as the installation of the second transformer for ACR. The relative small saving which may have been achieved in initial cable cost (smaller cable but the same installation costs) is off-set by the additional mobilisation and project management costs associated with the stand alone project. Due to the combination of the length and the capacitive characteristic of underground cables, a significant amount of reactive power will be generated by the cable at times of light load. Reactive compensation will, therefore, be required on the cable. Installation of reactors forms part of the scope of this project and associated costs have been included in the financial analysis presented in this final report.

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[7]   In section 11.1 of this Final Report, the cable cost has been varied by 20% above and 20% below the estimated cost (an amount greater than the 15% to 20% cost difference between a 750MV.A cable and a 450MV.A cable, as discussed above). Even subject to those variations, Option 1 remains the least present value cost option as shown in Table 9 of that section.
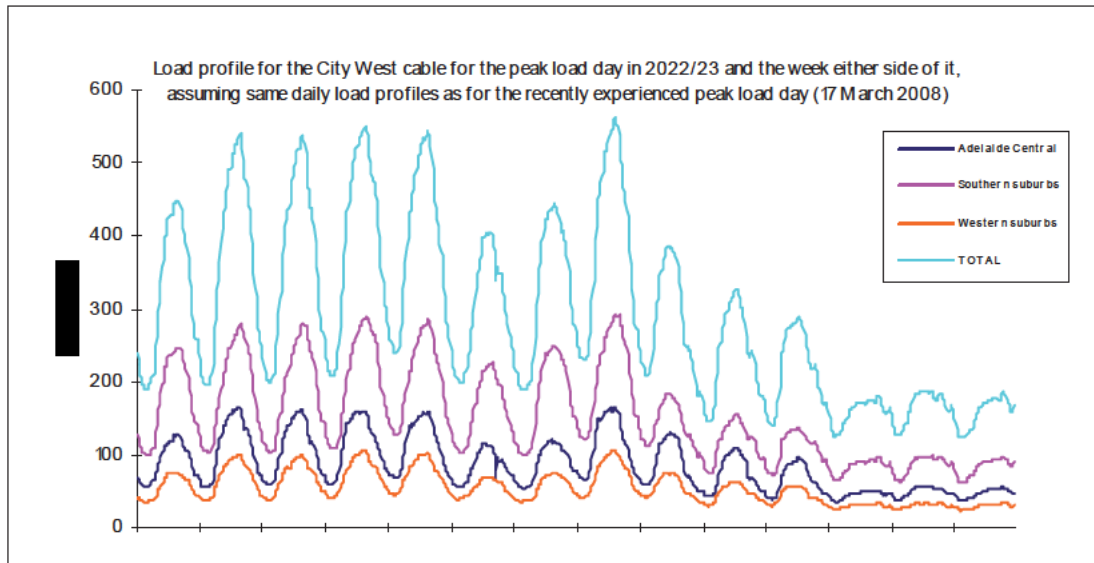
Figure 13

Calculated load profile for the 275kV connection to City West substation for the week of the latest recorded peak load day and subsequently scaled to forecast 2022/23 load levels
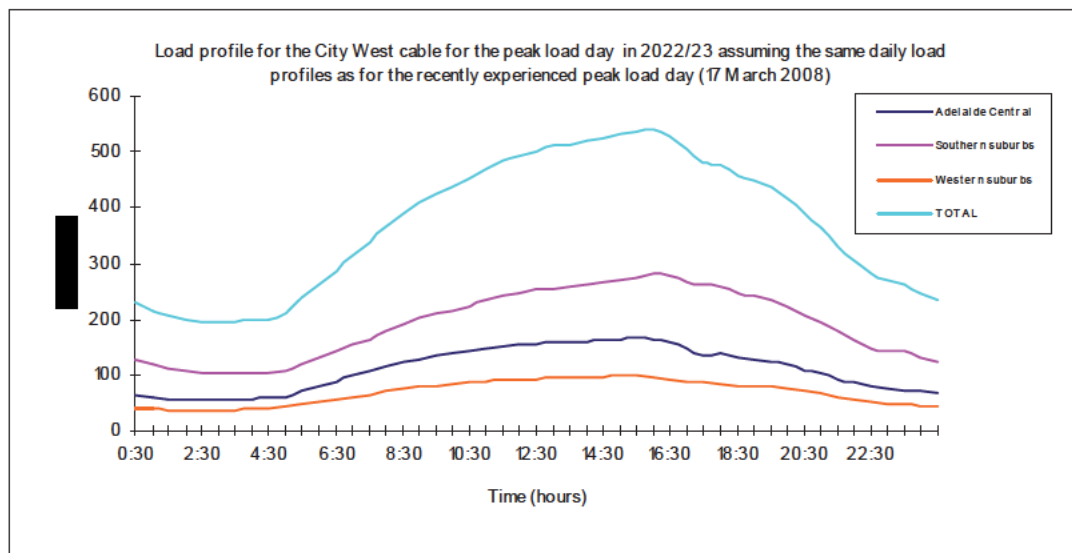
Figure 14

Calculated load profile for the 275kV connection to City West substation for the latest recorded peak load day and subsequently scaled to forecast 2022/23 load levels
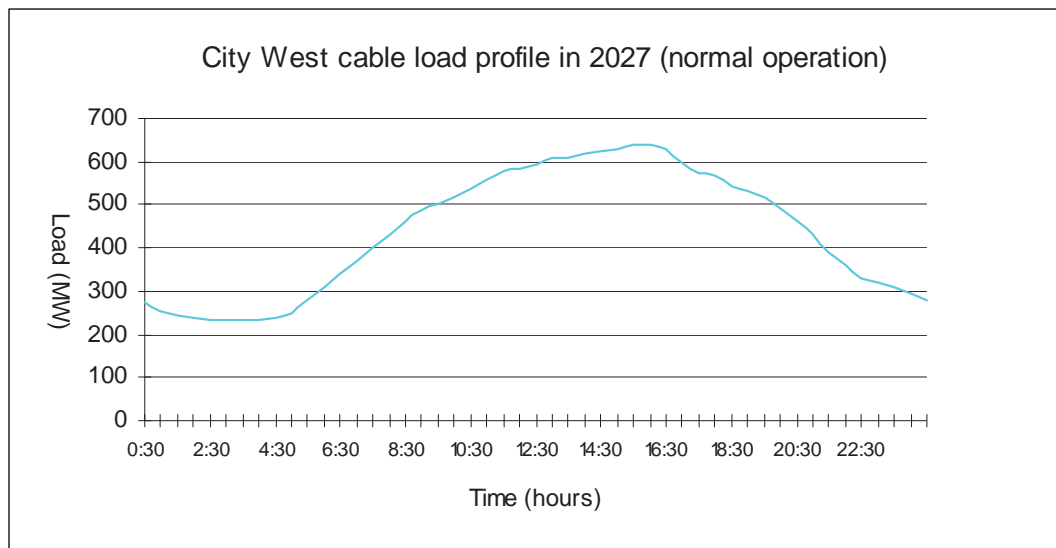
Figure 15

Calculated load profile for the 275kV connection to City West substation for the peak load day and subsequently scaled to forecast 2027 load levels – normal operating conditions
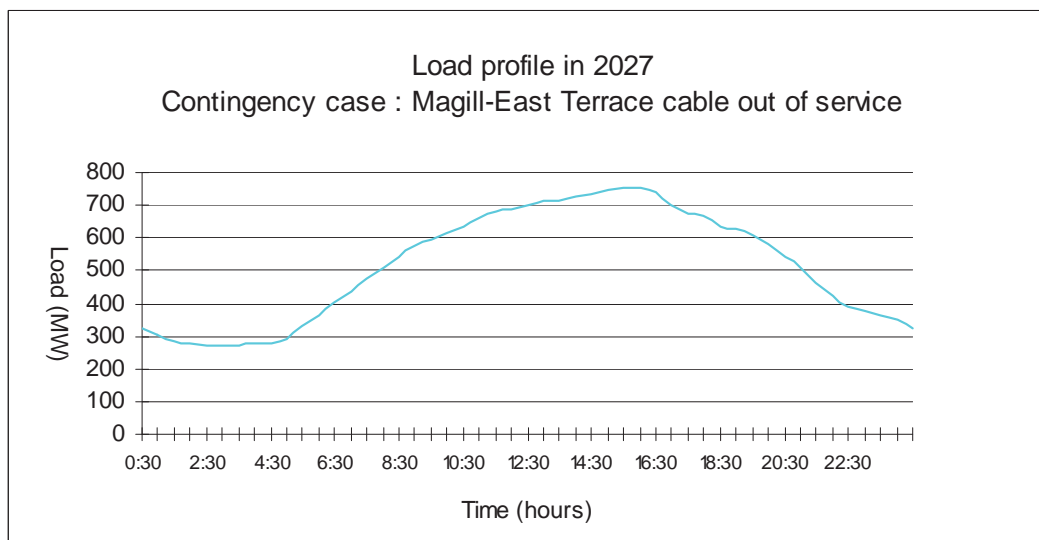
Figure 16

Calculated load profile for the 275kV connection to City West substation for the peak load day and subsequently scaled to forecast 2027 load levels – contingency operating conditions

8.4 City West Initial and Ultimate Composition

As discussed in section 7.1 of this report, the Richmond Road site offered strategic advantages for future additional connection points into the Southern and Western Suburbs.

A discussion follows on the projected limitations within those distribution networks electrically adjacent to the chosen site for City West that were taken into account in developing the ultimate composition or layout of the substation.

Southern suburbs 66kV sub transmission network

- In 2011/12 the remaining of the existing 275/66kV transformers, that are located in the southern reaches of the southern suburbs 66kV network at Happy Valley and Morphett Vale East, will overload should any one of those transformers fail at times of high load; and

- Also, in 2011/12, 66kV sub-transmission lines in the northern portion of the southern suburbs 66kV network, adjacent the City West substation site, will overload in the event of a single contingency on the 66kV network.

To resolve these limitations, ETSA Utilities has requested that ElectraNet install a 300MV.A 275/66kV transformer that injects into the northern portion of the southern suburbs 66kV network, notionally at the proposed City West substation, since this is ideally sited to eliminate both the connection point limitation and the 66kV sub transmission overloads. This transformer and associated switchgear will be installed at the same time as the Adelaide Central connection is being constructed.

ETSA Utilities and ElectraNet jointly issued a 'Request for Information/ Request for Proposals', RFP002/06 Projected Network Limitations: Adelaide Central Region, South Australia, Issue 1.0 – October 2006 on 20 October 2006 to address the projected limitations on ETSA Utilities' 66kV network that supplies the southern inner metropolitan (SIM) region of Adelaide.

No submissions were received for demand side load reduction in response to that RFI/RFP. Various options were subjected to the Regulatory Test, as required under the NER and ESCOSA Guideline 12. Analysis has shown that the installation of a new 300MV.A 275/66kV transformer dedicated to supplying the southern suburbs 66kV network, which is presently supplied by Happy Valley and Morphett Vale East substations, located at the same site as the proposed City West 275/66kV substation, is the most viable solution.

Evaluation of various options indicated that a comparable distribution solution or generation solution would be less reliable and more expensive than creating a new 275/66kV injection point. Those findings were published on 16 November 2007 in a combined Evaluation Report (RFP-ER 002/06) on reinforcement options to address the projected network constraints described in RFI/RFP 002/06.

<u>Western suburbs 66kV sub transmission network</u>

- Supply to the western suburbs 66kV network is presently supplied by 275/66kV connection points at Kilburn, LeFevre and TIPS, in the northern extremities of that region. In 2022/23 the western suburbs connection point transformer capacity will be exceeded in the event of failure of one of the existing 275/66kV transformers supplying that 66kV sub transmission network, and, as for the southern suburbs network, sub-transmission lines in both the northern and southern portions of that network will overload under 66kV line contingencies.

To overcome those limitations, ETSA Utilities has indicated that it will in the future request that ElectraNet install at City West substation a 300MV.A 275/66kV transformer that injects into the southern portion of the western suburbs 66kV network. As with the transformer that will be dedicated to supplying the southern suburbs network, City West will provide the ideal location to accommodate the proposed western suburbs transformer in order to eliminate both the connection point limitation and the 66kV sub transmission overloads.

Although the costs associated with establishing the SIM II and Western Suburbs connection points were considered in the PV calculation to determine the overall least cost option, those costs do not form part of the total project cost associated with the establishment of the City West substation, and are therefore excluded from this report.

<u>City West ultimate substation layout</u>

Based on the above discussion and supporting load-flow studies covering the fifteen plus-year period following commissioning, City West will ultimately comprise three 275kV cable bays (two cables to TIPS, and one nominally to East Terrace substation), five 300MV.A 275/66kV transformers, two 275kV reactors and will make provision for one phase-shifting transformer. Transformer allocation will be as follows:

- Two transformers dedicated to the supply of the Adelaide Central region (the Adelaide Central load is forecast to exceed the summer emergency cyclic rating of the initial Adelaide Central transformer, in the event of loss of supply from East Terrace substation, in 2025/26;

- Two transformers providing supply to ETSA Utilities' southern suburbs 66kV network (the installed transformer capacity supplying the southern suburbs under single contingency will be exceeded in 2023/24; and

- One transformer dedicated to supplying ETSA Utilities' western suburbs 66kV network (the western suburbs load will exceed the single-contingency capacity of the transformers supplying that region in 2022/23).

As mentioned, allowance has been made for the future installation of a phase-shifting transformer to enable supply to the Adelaide Central load to be equitably shared between East Terrace and City West by varying the phase angle between the two substations, thereby enabling control of real power flow.

Consideration of inclusion of a 66kV busbar

Consideration was given to the use of a 66kV busbar scheme that could provide increased future reliability and flexibility of the 66kV system. However, this arrangement was not pursued because:

- A 66kV bus is not needed as part of the initial project development.

- The fault level at the 66kV bus would increase significantly as a result of the decrease in transformer impedance resulting from paralleling transformers, combined with the potential in-feed from other transformers in the system. This outcome is undesirable since it would result in an increase in the required short circuit rating of new and existing switchgear to the extent where it becomes uneconomical (the ultimate fault level would increase above 40kA, which exceeds the maximum rating available for standard 66kV equipment from any supplier). Additionally this would also increase the fault current of the earthing mesh, which is not recommended due to the proximity of the substation to residential areas.

- A triple busbar scheme would be required to maintain Adelaide Central, the Southern Suburbs and Western Suburbs as three independent electrical regions. This would also add significant cost making the inclusion of a 66kV bus uneconomical.

Therefore, it was concluded that the ultimate site layout should be based on five individual supplies to each of the CBD1, CBD2, SIM II, SIM III and Western Suburbs.

Nevertheless, the design of the City West substation allows for the installation of a 66kV busbar should network developments change in a manner that would favour this in the future.

Distribution connections

The City West site located at Lot 500, Richmond Road, has an area of 22,000m^2, and is of sufficient area to accommodate ElectraNet's infrastructure requirements for the ultimate substation layout.

The physical location of the site for the City West substation is shown in Figure 17, and a single-line diagram of the staged development of the proposed City West substation that will be established on that site, up to and including the ultimate layout, is shown in Figure 18. Figure 19 shows the equipment layout drawing for the substation. The high-level scope of works for the initial stage of development of City West substation has been shown highlighted in green in that figure.

Further site and equipment layout optimisation will occur during the detailed design phase of the project.

With respect to the method in which the connection points could be integrated into the exiting 66kV networks, various connections options were considered. The initial concept was based on co-location of a new ETSA 66kV substation on the Richmond Road site, with 66kV feeders to various substations within those load areas. Following further detailed analysis and costing, ETSA Utilities has elected to implement a 66kV solution whereby a 66kV feeder is installed from the ElectraNet 66kV connection point to a key Distribution substation in each of the three load areas. This solution has the following advantages and disadvantages:

Advantages:

- The ultimate number of 66kV circuits will be reduced from fifteen to five, with the initial number of circuits required upon establishing the substation reduced from six to two;

- The number of 66kV cables required upon establishment will be reduced from six to four (two cables per circuit);

- This proposal will release to ElectraNet a significant portion of the City West substation site that would previously have been required for ETSA Utilities' 66kV switchgear;

- Upon re-costing of the original proposal, the overall cost to ETSA Utilities of its revised strategy is lower than that of the original proposal;

- Due to the physical desegregation, ElectraNet's and ETSA Utilities' developments will become largely independent of each other, thereby simplifying the timing and co-ordination of the two developments; and

- The necessary protection and control systems required for the augmentation will be greatly simplified.

Disadvantages:

- Constructability difficulties for the exits to the southern inner metropolitan 66kV network are still an issue, but the proposal that ETSA Utilities has now elected to adopt is far simpler than the original proposal.

Figure 17: Physical location of proposed City West substation - Lot 500, 1 Richmond Road, Keswick
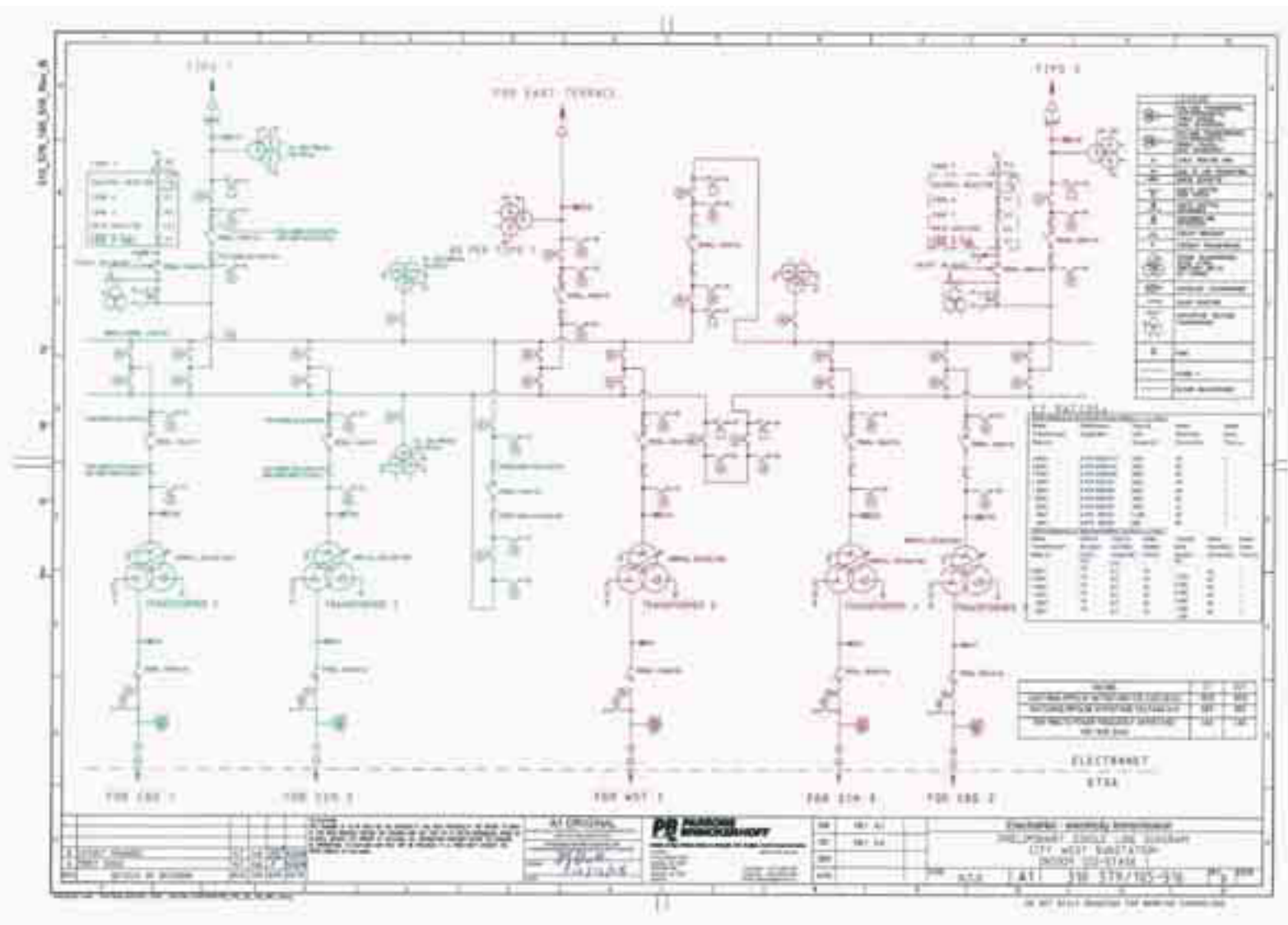
Figure 18: Ultimate configuration of City West substation

Figure 19: Preliminary ultimate layout of City West substation

8.5   Selection of Substation Technology

Designs based on a Gas Insulated Switchgear (GIS) substation were developed early in 2007 and included Single Busbar, Double Busbar, Breaker & Half and Mesh configurations. Those initial designs were 275kV GIS double busbar configuration to accommodate two incoming feeders, one East Terrace interconnector (with space for a future phase shifter) and five 275/66kV transformer bays. The low side of the transformers were to directly connect to a 66kV ETSA Utilities owned substation on the same City-West site adjacent to ElectraNet 275kV Substation.

ETSA Utilities' decision not to install any switchgear at the City-West site vacated a significant area of the proposed land. Considering the new space availability ElectraNet revisited the initial design options to include other switchgear arrangements as well as the requirement for 66kV switchgear, to be owned and operated by ElectraNet.

A variety of Air Insulated Switchgear (AIS), Highly Integrated Switchgear (HIS) and AIS/GIS combination arrangements, based on a breaker and a half and double busbar configuration were investigated and compared to the initial GIS double busbar option.

On the basis of PV cost analysis incorporating capital expenditure, as well as operating and maintenance costs and system losses over a substation operational life of 45 years, the following relativities in PV costs were determined:

AIS Low profile breaker and half arrangement – 3 Diameter:	1.13
AIS Low profile breaker and half arrangement – 4 Diameter:	1.18
HIS Low profile breaker and half arrangement – 3 Diameter:	1.32
GIS Double Busbar – Outdoor GIS:	1.01
GIS Double Busbar – Indoor GIS:	1.00

Table 7: Relativities in PV costs of available switchgear technologies

The AIS configurations described above could not be accommodated in the current land allotment and would require the purchase of additional land. This would have significant impact on adjacent businesses.

The additional land purchase required for the AIS and HIS solutions adds significantly to the costs of those options.

ElectraNet also investigated other switchgear arrangements based on individual stages of the project to accommodate the ultimate layout. Those relativities are presented in the following table.

	Stage 1	Stages 2 and 3	PV Cost relativity
Option A	Breaker and a half in AIS	Double Busbar GIS	1.28
Option B	Breaker and a Half in AIS	Breaker and a Half in GIS	1.30
Option C	AIS Double Busbar, Double Breaker	GIS Double Busbar Double Breaker	1.36

Table 8: Relativities in NPV costs of alternative switchgear technology timing

Alternative options A, B and C do not practically fit within the existing substation boundary and they may be ruled out on numerous technical and operational grounds. Also, the use of part AIS for Options A, B and C increases Development Approval (DA) risk over indoor, or outdoor GIS solutions and the requirement to procure adjacent property increases project risk.

PV's for the ultimate development of Options A, B and C are significantly higher than the lowest cost Indoor GIS option, due to land purchase requirements, as well as additional interface plant between AIS and GIS plant.

In view of the above significantly higher PV's, as well as technical and operational limitations associated with Options A, B and C, it is recommended that Stage 1 AIS development, with Stages 2 and 3 GIS development is not to be considered for the City-West substation site.

Thus, GIS switchgear is generally identified as the lowest cost option and is recommended for the development. Additionally, it must be acknowledged that there may be significant technical advantages (and potential planning approval advantages) in favour of indoor GIS.

ElectraNet has chosen a standard GIS double busbar / single breaker design for the layout as this arrangement has been proved in other high reliability installations in Australia and overseas and also provides the least cost over other designs.

8.6   66kV Connection to the New Substation

To meet the Electricity Distribution Code Reliability Standards, ETSA Utilities plans its CBD 66kV network to a continuous N-1 level of security during forecast peak load conditions; that is, no loss of customer supply during a single 66kV event. Typically, the new high-capacity 66kV cables used in the CBD can carry up to 160MVA of load, depending on installation restrictions such as size and depth of cable trench. System network modelling has shown that initially the new City West connection point will supply up to 160MVA of load into the Adelaide Central region at peak load times, with that load increasing each year at the approximate CBD growth rate of 2.2%. To manage that demand it will be necessary to install two 66kV cables in parallel to connect City West substation to the existing ETSA Utilities CBD network, providing a total connection capacity of up to 300MVA. That capacity is well matched to the ElectraNet transformer capacity of 300MVA.

ETSA Utilities' preferred option is to connect the parallel set of 66kV cables directly from City West substation to the CBD 66kV network at Whitmore Square substation (refer Figure 20) at an estimated cost of $65m. That cost includes installation of major new substation equipment at Whitmore Square substation. Whitmore Square substation already has direct 66kV cable connections to two other CBD substations (Hindley Street and Coromandel Place substations), and the remaining CBD substation at East Terrace (via the existing Coromandel Place to East Terrace 66kV cable). Therefore, power can readily be supplied to the Adelaide Central Region by the proposed arrangement. The costs of the associated protection, telecommunications and earthing systems upgrades that are required at the existing CBD substations to manage the new connections are included in the above figure.

A second alternative that ETSA Utilities considered but discarded because of a higher initial capital cost of $143m and higher costs over the evaluation period was to install three 66kV cables directly to three of ETSA Utilities' existing CBD substations from City West. Unfortunately, in comparison to the preferred option, that solution requires a major upgrade of the existing Hindley Street substation (switchgear limitation), the advancement of the planned fifth CBD substation, and additional 66kV cable works. Although a benefit of this option would be additional 66kV line redundancy provided to the Hindley Street substation and the future fifth CBD substation, those benefits cannot be directly attributed to the Adelaide Central reinforcement.

The third alternative that ETSA Utilities considered but discarded, again because of the higher initial capital cost of $112m and higher costs over the evaluation period, was to install two 66kV cables from City West to Whitmore Square substation and one 66kV cable from City West to the existing Hindley Street substation. That solution would also require a major upgrade of Hindley Street substation (switchgear limitation).
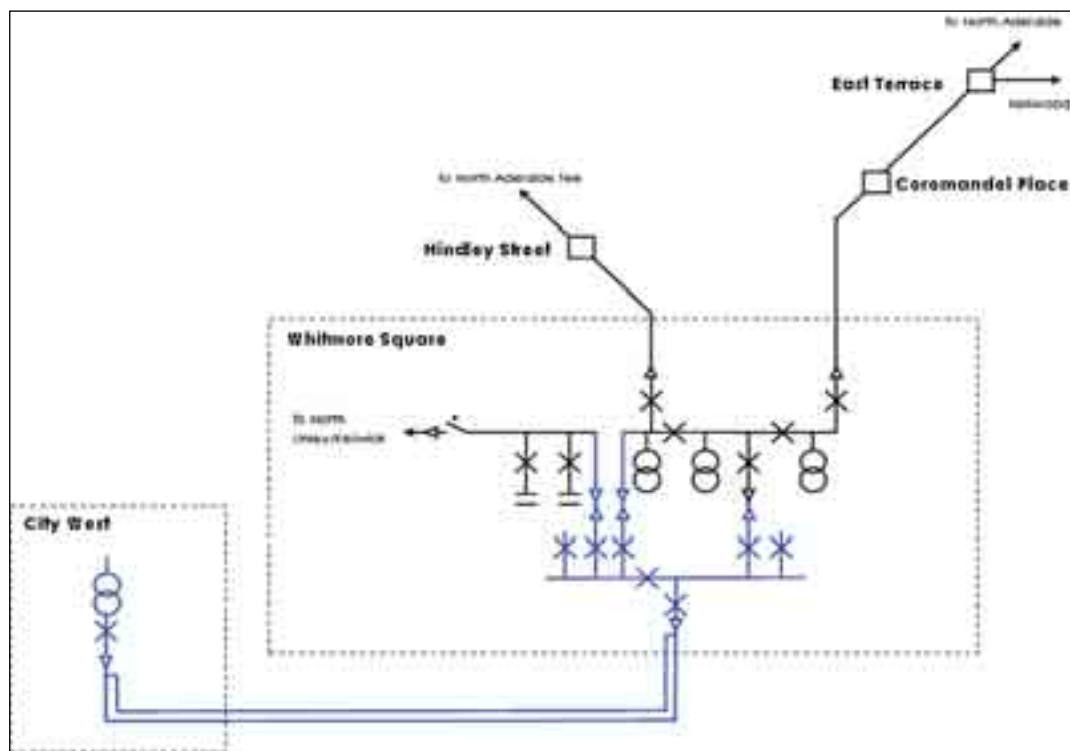
Figure 20: Proposed connection from City West substation to the existing 66kV Adelaide Central network

8.7 Scope of Work for Selected Option

The Preliminary Single Line Diagram (Figure 18) and the Preliminary Equipment Layout drawing (Figure 19) reflect the works proposed at City West Substation as part of this project.

The ElectraNet scope of works is as follows:

- Provide all project management activities associated with the delivery of the total scope of works;

- Obtain all required approvals; and

At the City West site:

- Establishment of a new substation, including associated infrastructure;

- Design, procurement and construction of indoor 275kV double busbar gas insulated switchgear (GIS) comprising 1x 275 kV incoming cable feeder bay, 1x 275kV switchable shunt reactor bay, 1x 275/66 kV transformer bay and 1x 275kV bus coupler bay;

- Design, procurement and installation of a 275/66 kV 300MVA transformer;

- Design, procurement and installation of 1x 275kV switchable shunt reactor;

- Design, procurement and installation of a 66 kV feeder bay;

- Design and construction of all earthworks and civil works for the site ;

- Design, supply and installation of auxiliary supply systems;

- Design, supply and installation of secondary systems and tele-communications; and

At Torrens Island Power Station (TIPS):

- Design, procurement and construction of bay B1 at TIPS B for a 275kV cable exit. Bay equipment to include circuit breaker, current transformers, voltage transformers, disconnectors, earth switches, cable sealing ends and all associated secondary systems;

- design, procurement and construction of a 275kV switchable reactor shunted to the cable exit.

Between City West site and TIPS:

- design, procurement and construction of approximately 18km of 275kV underground cable from TIPS B to City West Substation, including condition monitoring and Distributed Temperature Sensing equipment.

ElectraNet's capital costs associated with the above scope of works is $216.5m.

The ETSA Utilities' scope of work for integrating the new 66kV connection into the existing Adelaide central Region network is as follows:

- Provide a high capacity 66kV underground cable link from ElectraNet's City West substation at Keswick to ETSA Utilities' existing Whitmore Square distribution substation in the CBD. The cable link will be rated at 300MVA to match ElectraNet's transformer and will consist of two 66kV XLPE cables per phase;

- Establish a new 300MVA indoor 66kV GIS bus at Whitmore square consisting of one section circuit breaker and 5 exits;

- Connect the new 66kV bus at Whitmore Square to the existing Whitmore Square 66kV bus bars and exits by underground cables;

- Upgrade the Whitmore Square earth grid, general infrastructure, protection, telecommunications and supervision systems to manage the new connections and increased capacity and power system fault levels; and

- Upgrade the associated Distribution substations in the CBD to manage the increased capacity and power system fault levels.

ETSA Utilities' capital costs for the above scope of works is $65m.

8.8 Construction Timetable and Commissioning Date

The target construction and commissioning program for the remainder of the work associated with the establishment of the new City West Substation and associated infrastructure is as follows:

- Lodgement of development application - July 2009

- Civil works for Transmission line to commence April 2010

- Civil works for Substation to commence July 2010

- Delivery of transformers by March 2011

- Phased delivery of cable to be completed by April 2011

- Transformers pre-commissioned May 2011

- Cable installation and commissioning complete October 2011

- Substation commissioning November-December 2011

- New large transmission network asset commercially available by 31 December 2011.

8.9   Compliance with Service Obligations

Section 4 sets out the service obligations related to the proposed new large network asset for the Adelaide Central region. The following contingency analysis demonstrates that the proposed development meets the continuous N-1 transmission line and transformer capacity requirements of the ETC not only from 31 December 2011, but over the entire 15-year study period (refer to the network development diagram in Figure 6).

Note that the contingencies considered are worst case contingencies; i.e. they occur immediately prior to the implementations of the next phase of the staged network development which will address those N-1 emerging limitations in the following year.

- Loss of a City West ACR #1 transformer: Immediately prior to the installation of the second transformer at East Terrace in 2016/17, the ACR load will be 269MV.A. ElectraNet has undertaken a design review of the current East Terrace transformer and plans to adopt a cyclic rating of 270 MV.A for that transformer. With the loss of the City West ACR #1 transformer, the entire ACR load can be supplied via the single East Terrace transformer.

- Loss of East Terrace transformer(s) or loss of Magill to East Terrace 275 kV cable: By the year 2024/25, and immediately prior to the installation of the second TIPS to City West cable and the #2 ACR Transformer at City West, the load in the ACR will be 330 MV.A. At that time, East Terrace will have 2 transformers installed, each with a cyclic rating of no less than 270 MV.A. City West will still have only one ACR transformer installed with a cyclic rating of 360 MV.A. With the loss of either a transformer at East Terrace, or (worst contingency) the loss of the Magill to East Terrace cable, this load can be supplied from the City West substation via the ACR # 1 transformer.

- Loss of SIM transformer at City West: By the year 2022/23 and immediately prior to the installation of the second SIM transformer at City West, the combined SIM load will be 1025 MV.A. At that stage the load will be supplied by 3 x 180 MV.A transformers at Happy Valley, 2 x 225 MV.A transformers at Morphett Vale East, 1 x 225 MV.A at Magill and 1 x 360 MV.A at City West, a total installed transformer capacity of 1 575 MV.A. The worse contingency for the SIM region will be the loss of the SIM transformer at City West (360 MV.A). The remaining transformer capacity will then be 1215 MV.A, which is sufficient to supply the load.

- Loss of TIPS – City West Cable: Between the years 2022/23, after the installation of the Western Suburbs transformer at City West, and 2025/26 when the second TIPS – ACR cable will be installed, this contingency will result in the simultaneous loss of three 360 MV.A transformers at City West substation. As each of these transformers supply a separate load region, the N-1 contingency will be dealt with by the remaining 275/66kV transformers in each of those load regions.

In order to meet the requirement of the ETC to restore transmission line capacity within 4 hours of an interruption on a best endeavours basis, the underlying supply capability of the distribution network will be utilised. In the event that a source of transmission supply to the Adelaide Central region should be lost through a credible contingency event, it will thereby be possible to restore N-1 equivalent transmission

line capacity within 4 hours for a large proportion of the time through the distribution network, for all but extreme peak demands. This distribution network support would occur automatically.

However, it should be noted that even during times of extreme peak demand, there would be no expected loss of load following a single transmission outage event. Only in the event of multiple simultaneous outages at times of peak demand would loss of load become likely. In such circumstances, the coverage of load can be improved by switching within the distribution network to minimise any interruption to supply.

The proposed development therefore satisfies both the transmission line capacity requirements of the ETC, and best endeavours capacity restoration requirements following an interruption.

9.   Scenarios Considered

9.1   Context for Evaluation of Options

All feasible options to meet the identified supply requirements have been viewed in the context of wider developments in the NEM. ElectraNet is not aware of any inter-state or intra-state transmission network augmentations that will impact the ETC requirement to increase supply reliability to the Adelaide Central region.

9.2   Assumed Market Development Scenarios

The Regulatory Test for reliability augmentations requires that options to address network requirements be assessed against a number of reasonable market development scenarios. Those scenarios need to consider:

- The existing network;

- Future network developments;

- Variations in load growth;

- Committed generation and demand side developments; and

- Potential generation and demand side developments.

The purpose of this approach is to test the present value of the costs of the options being evaluated under a range of plausible scenarios.

9.2.1   Existing Network and Future Transmission Development

Existing and future network developments that have the potential to impact supply arrangements to the Adelaide Central region have been included as anticipated projects in the underlying analysis. Relevant future network developments are discussed in Section 8.1 of this report.

9.2.2   Variations in Demand Growth

The forecast demand growth used in this assessment was based on medium economic growth and hot weather forecasts (10% Probability of Exceedance, or PoE) for electricity demand. Use of 10% PoE weather forecasts is consistent with good electricity industry practice when planning the backbone 275kV transmission network.

Medium demand growth of 2.3% per annum was used as input to the analysis. However, scenarios assuming both high (4%) and low (1%) demand growth were also considered to ensure the robustness of the analysis to changes in the demand forecast.

The forecasts include all known information about existing and planned demand-side management initiatives, and include independent forecasts of existing and planned local embedded generation.

9.2.3   Existing and Committed Generators and Demand Side Developments

The public consultation undertaken as part of the RFI process confirmed that there are no committed generators proposing establishment in the Adelaide metropolitan region in the foreseeable future. For that reason, no scenarios have been developed in which the output of existing or committed generators is increased. Any demand-side management initiatives will not impact the mandated reliability of supply requirements for the Adelaide Central region, but merely reduce peak demand.

9.2.4   Potential New Generation

Neither ElectraNet nor ETSA Utilities are aware of any potential new local generation proposals that will impact supply to the Adelaide Central region. Committed generation facility expansion in the vicinity of the main generation node to the north-west near Torrens Island is progressing, but will not impact on the N-1 capability of the existing supply to the Adelaide Central region.

As electricity demand continues to grow, it is forecast that more additional generation will be required within the South Australian region. It has been assumed for the purposes of the planning studies examining future supply requirements to the Adelaide Central and metropolitan areas that, although entry of new generation will occur in the foreseeable future to meet the increasing electricity demand, that new generation plant will be located such that its direct impact on the Adelaide Central region will be immaterial. The increasing penetration of wind-generation, which will gradually displace fossil-fuel based generation, supports this assumption.

10. Format and Inputs to Analysis

10.1 Regulatory Test Requirements

The requirements for the comparison of options to address future supply needs are contained in the Regulatory Test[8]. The Regulatory Test requires that, for reliability augmentations, the recommended option be the option that "minimises the present value of costs, compared with a number of alternative options in a majority of reasonable scenarios".

The Regulatory Test contains guidelines for the methodology to be used to identify the lowest cost option. Information to be considered includes construction, operating and maintenance costs, and the cost of complying with existing and anticipated laws and regulations. However, the Regulatory Test specifically excludes indirect costs and costs that cannot be measured as a cost in terms of financial transactions in the electricity market.

10.2 Inputs to Analysis

A solution to address future supply requirements in the Adelaide Central region as outlined in this document is required to satisfy increased reliability standards specified in the July 2008 ETC.

According to the Regulatory Test, this means that the present value (PV) costs of all options must be compared, and the least cost solution is considered to satisfy the Regulatory Test. The results of that evaluation, carried out using a discounted cash flow model to determine the PV cost of the four options, are summarised in Section 7.4.

Cost inputs to the economic analysis are described below.

10.3 Cost of Network Augmentations

The economic analysis considers all foreseeable cost impacts of the proposed network augmentations to market participants.

The comparative capital cost to implement each of the feasible options outlined in Chapter 7 has been estimated by ElectraNet and ETSA Utilities based on a conceptual scope of works. Sensitivity studies have been carried out using variations in the capital cost estimates of plus and minus 20%.

10.4 Other Inputs to Analysis

The economic analysis of options includes the costs of anticipated future projects that will be needed to maintain the required reliability standards for the Adelaide Central region during the fifteen-year period following commissioning of the substation, as mentioned previously in this report.

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[8] ElectraNet is required to evaluate solutions for new transmission developments under the Regulatory Test in accordance with clause 5.6 of the NER.

For example, the Hindley Street 66kV substation will have to be rebuilt when an additional 66kV cable is connected to the substation since the accompanying increase in fault level will exceed the existing equipment's capability. That cable, which will connect between East Terrace and Hindley Street substations, will only be required after the second transformer is installed at East Terrace substation in about 2016, when the forecast load on that substation under contingency conditions will exceed the 270MV.A emergency rating of the existing transformer. The rebuilding of Hindley Street substation and the establishment of the new cable between East Terrace and Hindley Street, which will be completed in 2019, is estimated to cost $54m.

For the Rail Yards option, Hindley Street substation will have to be rebuilt in 2011, rather than 2019, to enable the new 66kV supply point to be connected into the existing network. That cost (estimated to be $24.7m) has consequently been brought forward in the financial present value cost calculations when performing the Regulatory Test, for those permutations involving establishing the new substation at the northern Rail Yards.

Timings for anticipated projects are based on meeting future electricity supply requirements for the Adelaide Central region using demand forecasts prepared by ETSA Utilities in April 2008 and published in ElectraNet's Annual Planning Report 2008. Actual timings of the anticipated projects may change as a result of future changes to demand forecasts for the Adelaide Central and metropolitan regions of Adelaide, and other market developments, during the 15-year planning horizon.

The sensitivity of the economic analysis to changes in the timing of those anticipated projects and therefore the timing of the capital expenditure, has been included in the analysis to ensure that the findings are robust.

10.5   Consideration of SIM 2 costs

As part of the initial establishment of the City West substation, ElectraNet and ETSA Utilities will also install a second 300MV.A 275kV transformer and associated switchgear at City West substation for the sole purpose of providing an additional 66kV injection point into the northern portion of ETSA Utilities' southern suburbs 66kV network.

Differentiating costs associated with installing the functionality of that second transformer have been *included* in the NPV calculations for all options, but have been *excluded* from the capital costs of the Adelaide Central reinforcement project.

The additional southern suburbs connection point ('SIM II') is the subject of a separate consultation that was undertaken by ETSA Utilities and ElectraNet. Analysis has shown that the installation of a new 300MV.A 275/66kV transformer dedicated to supplying the southern suburbs meshed connection point (presently supplied by Morphett Vale East and Happy Valley substations), and located at the same site as the proposed City West 275/66kV substation, is the most viable and least cost solution.

Evaluation of options has demonstrated that a comparable distribution or generation solution would be both less reliable and more expensive than the preferred solution. Those findings were published on 16 November 2007 in a joint Evaluation Report RFP-ER 002/06 which discussed reinforcement options to address projected network constraints described in RFI/RFP 002/06.

11. Economic Analysis

11.1 Inputs to Analysis

Economic analysis has been undertaken over a fifteen year period. The analysis takes into account the total capital cost of implementing each of the options as well as the costs of any progressive augmentations that would be required during the fifteen year period from the 2011/12 commissioning date to 2026/27, for each option.

The "Regulatory Test for reliability augmentations" has been used to identify the recommended option. That test compares the present value of each of the options over the fifteen year analysis period and under a range of feasible scenarios.

The Regulatory Test requires that the recommended option have the lowest present value cost to market participants when considered under a range of assumed scenarios in a majority of cases.

An 8.5% discount rate was used in the analysis. Sensitivity analysis using alternative discount rates of 6% and 10% was also undertaken.

Similarly, the $36/MW.h cost of losses figure that is currently used in the NEM, and that was used in the Regulatory Test analysis, was also subject to sensitivity analysis at $20/MW.h and $50/MW.h.

In addition to examining the impact of a range of reasonable scenarios, as required by the Rules, the sensitivity of the option-ranking to other critical parameters was also examined. Table 9 shows the parameters that were investigated in the sensitivity analysis, the range over which they were varied, and the resulting ranking of the options when subjected to those variations.

Parameter	Range over which the parameter was varied	Option 1 Supply from TIPS		Option 2 Kilburn by pass		Option 3 Supply from Happy Valley		Option 4 Supply from Magill	
		Present Value Cost	Rank	Present Value Cost	Rank	Present Value Cost	Rank	Present Value Cost	Rank
Demand growth rate	low	$335	1	$371	3	$387	4	$370	2
	medium	$322	1	$362	3	$374	4	$357	2
	high	$315	1	$360	3	$367	4	$350	2
Capital cost	80%	$261	1	$294	3	$303	4	$290	2
	100%	$322	1	$362	3	$374	4	$357	2
	120%	$382	1	$431	3	$444	4	$424	2
Discount rate	6%	$380	1	$427	3	$441	4	$421	2
	8.5%	$322	1	$362	3	$374	4	$357	2
	10%	$293	1	$330	3	$341	4	$325	2
Cost of losses ($MW.h)	$20	$313	1	$353	3	$365	4	$348	2
	$36	$322	1	$362	3	$374	4	$357	2
	$50	$329	1	$370	3	$381	4	$365	2

Table 9: Sensitivity analysis of supply options to City West Substation

As can be seen from the results of the economic analysis provided in Table 9, Option 1 has the lowest present value cost under all of the scenarios considered including those with changes to key variables.

On the basis of the economic analysis including sensitivity testing, Option 1 is the option that satisfies the Regulatory Test.

11.2   Inter-network Impact

Both ElectraNet and ETSA Utilities are required under the NER to assess whether a new large transmission network asset is reasonably likely to have a material inter-network impact. The proposed new large network asset will not impose power transfer constraints nor adversely impact the quality of supply within adjacent networks.

12.   Summary and Conclusions

The following summary and conclusions have been drawn from the analysis presented in this report:

- The augmentation proposed in this final report is defined as a 'reliability augmentation' under the NER as it is required to meet an increased reliability standard for the Adelaide Central region specified in the July 2008 ETC.

- There is no acceptable 'do-nothing' option as ElectraNet is required to meet the new ETC reliability standard for the Adelaide Central Region.

- ElectraNet and ETSA Utilities issued a joint RFI/ RFP paper in October 2006 that invited comment and submissions on the projected limitations that would impact the Adelaide Central region, to which no responses were received.

- Planning studies were undertaken to evaluate potential network options that would satisfy the ETC requirements, from which twelve viable options were identified.

- Economic analysis carried out in accordance with the Regulatory Test has identified that establishing a new substation adjacent the south-western corner of the Adelaide Central region and supplying that substation from TIPS switchyard directly via an underground cable essentially along a Port Road corridor as the least-cost solution over the 15 plus-year period of the analysis in all of the credible scenarios considered.

- Sensitivity studies have demonstrated that the results of the economic analysis are robust to variations in capital cost and other key factors.

The preferred option is, therefore, considered to satisfy the Regulatory Test.

13. Recommendation

Based on the conclusions drawn from the preceding analysis, it is recommended that the following actions be taken to address the future increased supply reliability requirements for the Adelaide Central region, required to be achieved by 31 December 2011:

- ElectraNet to establish at Lot 500, 1 Richmond Road, Keswick a new double bus GIS substation comprising one 300MV.A 275/66kV transformer dedicated to the provision, of N-1 continuous transformer capacity to the Adelaide Central region, in conjunction with the single 225MV.A 275/66kV transformer at the existing East Terrace substation ;

- ElectraNet to provide 275kV supply to the new substation from TIPS 275kV switchyard via approximately 17 kilometres of underground cable rated at 750MV.A continuous cyclic capacity;

- ETSA Utilities to establish a new 66kV GIS bus at Whitmore Square comprising one section breaker and 5 exits and tie this new bus to the existing 66kV bus; and

- ETSA Utilities to provide a 300MVA capacity 66kV underground connection from ElectraNet's City West substation to ETSA Utilities' existing 66kV Whitmore Square substation in the CBD, and modify the distribution network to manage the increased capacity;

at a total estimated cost of $281.5m, of which $216.5m will be attributable to ElectraNet's portion of the required works, and $65.0m to ETSA Utilities[9].

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[9] The estimated project costs vary from the initial capital cost estimates included in the economic analysis summarised in Section 7.4 because they exclude the costs of the 'SIM II' project but include the costs common to all options that were excluded from the NPV analysis.

14. Consultation

The Request for Information/ Request for Proposals paper titled "Projected network limitations, Adelaide Central Region, South Australia" was issued in accordance with the NER and ESCOSA Guideline 12 requirements. No submissions from stakeholders were received in response to this paper.

That paper was subsequently followed by the publishing of a joint application notice titled "Proposed new large network asset, Adelaide Central Region, South Australia" on 10 January 2008. Submissions to that paper closed on 27 February 2008. One submission from the ESIPC was received in response to the application notice. Responses to the issues raised within that submission have been addressed through the inclusion of the additional information contained in this report in accordance with clause 5.6.6(h) of the NER.

The options that have been considered in this report have been subjected to the Regulatory Test for reliability augmentations promulgated by the AER as required under both the NER and ESCOSA Guideline 12. Based on the results contained within this report, and given that the submission received in response to the application notice did not materially alter the findings contained within the application notice, the requirements of the NER and Guideline 12 have been met, and ElectraNet and ETSA Utilities are now in a position to make their investment decision.

In accordance with NER requirements, Registered Participants, the AEMC, Connection Applicants, Intending Participants, NEMMCO (AEMO) and interested parties may, by a referral to the AER, dispute this final report but only in relation to its contents, assumptions, findings or recommendations with respect to certain matters set out in clause 5.6.6(j).

A person disputing this final report under clause 5.6.6(j) must:

- Lodge notice of the dispute in writing (the dispute notice) with the AER;

- Give a copy of the dispute notice to ElectraNet and ETSA Utilities within 30 business days after publication of the summary of this final report on NEMMCO's (AEMO's) website; and

- Specify in the dispute notice the grounds for the dispute in accordance with clause 5.6.6(j).

The AER must resolve any disputes referred under clause 5.6.6(j) by making a determination.

Following the 30 business day period referred to above, the Regulatory Test consultation process will have concluded (subject to any disputes) and ElectraNet and ETSA Utilities will proceed to implement the proposed new large transmission network asset.

Please address any correspondence to:

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15. Glossary

Adelaide Central	That area of Adelaide which is located east of West Terrace, north of South Terrace, west of East Terrace, and south of the River Torrens.
AEMO	Australian Energy Market Operator
AIS	Air Insulated Switchgear
AER	Australian Energy Regulator
AMD	Agreed Maximum Demand – for a connection point or a group of connection points, it is the demand specified as such in the connection agreement between ElectraNet and the relevant transmission customers or ETSA Utilities.
Application Notice	A notice made available to Registered Participants and Interested Parties pursuant to clause 5.6.6 of the Rules
Distribution Code – EDC	South Australian Electricity Distribution Code – as issued by ESCOSA
DNSP	Distribution Network Service Provider
ElectraNet	ElectraNet is the principal transmission network service provider in South Australia. It is a privately owned company that has a long term lease for the operation, maintenance, and development of the South Australian transmission system which comprises plant and equipment mainly operating at voltages of 132 kV and above. ElectraNet is registered with NEMMCO (AEMO) as a Transmission Network Service Provider (TNSP)
Equivalent Transformer Capacity	Capacity to transform energy to meet demand using means including, but not limited to:
	transmission system capability; and
	network support arrangements,
	as defined in the ESCOSA Electricity Transmission Code.
ESCOSA	Essential Services Commission of South Australia established under the Essential Services Commission Act 2002
ESIPC	Electricity Supply Industry Planning Council
ETC	South Australian Electricity Transmission Code issued by ESCOSA
ETSA Utilities	ETSA Utilities is South Australia's principal Distribution Network Service Provider (DNSP), and is responsible for the distribution of electricity to all distribution grid connected customers within the State under a regulatory framework. ETSA Utilities is a

	partnership of Cheung Kong Infrastructure Holdings Ltd (CKI), Hong Kong Electric International Ltd (HEI), and Spark Infrastructure
GIS	Gas Insulated Switchgear
Guideline 12 (GL 12)	ESCOSA Electricity Industry Guideline 12 – Demand Management for Electricity Distribution Networks
HIS	Hybrid Insulated Switchgear
Market Participant	A person who has registered with NEMMCO (AEMO) as a Market Generator, Market Customer or Market Network Service Provider under Chapter 2
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company Limited
NER	National Electricity Rules
NPV	Net Present Value
Registered Participant	A person who is registered with NEMMCO (AEMO) as a Network Service Provider, a System Operator, a Network Operator, a Special Participant, a Generator, a Customer or a Market Participant
Regulatory Test	The test promulgated by the AER, which all major regulated network augmentation investments must comply with
RFI	Request for Information
RFP	Request for Proposals
Rules	National Electricity Rules (Rules) formerly the National Electricity Code (NEC)
TNSP	Transmission Network Service Provider
TUOS	Transmission Use of System charges applicable to Registered Participants in the NEM
WACC	Weighted Average Cost of Capital

Appendix A – Financial Analysis

Option 1: TIPS – City West

Scenario B				Medium load Growth														
			0 11/12	1 12/13	2 13/14	3 14/15	4 15/16	5 16/17	6 17/18	7 18/19	8 19/20	9 20/21	10 21/22	11 22/23	12 23/24	13 24/25	14 25/26	15 26/27
Option 1				**TIPS (cable)-Northern Rail Yards**														
TIPS (cable)-Northern Rail Yards		303.2571																
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
* WDV		303.2571	318.42	318.420	311.344	304.268	297.192	290.116	283.040	275.964	268.888	261.812	254.736	247.660	240.584	233.508	226.432	219.356
* Depreciation over		48		7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760	7.0760
* Opex		0.026		7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606	7.9606
* WACC		0.08555		27.075	26.474	25.872	25.270	24.669	24.067	23.465	22.864	22.262	21.660	21.059	20.457	19.855	19.254	18.652
=> TUOS				42.112	41.510	40.909	40.307	39.705	39.103	38.502	37.900	37.298	36.697	36.095	35.493	34.892	34.290	33.688
===> NPV of TUOS	$322.10																	
				318.420	7.430													
Install Western suburbs tfr at City West		84.7619																
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
* WDV		84.7619	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.000	87.846	85.869	83.891	81.913
* Depreciation over		48		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1637	1.9778	1.9778	1.9778	1.9778
* Opex		0.026		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2979	2.2250	2.2250	2.2250	2.2250
* WACC		0.08503		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.414	7.470	7.301	7.133	6.965
=> TUOS			0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.866	11.672	11.504	11.336	11.168
===> NPV of TUOS	$19.06																	
Install SIM III tfr at City West		93.33333																
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	19/20	20/21	21/22	22/23	23/24	24/25	25/26
* WDV		93.33333	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	99	96.72963	94.551852
* Depreciation over		48		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2704	2.1778	2.1778
* Opex		0.026		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4292	2.4500	2.4500
* WACC		0.08503		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.861	8.225	8.040
=> TUOS			0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.560	12.853	12.668
===> NPV of TUOS	$15.44																	
Install 2nd ACR tfr. TIPS-City West cable		74.9																
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
* WDV		74.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	78.670	77.650
* Depreciation over		48		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0198	1.7482
* Opex		2.5%		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1473	1.9668
* WACC		8.5%		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.902	6.603
=> TUOS			0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.069	10.318
===> NPV of TUOS	$4.07																	
Total TUOS per year				42.112	41.510	40.909	40.307	39.705	39.103	38.502	37.900	37.298	36.697	42.961	47.165	53.956	64.549	67.841
NPV of total TUOS	$355.58																	
Cost of Losses																		
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
Losses after implementation (MW)			0	22	24	25	26	28	29	31	33	35	37	39	41	43	45	47
Cost of Losses $			0	1.606	1.798	1.892	1.991	2.097	2.225	2.354	2.483	2.634	2.793	2.974	3.111	3.255	3.406	3.565
=> NPV of Cost of Losses	$19.52																	
Reliability Costs																		
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
			0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Reliability Costs	$0.00																	
Total for Option 1	**$375.09**																	

Option 1 (ctd.) : TIPS – Rail Yards

Option 1 (ctd.) : TIPS – Whitmore Square

Option 2 : Kilburn – City West

Option 2 (ctd.) : Kilburn – Rail Yards

Medium load Growth

Scenario B

Option 2 (ctd.) : Kilburn – Whitmore Square

Option 3 : Happy Valley – City West

Option 3 (ctd.) : Happy Valley – Rail Yards

Option 3 (ctd.) : Happy Valley – Whitmore Square

Scenario B

Medium load Growth

Option 4 : Magill – City West

Option 4 (ctd.) : Magill – Rail Yards

Option 4 (ctd.) : Magill – Whitmore Square