

Halcrow Pacific Pty Ltd

in association with

Albany Interactive Pty Ltd

January 2011



**Economic Regulation Authority
of Western Australia**

Inquiry into State Underground Power Program
Cost Benefit Study
- Technical Assessment
Final Report



Halcrow

Halcrow Pacific Pty Ltd

in association with

Albany Interactive Pty Ltd

January 2011

Economic Regulation Authority of Western Australia

Inquiry into State Underground Power Program
Cost Benefit Study
- Technical Assessment

Final Report

Halcrow Pacific Pty Ltd

Level 1, 542 Station Street, Box Hill, Melbourne, VIC 3128

Tel +61 3 9899 9777 Fax +61 3 9899 1214

Level 22, 68 Pitt Street, Sydney, NSW 2000

Tel +61 2 9250 9900 Fax +61 2 9241 2228

Level 19, 215 Adelaide Street, Brisbane, QLD, 4000

Tel +61 7 3169 2900 Fax +61 7 3169 2999

www.halcrow.com/australasia

Halcrow Pacific Pty Ltd has prepared this report in accordance with the instructions of their client, *Economic Regulation Authority* of Western Australia, for their sole and specific use. Any other persons who use any information contained herein do so at their own risk.

© Halcrow Pacific Pty Ltd 2011

Economic Regulation Authority of Western Australia

Inquiry into State Underground Power Program Cost Benefit Study

- Technical Assessment

Final Report

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Prepared by	Checked by	Authorised by
1	0	Draft Report	8 December 2010	DS/NH	JOS	JOS
2	0	Final Report	4 January 2011	DS/NH	JOS	JOS

Filename & Path:

W:\Project\Water\KMWKBV - ERA State Underground Power Review\JA_32 - Reports\KMWKBV
- Final Technical Report (Issue 2, Rev 0).Doc

Contents

List of Acronyms	iv
Executive Summary	I
1 Introduction	1
1.1 General	1
1.2 Background	1
1.3 Scope of Work	3
1.4 Review Methodology	4
1.5 Limitations	5
1.6 Documentation Provided for the Technical Assessment	6
1.7 Structure of this Report	8
2 State Underground Power Program	9
2.1 Overview	9
2.2 Context and Background of the SUPP	9
2.2.1 Establishment of the SUPP	9
2.2.2 SUPP goals and objectives	10
2.2.3 SUPP Governance and funding arrangements	10
2.3 What does the SUPP involve?	12
3 Reliability	13
3.1 Overview	13
3.2 What is Reliability?	13
3.2.1 General	13
3.2.2 Types of Interruptions	13
3.2.3 Reliability Measures	14
3.3 Reliability Characteristics of Overhead and Underground Systems	15
3.3.1 Overview	15
3.3.2 Overhead Systems	15
3.3.3 Maintainability of Overhead Systems	16
3.3.4 Underground Systems	16
3.3.5 Maintainability of Underground Systems.	17
3.3.6 Overall	17

3.4	<i>Analysis of Reliability Information Provided</i>	18
3.4.1	Overview	18
3.4.2	The City Beach Study	18
3.4.3	Round 3 SUPP Reliability Analysis	19
3.4.4	Overall Rate of Faults	21
3.4.5	Reliability and System Age	21
3.4.6	Accuracy of data	22
3.5	<i>Findings</i>	22
4	SUPP Selection Process	24
4.1	<i>Overview</i>	24
4.2	<i>Summary of SUPP Selection Process</i>	24
4.2.1	SUPP project selection process for Major Residential Projects	24
4.2.2	SUPP project selection process for Localised Enhancement Projects	29
4.2.3	Comments on selection processes	31
4.3	<i>Impact of Selection Process on SUPP Costs</i>	32
4.3.1	Overview	32
4.3.2	Construction cost competitiveness	33
4.3.3	Economies of scale	34
4.3.4	Successive roll-out of the SUPP	34
4.4	<i>Findings</i>	34
5	Assessment of SUPP Costs	36
5.1	<i>Overview</i>	36
5.2	<i>Examination of SUPP costs</i>	36
5.2.1	General	36
5.2.2	Project management costs	38
5.2.3	Material costs	39
5.2.4	Labour costs	41
5.2.5	Project cost omissions	42
5.3	<i>Comparison of Maintenance Costs</i>	43
5.3.1	Overview	43
5.3.2	Operating maintenance expenditure	43
5.3.3	Comparison of maintenance costs with other distribution businesses	45
5.4	<i>Findings</i>	46

6	Alternative Options	48
6.1	<i>Overview</i>	48
6.2	<i>Alternative Options to Meet the Objectives of the SUPP</i>	48
6.2.1	Alternative options	48
6.2.2	Undergrounding main feeders	49
6.2.3	Aerial bundled cable	49
6.2.4	Maintenance of existing overhead system	50
6.2.5	Pole to pillar – undergrounding of house service only	50
6.2.6	Hendrix spacer cable distribution system	50
6.3	<i>Findings</i>	51
7	Conclusions	52
7.1	<i>Overview</i>	52
7.2	<i>Reliability</i>	52
7.3	<i>SUPP Selection Process</i>	53
7.4	<i>Assessment of SUPP Costs</i>	53
7.4.1	Examination of SUPP costs	53
7.4.2	Comparison of maintenance costs	54
7.5	<i>Alternative Options</i>	54
Appendix A	Information Requested for Review	A-1
Appendix B	Information Provided for Review	B-1

List of Acronyms

CAIDI	Customer Average Interruption Duration Index (reliability measure)
CCTV	Closed Circuit Television
DFIS	Distribution Facilities Information System
EOI	Expression of Interest
ERA	Economic Regulation Authority
KPI	Key Performance Indicator
kV	Kilovolt
LEP	Localised Enhancement Project
MRP	Major Residential Project
MWh	Megawatt hour
SWIS	South West Interconnected System, ie. the power supply network operated and maintained by Western Power
SAIFI	System Average Interruption Frequency Index (reliability measure)
SAIDI	System Average Interruption Duration Index (reliability measure)

Executive Summary

Background

Halcrow Pacific Pty Ltd (Halcrow) has been engaged by the Economic Regulation Authority of Western Australia (the Authority) to undertake a Technical Assessment and provide technical advice on Western Power's reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the State Underground Power Program (SUPP). Halcrow is supported in providing these technical services by Albany Interactive Pty Ltd.

State Underground Power Program

The SUPP was established by the Western Australian State Government (the State Government) in 1996, following a severe storm event that caused widespread damage to the overhead electricity distribution network in Perth and surrounding regions in May 1994. The SUPP involves the retrospective undergrounding of Western Power's existing overhead distribution lines in residential areas and aims to:

- improve the energy security of Western Australia's electricity distribution system; and
- improve the standard of electricity supply to consumers by addressing reliability issues in areas with existing overhead power lines.

The SUPP is undertaken as a partnership between the State Government, Western Power and participating Local Government Authorities, and contributes to the State Government's broader objective of providing underground distribution power to 50 percent of residential properties in Perth by 2010, and more broadly, the long-term goal of improving the performance of the electrical distribution network.

Summary of Key Findings

This section collates the key findings of the Technical Assessment undertaken by Halcrow.

Reliability

Undergrounding generally results in improved reliability, expressed as lower SAIDI and SAIFI. Maintainability is normally reduced due to underground cables being harder to access for repair. This results in a higher value of CAIDI.

The reliability data presented by Western Power follows this pattern but gives superior results for reductions in SAIDI and SAIFI to those typically obtained. The probable reason for this is that the Western Power SUPP project involves the selection of older overhead areas with high SAIDI and replacing them with new underground systems. It is expected that the reliability of the underground system will deteriorate to some extent as it ages. However, it is expected that the improvement in reliability will be sustained over the average projected life of the underground systems.

Other positive factors are that improvements in the reliability of cables have occurred in recent years, and Western Power has developed particular expertise in cable selection and installation. In addition, improved reliability and safety in regard to storms, bushfires, danger from fallen wires and pole-top fires are significant factors favouring undergrounding.

SUPP Selection Process

The SUPP selection process has a range of potential impacts on cost efficiency. These impacts, which are also influenced by the level of Government/Western Power funding (ie. overall program funding), include:

- the ability to maintain cost competitiveness through continuity of work at an appropriate level;
- project size/economies of scale; and
- the successive roll-out of the program.

Western Power has indicated that if funding constraints were removed, and the selection process allowed for a successive roll-out of the SUPP, there is potential to reduce SUPP costs by approximately 15 to 20 percent.

Examination of SUPP Costs

A review of the Como East project budget indicates that, overall, the project management, material and labour cost components and cost estimates appear to be comprehensive and complete, and provide a reasonable and appropriate level of detail, allowing for rigorous analysis and review. Overall, there are no obvious omissions in relation to particular cost items, and that the cost estimates are

detailed and reflect what Halcrow would ordinarily expect for a project of this nature and scale.

The project cost estimates do not provide an indication of the level of future operations and maintenance expenditure saved through undergrounding the distribution network.

Comparison of Maintenance Costs

It was not possible to establish a cost per metre for overhead powerlines and underground cables with the limited information available. Western Power provided 2010-11 operating maintenance expenditure budgets for planned and unplanned maintenance of the overhead and underground distribution networks in the SWIS. In all instances (country, metro, SWIS-wide), planned and unplanned operating expenditure on the overhead distribution network is budgeted to be significantly greater than the underground distribution network.

This Technical Assessment did not allow for a detailed benchmarking exercise, however, a brief desktop review of a previous benchmarking study indicates that Western Power's past performance across a range of operating and maintenance expenditure measures has been in the top half (higher performing) of comparable distribution businesses. It is possible that the increasing size of Western Power's underground distribution network relative to the existing overhead network is a contributing factor to its performance relative to other distribution businesses

Alternative Options

A range of alternative options to meet the objectives of the SUPP were identified as part of this Technical Assessment. Each of the options provides an improvement in energy security and reliability, meeting a core objective of the SUPP. In many instances, these alternative options would be cheaper to retrospectively install, however, none of the alternative options identified as part of this Technical Assessment would provide the level of local amenity value as that achieved by the SUPP.

1 Introduction

1.1 *General*

The Economic Regulation Authority of Western Australia (ERA or the Authority), at the request of the Treasurer of Western Australia, is conducting an inquiry into the overall costs and benefits of the State Underground Power Program (SUPP). In accordance with the inquiry's Terms of Reference, the Authority is required to have regard to the costs of undergrounding the overhead electricity distribution network, compare the costs associated with maintaining the current distribution network with the costs of undergrounding, and determine the types of costs which are avoided as a result of undergrounding the overhead electricity distribution network.¹

The inquiry has been referred to the Authority under Section 32(1) of the *Economic Regulation Authority Act 2003*, which provides for the Treasurer to refer to the Authority inquiries on matters related to regulated industries (electricity, gas, rail and water).

Halcrow Pacific Pty Ltd (Halcrow) has been engaged by the Authority to undertake a Technical Assessment and provide technical advice on Western Power's reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the SUPP. Halcrow is supported in providing these technical services by Albany Interactive Pty Ltd.

1.2 *Background*

The SUPP was established by the Western Australian State Government (the State Government) in 1996, following a severe storm event that caused widespread damage to the overhead electricity distribution network in Perth and surrounding regions in May 1994.² During the May 1994 storm, winds peaked at 140 kilometres per hour during the 18 hour storm, causing two fatalities and approximately 20 injuries, and seriously damaging approximately 600 houses.³ The

¹ ERA, *Inquiry into State Underground Power Program Cost Benefit Study: Issues Paper*, 28 June 2010, pg1.

² Ibid, pg2.

³ Western Power, *Underground Power Program Review*, November 2008, pg3.

storm resulted in over 60,000 homes losing power and lead to significant commercial and industrial losses. Approximately 80 percent of the damage in the May 1994 storm was caused by falling trees.

The SUPP involves the retrospective undergrounding of Western Power's existing overhead distribution lines in residential areas. Local Governments submit proposals, or Expressions of Interest (EOIs), for areas they want to be undergrounded to the Underground Power Steering Committee (the Committee). The Committee evaluates the EOIs according to a set of publicly available evaluation guidelines and criteria, while a local survey of affected rate payers is conducted to gauge community support for undergrounding a specific area.

As part of the evaluation phase, the Committee identifies proposals that will be subjected to a more detailed evaluation process. Following on from this detailed evaluation, the Committee provides a list of recommended SUPP projects to the Minister for Energy for approval. The Ministerially approved projects are subsequently implemented by the SUPP group within Western Power.

The SUPP is undertaken as a partnership between the State Government, Western Power and participating Local Government Authorities, with funding shared 25 percent, 25 percent, and 50 percent respectively.⁴ The SUPP is contributing to the State Government's broader objective of providing underground distribution power to 50 percent of residential properties in Perth by 2010, and more broadly, the long-term goal of improving the performance of the electrical distribution network.

Since the SUPP began to replace existing overhead distribution lines with underground cables, a total of 65 projects have been completed and just over half of residential properties in the Perth metropolitan area are now serviced by underground power.⁵ A fourth round of projects is currently underway and is expected to be completed in 2011-12, with funding for a fifth round of projects being announced by the Minister for Energy in December 2009.

⁴ Western PowerIbid, pg1.

⁵ ERA, *Inquiry into State Underground Power Program Cost Benefit Study: Issues Paper*, 28 June 2010, pg2.

1.3

Scope of Work

Halcrow has been engaged to undertake a Technical Assessment and provide advice on Western Power's reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the SUPP.

Reliability Data

Halcrow is required to:

- examine and provide recommendations on the accuracy of Western Power's reliability data⁶ for areas with and without underground power, and, for areas undergrounded as part of the SUPP, the reliability data before and after the projects were completed; and
- review any other reliability information that Western Power has collected since the SUPP began in 1996.

Other Technical Information

Halcrow is required to:

- examine the costs that are currently included in the costs of the SUPP, and whether or not any costs that should be included are omitted or if any costs are included that should not be;
- review the impact that the existing selection process has on costs, given that projects are not undertaken in a successive manner; and
- establish Western Power's maintenance costs per metre of overhead power lines and underground cables, and if possible benchmark these costs with other distribution companies.

Alternative Options

Halcrow is required to identify any alternative options to meet the objectives of the SUPP, which may include the undergrounding of the first feeder section of distribution lines from zone substations. For the purposes of this assessment, it is noted that:

- the objectives of the Major Residential Projects, which account for around 96 percent of the costs of the SUPP, are to improve the energy security of Western Australia's distribution system in extreme weather events, as well as

⁶ SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index), and CAIDI (Customer Average Interruption Duration Index).

- the standard of electricity to supply to consumers during normal weather, by addressing reliability issues in areas with existing overhead power lines; and
- the objectives of Localised Enhancement Projects, which account for the remaining 4 percent of the SUPP costs, are to achieve efficient retrospective installation of underground power and significant contributions to local communities, including enhanced streetscapes and visual amenity of public places, improved property values and improved safety.⁷

1.4

Review Methodology

An inception meeting with the Authority, to review and confirm the requirements of the Technical Assessment and identify any areas of particular interest, was conducted (via telephone) on Friday, 24 September 2010.

Communication protocols were established at the inception meeting between the Authority and the Technical Assessment team to ensure efficient and transparent information transfer, and to foster an open and professional working relationship between all parties.

Halcrow developed a detailed information request prior to the commencement of interviews with Western Power to assist with the Technical Assessment. The information request outlined key areas of interest in relation to Western Power's reliability data, other technical information and alternative options and was provided to the Authority (for circulation to Western Power) on Thursday, 30 September 2010.

Halcrow attended meetings and presentations with representatives from Western Power over Monday, 18 and Tuesday, 19 October 2010 in Western Power's Fremantle and Perth-based offices. Representatives from Western Power included the SUPP Strategic Projects Manager, the Projects Delivery Manager, the Public Liaison Officer, the Program Planning Manager and the Project Development and Engineering Manager. The pre-prepared information request and meeting agenda was used as a guide to the meetings and presentations. There was an opportunity for the Technical Assessment team to ask additional questions and request further information where necessary.

A detailed review of the information collected prior to, during and subsequent to the discussions and meetings with Western Power has been undertaken to enable

⁷ ERA, *Inquiry into State Underground Power Program Cost Benefit Study: Scope of Work – Technical Consultant*, 26 August 2010.

Halcrow to form its views and provide advice to the Authority on Western Power’s reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the SUPP.

The Technical Assessment team for this project was made up of a team of experienced electrical and regulatory consultants coordinated by the Project Manager. The Technical Assessment team is outlined in **Figure 1.1**.

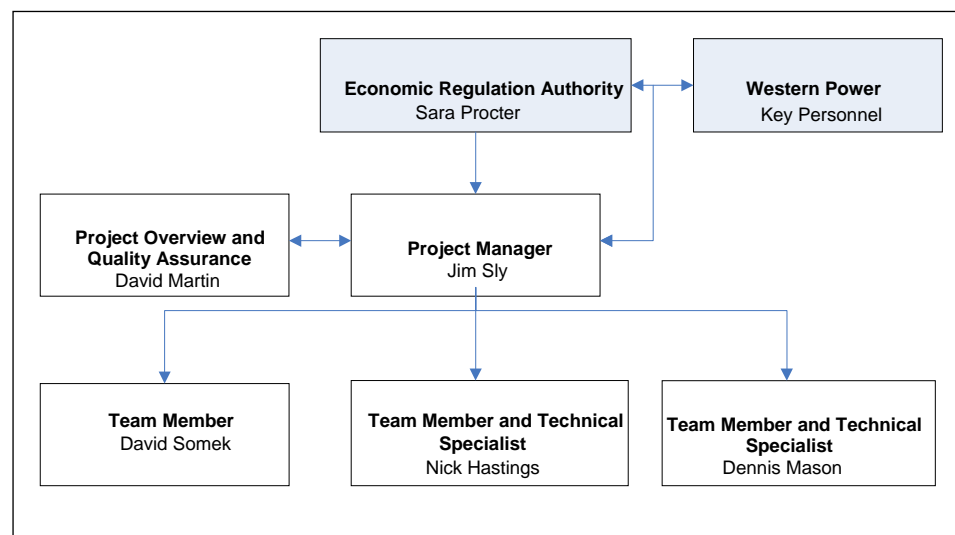


Figure 1.1 Technical Assessment Team Structure

1.5

Limitations

This report has been prepared for the Authority by Halcrow for the sole purpose of providing a Technical Assessment and advice on Western Power’s reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the SUPP. This report cannot be relied upon by any other party or used for any other purpose.

Halcrow’s assessment has been undertaken on the basis of information and material provided by the Authority, Western Power, meetings/discussions held with Western Power representatives and information provided by Western Power subsequent to those discussions.

1.6

Documentation Provided for the Technical Assessment

To assist with the Technical Assessment, Halcrow requested a range of information from Western Power in relation to areas of reliability, costs and alternative options to meet the objectives of the SUPP. This Information Request, submitted to Western Power on 30 September 2010, was informed by the Terms of Reference for this Technical Assessment and the Authority's Issues Paper.⁸ A list of the information requested as part of this Technical Assessment is presented in **Appendix A**.

In response to Halcrow's Information Request, and Halcrow's subsequent visit to Western Power's Perth and Fremantle-based offices on 18 and 19 October 2010, Western Power provided a range of information in relation to:

- underground and overhead power reliability data;
- the SUPP selection process;
- SUPP project costs;
- comparative operating maintenance expenditure data for underground and overhead distribution networks; and
- alternative options to meet the objectives of the SUPP.

A list of the information provided, and reviewed, for the purpose of this Technical Assessment is presented in **Appendix B**.

The information provided by Western Power in response to Halcrow's Information Request was in some respects limited in terms of detail and breadth. Consequently, Halcrow's ability to undertake a detailed examination of information and provide recommendations was to some degree constrained. For example:

- **Reliability data:** Halcrow requested a range of detailed reliability data relating to underground systems, including those projects installed prior to SUPP Round 3. It was not, however, possible to examine a range of historical reliability data as part of this Technical Assessment, primarily for two reasons. Firstly, data for projects in the Pilot study and early SUPP rounds was deemed (by Western Power) to be of limited use due to recognised problems associated with the "like with like" replacement basis adopted for these projects, subsequent improvements in cable reliability

⁸ Economic Regulation Authority, 2010. *Inquiry into State Underground Power Program Cost Benefit Study: Scope of Work – Technical Consultant*, and Economic Regulation Authority, 2010. *Inquiry into State Underground Power Program Cost Benefit Study: Issues Paper*.

performance and the fact that the data could not be geographically assigned to individual SUPP project areas (these issues are discussed in **Section 3.4.5**). Secondly, in view of their recent installation, there is insufficient data available in respect of SUPP Round 4 projects for comparative performance assessment (at least 24 months of data since completion is required). Consequently, Halcrow's examination of the accuracy of Western Power's reliability data was limited to projects installed no earlier than Round 3 of the SUPP.

- **Maintenance costs:** Halcrow requested detailed information in relation to planned and reactive maintenance costs for underground and overhead distribution systems. Western Power's network maintenance, refurbishment and replacement programs are, however, rolled out across the entire South West Interconnected System (SWIS) network and budgets/costs are not broken down on a more refined geographical basis. Consequently, the information provided by Western Power for the purposes of this Technical Assessment was high-level in nature and lacked detail. This has severely limited any attempt by Halcrow to undertake a detailed examination Western Power's maintenance costs for overhead powerlines and underground cables.
- **Alternative options:** Halcrow requested detailed information in relation to alternative options that could be considered to achieve the SUPP objectives. The information provided by Western Power in this respect was severely limited in detail, scope and analysis. This posed significant constraints on Halcrow's ability to undertake an examination, and provide a robust analysis of, possible alternative options.

In respect of **SUPP project costs**, Halcrow requested a detailed breakdown of all costs included in the SUPP costings, including (but not limited to) installation, operating, decommissioning of overhead powerlines and poles, and installation of the underground power cables. In response, Western Power provided a detailed SUPP project budget estimate for the Round 3 Como East SUPP project. The information provided in respect of this project was considered to be adequate for the purposes of this Technical Assessment, however, had additional time been available it may have been advantageous to have sought and analysed data for a second area to confirm the consistency of project costings. On this basis, Halcrow's examination of the costs included in the SUPP has been limited solely to the review of the Como East SUPP project.

1.7 *Structure of this Report*

This report discusses and presents Halcrow’s key findings and recommendations from the Technical Assessment of Western Power’s reliability data and other technical information associated with underground power, as well as consideration of alternative options to meet the objectives of the SUPP.

Section 1 provides a general introduction to the Authority’s inquiry into the SUPP and background on the SUPP, the scope of Halcrow engagement, and an overview of the review methodology adopted by Halcrow.

Section 2 provides an overview of the SUPP, including the context and background to the program and an overview of program scope.

Section 3 provides an examination of the accuracy of Western Power’s reliability data for areas with and without underground power, and, for areas undergrounded as part of the SUPP, the reliability data before and after the projects were completed.

Section 4 reviews the impact that the existing selection process has on costs, given that projects are not undertaken in a successive manner, and **Section 5** examines the appropriateness of costs that are included in, or omitted from, the SUPP.

Section 6 identifies and examines any alternative options that meet the objectives of the SUPP.

Finally, **Section 7** provides a summary of Halcrow’s conclusions and recommendations in relation to this Technical Assessment of reliability data, other technical information and alternative options to meet the objectives of the SUPP.

2 State Underground Power Program

2.1 *Overview*

This section provides a brief outline of the State Underground Power Program (SUPP), in particular outlining the drivers and objectives of the SUPP, the two streams which make up the SUPP, and the relevant funding arrangements of the program. An overview of technical components of the SUPP is also provided, for example what aspects of the existing overhead distribution power network is being replaced, and what it is being replaced with.

2.2 *Context and Background of the SUPP*

2.2.1 *Establishment of the SUPP*

The SUPP was established by the Western Australian State Government (the State Government) in 1996, following a severe storm event that cause widespread damage to the overhead electricity distribution network in Perth and surrounding regions in May 1994.⁹ The storm resulted in over 60,000 homes losing power and lead to significant commercial and industrial losses. Approximately 80 percent of the damage in the May 1994 storm was caused by falling trees.

The State Government recognised that the installation of power cables underground resulted in improved security of energy supply in severe weather conditions. Planning rules were subsequently changed to require underground power for all new developments, and the SUPP was established to retrospectively replace the existing overhead distribution network with underground power cables.

Since inception of the SUPP, 65 Major Residential Projects (MRPs) have been completed, providing underground distribution systems to over 70,000 homes, at a cost of approximately \$246 million (nominally).¹⁰

⁹ Economic Regulation Authority, 2010. *Inquiry into State Underground Power Program Cost Benefit Study: Issues Paper*.

¹⁰ See: www.energy.wa.gov.au

2.2.2

SUPP goals and objectives

The overall goals of the SUPP are to:¹¹

- improve the energy security of Western Australia's electricity distribution system; and
- improve the standard of electricity supply to consumers by addressing reliability issues in areas with existing overhead power lines.

Consistent with these overall goals, the Government's aim has been to provide underground power to 50 percent of residential properties in Perth by 2010, with a corresponding improvement in regional towns.¹²

The SUPP contributes towards achieving its goals through two project streams:¹³

- Major Residential Projects (MRPs): projects that aim to improve power system reliability through the replacement of overhead distribution lines and service connections with underground power cable in residential areas; and
- Localised Enhancement Projects (LEPs): projects that aim to beautify streetscapes, urban gateways and traffic routes of significance that are recognised as having scenic, tourism and/or heritage value. LEPs aim to provide improved local area amenity only and result in little or no reliability improvement.

Aside from the objectives of the Government, the SUPP also addresses the needs of the broader community who are concerned with the visual appearance, environmental impact and safety of an over head power system.¹⁴

2.2.3

SUPP Governance and funding arrangements

The SUPP is undertaken as a partnership and jointly funded by the State Government, Western Power and participating Local Government Authorities. The management of the SUPP is overseen by a Steering Committee, which is chaired by the Office of Energy and is comprised of representatives from Western Power and the Western Australian Local Government Association.

¹¹ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*.

¹² Western Power, *Underground Power Program Review*, November 2008, pg3.

¹³ Western Power Ibid.

¹⁴ Ibid.

The relationship between these parties, the Steering Committee, the SUPP group within Western Power, and other contributors to the SUPP are illustrated by **Figure 2.1**.¹⁵

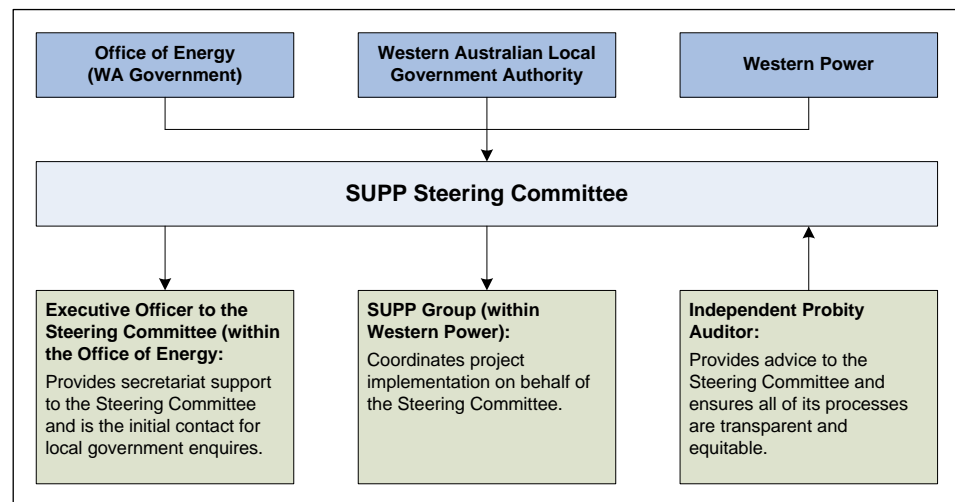


Figure 2.1 SUPP governance arrangements

The primary objectives of the SUPP Steering Committee (the Committee) are to achieve¹⁶:

- efficient retrospective installation of underground power, contributing to improved power system reliability and cost savings in terms of maintenance and reduced distribution losses; and
- significant contributions to local communities, including enhanced streetscapes and visual amenity of public places, improved property values and improved safety.

The funding of SUPP projects is shared by the State Government, Western Power and participating Local Government Authorities, with funding split 25 percent, 25 percent and 50 percent respectively. In low socio-economic areas, the Local Government funding contribution is reduced from 50 percent to 35 percent. Of the \$20 million annual SUPP budget, approximately 96 percent is attributable to MRPs, with the remainder for LEPs.

¹⁵ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*, pg2.

¹⁶ Western Power, *Underground Power Program Review*, November 2008, pg4.

SUPP projects (both MRPs and LEPs) involve Local Governments submitting Expressions of Interest (EOIs) proposals, for areas they want to be undergrounded, to the Underground Power Steering Committee (the Committee). The Committee evaluates the EOI proposals according to a set of publicly available evaluation guidelines and criteria, while a local survey of affected rate payers is conducted to gauge community support for undergrounding a specific area.

As part of the evaluation phase, the Committee identifies proposals (based on a range of technical and non-technical criteria) that will be subjected to a more detailed evaluation process. Following on from this detailed evaluation, the Committee provides a list of recommended SUPP projects to the Minister for Energy for approval. The Ministerially approved projects are subsequently implemented by the SUPP group within Western Power. A detailed overview and discussion of the SUPP selection process is presented in **Section 4**.

2.3

What does the SUPP involve?

The SUPP involves the replacement of existing overhead distribution lines with underground power cables in residential areas. In summary, this involves the following:¹⁷

- laying of the new distribution network power cables in the ground (usually in the road verge) by use of directional drilling or underground boring machine;
- installation of mini pillars/customer service pits (green domes);
- installation of transformers and switchgear in the road verge and in public open spaces (where approval has been granted);
- running an underground connection from the mini pillars to the individual property meter boxes (service connection);
- upgrading of meter boxes from single-phase to three-phase (if required). This work is in addition to the SUPP works, and may involve the property owner paying an additional charge for this work;
- installation of new streetlight poles; and
- decommissioning and removal of existing wooden poles and overhead distribution lines (excluding transmission lines and poles).

¹⁷ Town of Vincent, 2006. *General Information on the State Underground Power Program*, pg2-3.

3 Reliability

3.1 *Overview*

This section provides an outline of the terms in which the reliability of distribution systems is measured. The term ‘reliability’ is used in a general sense to include measures that relate to reliability in the sense of failure frequency and to system availability and maintainability.

The reliability characteristics of overhead and underground systems are discussed as background prior to considering the specifics of the SUPP project. The reliability data provided by Western Power is then summarised and discussed and conclusions are drawn.

3.2 *What is Reliability?*

3.2.1 *General*

The operational aim of an electricity distribution system is to make electricity available to consumers. In order to specify and compare reliability there is a need to identify in detail how reliability is measured. The background to this is contained in IEEE Standard 1366-2003¹⁸. Because the supply is highly reliable, the measures work in terms of unreliability. Unreliability occurs when supply fails, the failure events being referred to as ‘interruptions’.

3.2.2 *Types of Interruptions*

3.2.2.1 *Momentary Interruptions*

Momentary interruptions are interruptions of duration less than one minute. These interruptions, though undesirable, are disregarded in the standard measuring processes and in the Western Power reliability analysis.

3.2.2.2 *Sustained Interruptions*

These are interruptions of duration longer than one minute.

¹⁸ Institution of Electrical and Electronic Engineers, IEEE Standard 1366-2003, *Guide to Electric Power Distribution Reliability Indices*.

3.2.2.3

Major Events

An issue in measuring system reliability is the occurrence of ‘Major Events’. Major Events are events such as a large storm or a bush fire which causes more and longer interruptions than occur in the normal routine data. If the reliability of two systems is being compared and one is subject to a major event and the other is not, then the existence of the major event will dominate the comparison.

IEEE Standard 1366-2003 gives a statistical method for identifying ‘Major Event Days’ and this standard is adopted by Western Power. Comparisons under the standard normally exclude Major Event Days, however, Major Events cannot be entirely disregarded as a key driver for the change from overhead to underground power is to enable the system to better resist Major Events, particularly storm events. Because response to storms is an issue, some of Western Power’s data includes Major Events and some excludes them. This point is discussed further in relation to particular analyses.

3.2.3

Reliability Measures

The following measures are defined in the IEEE standard:

- System Average Interruption Frequency Index (SAIFI) – this is the average number of interruptions per customer per year (or other time period). The SAIFI measures the rate of interruptions and the larger the SAIFI, the lower the reliability.
- System Average Interruption Duration Index (SAIDI) – this is the average number of minutes lost to interruptions per customer per year. This is a measure of the unavailability of supply. The larger the SAIDI the lower the reliability.¹⁹
- Customer Average Interruption Duration Index (CAIDI) – this is the average duration of interruptions experienced by those customers that experience an interruption. This is a measure of maintainability. The larger the CAIDI the worse the maintainability.

Collectively, SAIDI, SAIFI and CAIDI are referred to as the Key Performance Indicators (KPIs) of system reliability.

¹⁹ Note that customers who have no interruptions are taken into account in the averaging process in the SAIDI and SAIFI measures.

3.3 Reliability Characteristics of Overhead and Underground Systems

3.3.1 Overview

Western Power has provided information in respect of failure causes for both overhead and underground systems²⁰. Both types of systems are subject to the occurrence of electrical faults in conductors, insulators and other electrical hardware. In addition, the following considerations apply to the separate systems.

3.3.2 Overhead Systems

Overhead systems are exposed to degradation by the weather and to damage by storms, including lightning, falling or flying vegetation and debris. Storm damage is a significant issue in the SUPP areas, and was highlighted in a benchmarking report on the system in 2005.²¹ Overhead systems are also vulnerable to bushfires and to pole-top fires. Major Event Days resulting from these various causes are listed in Appendix D of Western Power's Underground Power Program Review dated November 2008²² and a detailed report into the effects of the March 2010 storm is also available.²³

Additional risk factors relating to the reliability of overhead systems are:

- fallen wires – fallen power lines can pose a risk of electric shock;
- bushfires – overhead lines sometimes initiate or promote bushfires. The 2009 Victorian Bushfire Royal Commission²⁴ made recommendations that proposed the undergrounding of 22 kV feeders and single wire earth return lines; and
- motor vehicle accidents – Western Power²⁵ noted the impact of undergrounding distribution systems on vehicular pole collisions, however, no statistically rigorous conclusions regarding the overall effect on motor vehicle accidents can be drawn.

²⁰ Western Power. *Reliability Performance of Selected Round 3 SUPP Programs*. November 2010, Appendix A2.

²¹ Meyrick and Associates, 2005. *Benchmarking Western Power's Electricity Distribution Operations and Maintenance and Capital Expenditure*.

²² Western Power, *Underground Power Program Review*, November 2008.

²³ Western Power. *State Underground Power Program Distribution Network Performance March 2010 Storm*.

²⁴ 2009 Victorian Bushfires Royal Commission *Final Report*. www.royalcommission.vic.gov.au

²⁵ Western Power, 2008. *Underground Power Program Review*, pg89.

3.3.3 *Maintainability of Overhead Systems*

Maintainability relates to the ease with which a system can be repaired when it fails. Engineering design often involves a trade-off between reliability and maintainability.

Overhead systems are relatively easy to access, inspect and repair, both in the event of failure and for routine maintenance. Inspections are carried out at intervals to identify degraded components which can then be replaced. Inspection procedures are increasingly sophisticated, using stabilised binoculars, digital and infrared cameras, for example. Repair work can often be carried out without turning the power off. The individual components are relatively cheap when compared with underground cables, however, over several decades there is a trend towards decreasing reliability (increasing SAIDI) and component obsolescence which eventually makes more comprehensive refurbishment worthwhile. In view of the piecemeal replacement of components, it is difficult to identify a precise length of life cycle.

3.3.4 *Underground Systems*

Underground cables²⁶ have little or no susceptibility to storm damage from wind or wind blown debris, but can be affected by flooding. This can cause long outages and shorten the life of cables and other underground equipment. Undergrounding should not be used in areas known to be subject to flooding, including stormwater flooding.

Above ground components such as transformers and switch gear are generally placed in cabinets at ground level, further from the roadside than power poles. They are thus less susceptible to external damage than pole mounted equipment.

Underground cables are susceptible to electrical faults, particularly due to the deterioration of insulation as the cable ages. Faults may be caused by moisture ingress, flooding and overheating. Other sources of faults are mechanical intrusion, termites, rodents, the growth of tree roots and faults at a joint or termination.

²⁶ Note: Bare conductors, used extensively in overhead systems, are referred to as “wires” whereas insulated conductors are referred to as “cables”. Underground conductors must be insulated.

3.3.5

Maintainability of Underground Systems.

For underground cables, Praks et al²⁷ state in a 2009 article that “underground cables are not maintainable, so the influence on reliability of their wear-out is more significant than that of other underground electric distribution system components.” Visual inspection of underground cables is impractical, making diagnosis difficult and it is harder to foresee incipient failures. Cables themselves are significantly more expensive than conductor wire and the work involved in replacement is more extensive.

The design of underground cables has evolved over recent years. Early designs of cable were of the “paper insulated lead covered” or PILC type. These were reliable but were expensive. A less expensive type of cable known as XLPE or cross linked polyethylene was developed from about 1970. Initially, this type of cable suffered from unreliability due to poor resistance of the insulation to water ingress. To some extent, a poor image of underground costs and reliability has carried forward through time.

The projected lifetime of XLPE cables has improved considerably with design changes in recent years. Naylor²⁸ indicates a projected lifetime of 40+ years for “third generation” XLPE cables. These types of cables have only been available since about 2000, so this figure is based on accelerated testing rather than actual service experience. These are the types of cable now used by Western Power in the SUPP program.

Recently, Western Power has moved from using copper cored XPLE cables to aluminium cored XPLE cables and to carrying each phase of three-phase electricity in a separate cable.²⁹ This further reduces costs and simplifies cable termination, jointing and connections. Western Power is seen as being at the forefront in terms of the adoption of “best practice” in undergrounding materials and techniques.

3.3.6

Overall

In summary, underground systems are more reliable but overhead systems are more maintainable.

Underground systems have fewer interruptions than overhead systems, however, those interruptions that do occur are of longer average duration. Technically this

²⁷ P.Praks et al, *Wearout characteristics of underground cables by one- and two-mode models*, Electric Power Engineering 2009.

²⁸ Paul Naylor. *Medium Voltage Cables Life Expectancy*, www.eea.co.nz 2007.

²⁹ Source: Robert Rogerson, Western Power 2010.

corresponds to lower SAIFI and SAIDI but a higher CAIDI than for overhead systems.

The following statement is seen as representative of a general assessment of the relative reliability measures in relation to overhead versus underground systems:

“A five-year survey (1998-2002) of underground and overhead reliability comparisons for North Carolina utilities indicated that the frequency of outages in underground systems was 50% less than for overhead systems, but that the average duration of an underground outage was 58% longer...”³⁰

From a reliability viewpoint for domestic consumers, particularly in storm prone areas, the reduction in the number of interruptions resulting from undergrounding may be the most significant factor. For commercial consumers the longer average interruptions will carry some significance.

Reliability and projected lifetimes of underground cables has increased over recent years due to design improvements in the cable materials.

3.4 Analysis of Reliability Information Provided

3.4.1 Overview

This section looks specifically at the reliability data provided by Western Power on its SUPP program. This included data presented in a case study in respect of undergrounding in the City Beach area and data provided in respect of a number of areas undergrounded as part of the Round 3 SUPP.

Western Power’s SUPP Review of November 2008 included a review of program impact on reliability at Chapter 6.³¹ This document includes a report on the reliability performance of a number of projects.

3.4.2 The City Beach Study

3.4.2.1 Reliability performance

A detailed case study is presented for City Beach. This reveals the reliability results presented in **Table 3.1** shows the comparison between the reliability performance results for the original overhead system and the underground system which replaced it.

³⁰ See: www.entergy.com/2008_hurricanes/underground-lines.pdf.

³¹ Western Power. *Underground Power Program Review*, November 2008.

Table 3.1 Reliability data from the City Beach study

Overhead System	Underground System
SAIDI: 382 mins/year	SAIDI: 102 mins/year
SAIFI: 2.83 interruptions/year	SAIFI: 0.48 interruptions/year
CAIDI: 85 minutes	CAIDI: 136 minutes.

These results shows reductions in interruption frequency and total interruption duration following undergrounding, but an increase in average outage time for those customers that experience interruptions.

3.4.2.2

Comments on the City Beach results

In the City Beach case study Major Event days are *included*, so the analysis is not in accordance with IEEE 1366-2003 in that respect. A Major Event Day occurred as a result of a storm on 16 May 2005 and the extensive outages at that time (amounting to 187 SAIDI minutes) dominate the City Beach analysis. However, it can be argued that the focus of the City Beach undergrounding was on the reduction in susceptibility to storm damage, and that the study illustrates this. Another storm on 1 July 2007, ie. after undergrounding, caused only 0.4 SAIDI minutes loss. While the reduction in SAIDI minutes lost is significant, it is not clear to what extent this may have been influenced by the relative severity and location of the two storms.

The calculations in the City Beach study also use differing averaging periods of 16 months before the undergrounding and 23 months after the undergrounding.

3.4.3

Round 3 SUPP Reliability Analysis

3.4.3.1

Reliability performance

Following a consideration of the City Beach study, Halcrow requested a more extensive analysis of SUPP data covering a number of SUPP areas, with Major Event Days excluded and with averaging of data over uniform 24 month periods before and after undergrounding. Western Power provided a Reliability Analysis Report³² which presents detailed data on SAIDI, SAIFI and CAIDI for six areas undergrounded in Round 3 of the SUPP Program. The results are also presented graphically showing the average of results across all six areas over 24 month periods.

³² Western Power, 2010. *Reliability Performance of Selected Round 3 SUPP Programs*, pg10.

This study gives results as in **Table 3.2**. The overhead data are for 24 months prior to undergrounding and the underground data are for 24 months to September 2010.

Table 3.2 Reliability data for SUPP Round 3

Overhead System	Underground System
SAIDI: 202 mins/year	SAIDI: 60 mins/year
SAIFI: 1.82 interruptions/yr	SAIFI: 0.67 interruptions/year
CAIDI: 111 minutes	CAIDI: 91 minutes. The graphical results show, additionally, that the CAIDI for the last six months of data goes above the overhead average

3.4.3.2

Comments on the Round 3 SUPP Reliability Data

The reliability comparisons between overhead and underground systems in the City Beach and Round 3 SUPP returned results similar in principle to a range of international studies examined as part of this Technical Assessment. For example:

- a 1998-2002 survey for underground power cables in North Carolina, USA, indicated that the frequency of outages for underground systems was 50 percent less than for overhead systems, but that the average duration of an underground outage was 58 percent longer than an average overhead outage;³³
- the Los Angeles Department of Water and Power outlined in the *2010 Power Integrated Resources Plan* that undergrounding overhead lines has a reliability benefit of reducing the frequency of outages to almost half that of overhead;³⁴ and
- Florida Power and Light, in discussing the relative merits of underground and overhead distribution networks, noted that underground facilities are not as susceptible to wind and debris-blown damage, but are more susceptible to water intrusion and local flood damage. It was also noted that overhead

³³ See: www.entergy.com/2008_hurricanes/underground-lines.pdf

³⁴ See: www.lapowerplan.org/documents/final_draft/IRP_Final_Draft_Appendix_E.pdf

facility damage is easier to locate than underground and can generally be repaired quicker.³⁵

The results obtained by Western Power were more favourable to undergrounding than the international studies outlined above. The probable reason for this is that the Western Power overhead systems were selected for replacement according to criteria which required them to be at least 30 years old and to have high SAIDI. On the other hand, the underground systems which replaced them were new.

This point is acknowledged by Western Power in the Conclusion to the Reliability Analysis Report,³⁶ where it is stated that: *“It is likely that as the underground areas of SWIS age, the number of faults will increase. Underground faults are harder to locate and take longer to repair than for the overhead network.”*

3.4.4 *Overall Rate of Faults*

Western Power provided the following analysis³⁷ of faults in the Metropolitan/Mandurah area over 12 months to October 2010:

- overhead Distribution Networks: 20.7 faults per 100km per year; and
- underground Distribution Network: 2.3 faults per 100km per year.

3.4.5 *Reliability and System Age*

Halcrow raised with Western Power representatives the possibility of obtaining data on older underground systems than those in SUPP Round 3. However, two problems are recognised as follows.

Firstly, in the Pilot study and the early rounds of SUPP the policy was one of “like with like” replacement of the overhead distribution system. This did not allow for the volume or pattern of increase in electricity demand since the original overhead system was designed. This caused problems which led to subsequent upgrading of the underground system. The early reliability data cannot therefore be regarded as representative of the current situation. Secondly, the improvements in the design reliability of underground cables by cable manufacturers means that service data on older cables is not representative of the reliability and life expectancy of current era cables.

³⁵ See: www.fpl.com/faqs/underground.shtml

³⁶ Western Power, 2010. *Reliability Performance of Selected Round 3 SUPP Programs*, pg16.

³⁷ Western Power . Response to ERA Consultant Halcrow Information request 90626, 16 November 2010.

Western Power also advised that information in respect of these areas was not informative as, prior to 2002, the basis upon which reliability data was collected meant that it could not be geographically allocated (ie. prior performance of a SUPP project area could not be determined on a consistent basis).

3.4.6

Accuracy of data

In respect of the accuracy of Western Power's reliability data, Halcrow has not undertaken an audit of the data provided down to individual event level. It is noted, however, that the raw data presented in Appendix A of the Reliability Analysis Report,³⁸ which is aggregated by month, shows very variable performance. This is to be expected and provides confidence that the data is a true representative of actual performance and has not been manipulated for the purposes of reporting. It may also reflect the fact that the data has been collected in respect of relatively small geographical area.

Halcrow has undertaken an analysis of the monthly level data provided in respect of the City Beach SUPP Area and has been able to confirm that the analysis undertaken to determine reliability performance characteristics (SAIDI, SAIFI and CAIDI) appears to be correct.

3.5

Findings

Undergrounding generally results in improved reliability, expressed as lower SAIDI and SAIFI. Maintainability is normally reduced due to underground cables being harder to access for repair. This results in a higher value of CAIDI.

The reliability data presented by Western Power follows this pattern but gives superior results for reductions in SAIDI and SAIFI to those typically obtained. The probable reason for this is that the Western Power SUPP project involves selecting older overhead areas with high SAIDI and replacing them with new underground systems. It is expected that the reliability of the underground system will deteriorate to some extent as it ages. However, it is expected that the improvement in reliability will be sustained over the average projected life of the underground systems.

Other positive factors are that improvements in the reliability of cables have occurred in recent years, and Western Power has developed particular expertise in cable selection and installation. In addition, improved reliability and safety in

³⁸ Western Power, 2010. *Reliability Performance of Selected Round 3 SUPP Programs*.

regard to storms, bushfires, danger from fallen wires and pole-top fires are significant factors favouring undergrounding.

It is also noted that, in respect of the accuracy of reliability data, Halcrow has not undertaken a detailed audit down to individual event level of the information provided by Western Power. An analysis of a sample of monthly level data has, however, confirmed that Western Power has correctly analysed the data to determine the reliability performance characteristics (SAIDI, SAIFI and CAIDI).

4 SUPP Selection Process

4.1 *Overview*

This section presents a review and discussion of the existing process for selecting potential SUPP projects, and in particular the impact that the existing selection process has on costs given that projects are not undertaken in a successive manner.

As previously described, the SUPP comprises two streams, ie. Major Residential Projects (MRPs) and Localised Enhancement Projects (LEPs). The selection process for each of these streams is briefly outlined in the following sections before the impact of the selection process on program cost is assessed.

4.2 *Summary of SUPP Selection Process*

4.2.1 *SUPP project selection process for Major Residential Projects*

4.2.1.1 *General*

Major Residential Projects (MRPs) involve the conversion of overhead supply to underground distribution line operating at 33,000 volts or less in suburban areas, with the aim to improve electricity reliability. For the purposes of Round 5, MRPs aim to cover between 500 and 800 residential lots in order to achieve the required economies of scale and to underground a sufficient part of the network to achieve reliability improvements. The selection process outlined as part of this Technical Assessment reflects the selection process established for Round 5 of the SUPP.

The major goals of the MRPs are to improve³⁹:

- the energy security of Western Australia's electricity distribution system in extreme weather events; and
- the standard or electricity supply to consumers by addressing reliability issues in areas with existing overhead powerlines.

The process for selecting MRPs in Round 5 is illustrated in **Figure 4.1** below.

³⁹ ERA, 28 June 2010. *Inquiry into State Underground Power Program Cost Benefit Study: Issues Paper*.

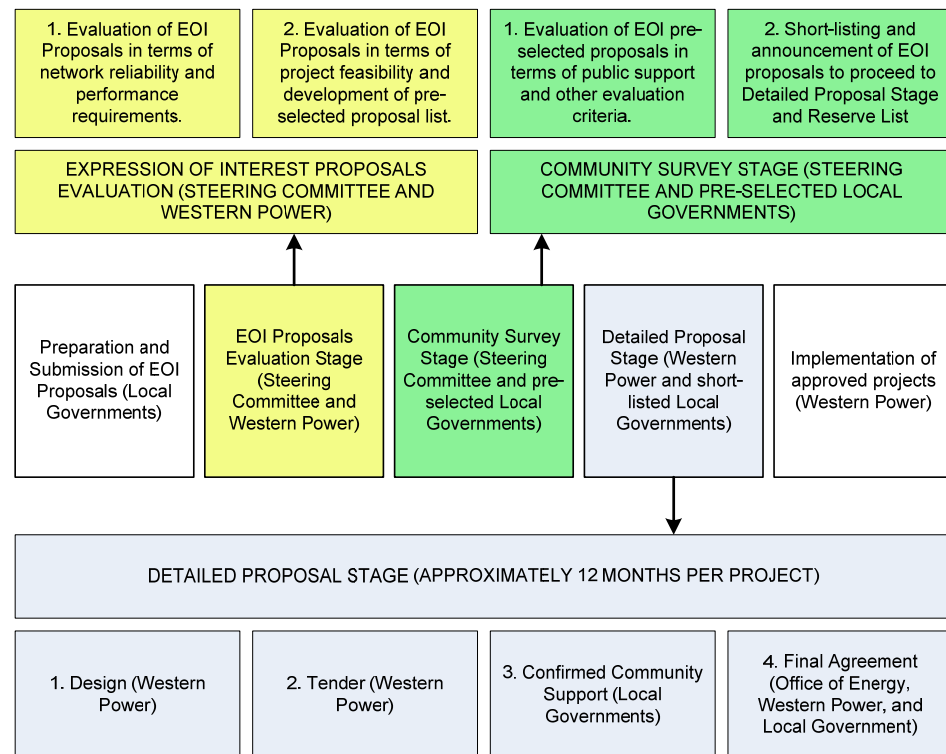


Figure 4.1 Major Residential Project selection process⁴⁰

4.2.1.2 Submission of EOIs

The initial step in the selection process is the submission of expressions of interest (EOIs) for consideration by the Committee. As part of their respective EOIs, local governments are required to clearly nominate the area within their jurisdictions in which they are proposing to replace existing overhead lines with underground cables.

4.2.1.3 Evaluation of EOI proposals

The EOIs submitted by Local Governments are evaluated by a team with representatives from the Office of Energy and Western Power. The evaluation of EOIs is undertaken in two stages:⁴¹

- technical criteria assessment: evaluation and ranking of proposals in terms of system reliability, power quality, network growth requirements and network characteristics; and

⁴⁰ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*, p. 4.

⁴¹ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*, p. 8.

- non-technical (project feasibility) criteria assessment: evaluation of the project feasibility of EOI proposals, including nominated area related issues (eg. number and size of residential lots, suitability of ground conditions), project budget, local government and community commitment and support.

The purpose of the Technical Assessment is to assess and rank each proposal against its current and future requirements for the power system, and identify the relative risk of power system failure within the nominated local government area. Those EOI proposals that do not meet the minimum Technical Assessment requirements are not considered any further.

The EOI proposals are assessed and ranked against the following criteria:⁴²

- System reliability including annual customer interruptions minutes due to:
 - pole top fires;
 - pole-related traffic accidents;
 - equipment failures;
 - overloaded equipment;
 - conductor clashing;
 - extreme weather and storm-related damage; and
 - pollution, wildlife and vegetation related faults.
- Power quality, including:
 - number of power quality complaints; and
 - system reinforcement priority for project area.
- Network growth requirements, including fault rating of conductors.
- Network characteristics, including:
 - proximity to zone substation;
 - voltage conversion requirements;
 - proximity to the coast;
 - zoning changes that may lead to system overloading; and
 - age of existing network infrastructure.

The EOI proposals that meet the minimum Technical Assessment requirements are then evaluated in terms of project feasibility. The project feasibility evaluation includes a range of criteria that have ‘minimum hurdle requirements’. An EOI proposal must meet all ‘minimum hurdle requirements’ to be deemed feasible. Those projects that are not deemed feasible are rejected and do not progress to the Community Survey Stage of the selection process.

⁴² Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*, p. 10.

During the Round Five selection process, a total of 89 EOI proposals were received. Of those, 35 EOI proposals progressed past the technical criteria assessment, with a further 12 proposals rejected as part of the project feasibility criteria assessment. Of the total 89 EOI proposals received, 23 passed the technical and project feasibility criteria assessment. The top ranking 20 proposals were progressed to the Community Survey Stage.

4.2.1.4 Community Survey Stage

Those EOI proposals that pass the technical and feasibility criteria assessment are then evaluated against the level of community support in the proposal area via a community survey. Under the selection process, the community survey must demonstrate a clear majority of local government ratepayers (of respondents to the community survey) support the undergrounding of power.

As part of the Community Survey Stage, affected residents are mailed an information and survey pack from their respective local government councils. The information pack provides information on the proposed underground power project, including:

- letter from the relevant Local Government Mayor;
- residential survey;
- the purpose of the project;
- the underground power project budget;
- average costs payable by the property owner;
- other relevant project information (related to street lighting, transformers and switchgear, house service connections, etc); and
- the proposed underground project area.

Western Power has indicated that the typical return rate for community surveys is approximately 30 to 35 percent. As part of the survey, residents are asked directly if they would be prepared to pay the stated average cost of installing underground power in the proposed project area. This stage of the selection process drives the final short-listing of proposals, as only those proposed projects that can demonstrate that a clear majority of ratepayers support the underground power project will be invited to participate in the Detailed Proposal Stage.

Of the top ranking 20 proposals progressed to the Community Survey Stage under the Round 5 assessment, Western Power indicated that two proposals were dropped due to an inability to meet the requirements of the Community Survey Stage.

4.2.1.5 Detailed Proposal Stage

Prior to receiving final approval for implementation, detailed proposals are developed for short-listed projects so as to finalise MRP designs, boundaries and budgets. In order to proceed to project implementation, local governments must satisfy all the requirements of the Detailed Proposal Stage.⁴³

The Detailed Proposal Stage seeks to address the following critical issues:⁴⁴

- demonstrated ability that the project will improve the energy security and reliability of the power supply to residents in the nominated areas;
- demonstrated ability of the local government to meet its share of the proposed project's costs;
- finalisation of underground power project boundaries, and preparation of detailed design and cost estimates;
- equivalent service level to original overhead power system;
- streetlight design and costs;
- costs of any agreed extra project requirements, such as painted streetlight columns or system reinforcement;
- boundary issues with other local governments (should the Steering Committee agree to expand the scope of the project to include a street adjacent to the project boundary and where it crosses a local government boundary);
- community support – State funding is conditional on the availability of clear evidence of continuing community support for the proposed underground power project; and
- an in-principle agreement between all relevant parties on all of the above issues, including a 'cash process' that sets out the process for cash calls and other issues relating to account management.

Those MRPs that meet all requirements of the Detailed Proposal Stage will be recommended by the Steering Committee for implementation as part of the SUPP to the Minister for Energy. Formal agreements that define the respective roles, responsibilities and obligations of all parties are developed and signed prior to the implementation of all MRPs.

⁴³ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*.

⁴⁴ Ibid.

4.2.2 *SUPP project selection process for Localised Enhancement Projects*

4.2.2.1 General

Localised Enhancement Projects (LEPs) are the second stream of the SUPP⁴⁵ and are typically much smaller in scale compared to MRPs; they typically involve the replacement of up to 1,000 metres of overhead distribution network. The objective of LEPs is to “beautify streetscapes, gateways and traffic routes of significance that are recognised as having scenic, tourism and/or heritage value.”⁴⁶ The aim of LEPs is to improve local area amenity only and “result in little or no reliability improvement”⁴⁷. LEPs target mainly non-metropolitan areas and projects in regional towns are generally given preference.

At the time of this Technical Assessment, the Selection Guidelines for Round 5 of the LEPs have yet to be released. Consequently, this assessment is based on the selection process established for Round 4 LEPs, which is illustrated in **Figure 4.2**.

⁴⁵ Horizon Power is also a participating partner of the Localised Enhancement Projects component of the SUPP.

⁴⁶ Western Power, *Underground Power Program Review*, November 2008, pg3.

⁴⁷ Western PowerIbid.

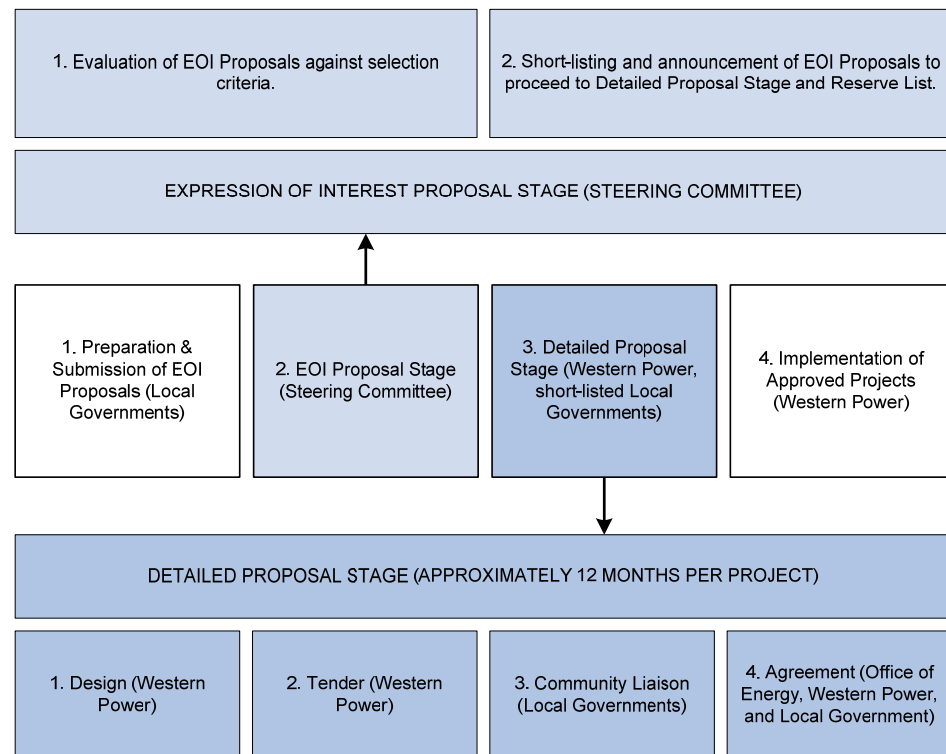


Figure 4.2 Localised Enhancement Projects selection process⁴⁸

4.2.2.2

EOI Proposal Stage (short-listing of projects)

In submitting EOI proposals, local governments must clearly nominate the areas in which they are intending to underground power. This stage takes into consideration:⁴⁹

- the regional location of the proposed project
- the level of heritage, tourism, scenic and geographic significance;
- the estimated project budget;
- the demonstrated level of commitment by the local government to fund at least half of the cost of the project and the development of a funding strategy;
- the community's willingness to participate in and contribute (if required) to the project and any plans for follow-up consultation with affected ratepayers; and
- the power system criteria assessed by Western Power.

⁴⁸ Office of Energy, 2007. *Underground Power Program: Localised Enhancement Projects – Round Four Guidelines*, pg8.

⁴⁹ Ibid, pg11.

The EOI proposals are scored and ranked on the basis of how they satisfy the above considerations. The Steering Committee will then select the most competitive proposals to be short-listed and progressed to the Detailed Proposal Stage.

4.2.2.3 Detailed Proposals Stage

As with the MRP selection process outlined above, prior to receiving final approval for implementation, detailed proposals are developed for short-listed projects so as to finalise LEP designs, boundaries and budgets. In order to proceed to project implementation, local governments (in consultation with Western Power and the Steering Committee) must complete the Detailed Proposal Stage which involves considering and addressing the following issues:⁵⁰

- local government deposit on design work;
- confirmed community support, particularly ratepayers directly affected by the project;
- inclusion of practical proposals for raising the Local Government's share of finance;
- final project boundaries, project design and cost;
- equivalent service level to original overhead power system;
- equivalent streetlight design and cost;
- exclusion of any non-equivalent direct costs, such as painted streetlight columns, or system enhancements or reinforcements;
- an agreed process with respect to cash calls and other issues relating to accounting management; and
- an in-principle Agreement approved by all parties, and a formal commitment to proceed.

Those EOI proposals that satisfy the requirements of the Detailed Design Stage are approved by the Minister for Energy and selected for project implementation.

4.2.3 *Comments on selection processes*

A review of the selection processes has found that they are consistent with Government's policies and the objectives of the SUPP. The primary focus of the selection process for the MRPs remains energy security and power system reliability. However, once a nominated MRP proposal is deemed to meet the minimum security and reliability requirements for selection, the focus of the

⁵⁰ Ibid, pg17-19.

selection process is then directed to assessing the feasibility of proposals (cost, size, ground conditions, community support, etc.).

EOI proposals for MRPs that may bring about a significant improvement in energy security and power system reliability per se, but are deemed to be unfeasible due to a range budgetary and community support factors, will not be progressed to the community support and/or detailed design stage of the selection process. This is an appropriate screening process and ensures that only the most cost-effective of the EOI proposals are implemented.

With regard to LEPs, the selection criteria explicitly notes that the aim is to beautify streetscapes, gateways and traffic routes of significance that are recognised as having scenic, tourism and/or heritage value, with little or no reliability improvement.

During meetings held as part of this Technical Assessment, Western Power demonstrated implementation of the Round 5 MRP assessment process, working through each of the assessment criteria. In each case, the basis of the criteria, the assigned weightings and “minimum hurdle requirements” was outlined. On the basis of this demonstration, Halcrow is of the view that the process is robust and represents an appropriate approach to the assessment of undergrounding proposals. Of key importance is the adoption of technical criteria, ie. security and reliability, as the primary basis for project selection.

4.3 *Impact of Selection Process on SUPP Costs*

4.3.1 *Overview*

On the basis of Halcrow’s understanding of the selection process, it appears that it is likely to have an impact on SUPP costs; this view was reinforced following discussions with Western Power.

Whilst security and reliability are the primary drivers of the SUPP, it is apparent that undergrounding is not financially viable on these bases alone.⁵¹ Accordingly, the selection process takes into consideration area related criteria (which impact on the cost of undergrounding per customer service point) and the community willingness to pay in response to improved amenity and related benefits. It is Halcrow’s view that, whilst this approach is aimed at securing the required funding under the shared funding arrangements, it may not necessarily (and in fact, is unlikely to) lead to the most cost efficient implementation of the program.

⁵¹ Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*.

The selection process, which in essence is ultimately driven by the joint funding arrangements and more specifically community willingness to pay, has a number of potential impacts on cost efficiency. These impacts, which are also influenced by the level of Government/Western Power funding (ie. overall program funding), include:

- the ability to maintain cost competitiveness through continuity of work at an appropriate level;
- project size/economies of scale; and
- successive roll-out of the program.

4.3.2

Construction cost competitiveness

Cost effective implementation of the SUPP is dependent upon the availability of construction contractors with the relevant specialist skills. Western Power contract out five categories of works related to the undergrounding of power:

- street services: installation of cabling, switch gear and transformers;
- streetlight services: erection of streetlights and fixtures;
- house services: installation of consumer mains within the property;
- decommissioning services: demolition and removal of redundant overhead infrastructure, in addition to reinforcing existing poles prior to removal; and
- interface services: connection of underground and overhead network, and installation of cross arms.

These services are contracted out in three streams, as follows:

- street and streetlight services;
- house services; and
- decommissioning and interface services.

The current SUPP selection process restricts the size of the work packages Western Power can offer for each construction stream. This reduces commercial attractiveness of the work packages, thereby impacting competitiveness of the tendering process and increasing the risk that contractors with the required specialist skills may move into other markets and be no longer available to the program. The selection process also results in considerable time delays between the commissioning of additional streams of work, impacting on the mobilisation of contractors and increasing the amount of ‘standing time’. These mobilisation and standing time costs are currently passed on to Western Power (and the State Government and relevant Local Governments).

4.3.3

Economies of scale

Western Power's ability to take advantage of economies of scale is hindered by the selection process and funding arrangements and the impact of rising materials and labour costs. In previous SUPP rounds, Western Power has typically delivered MRPs of between 800 and 1,300 residential properties. Due to the current funding arrangements and rising costs, MRPs for Round 5 are now targeting residential areas of between 500 and 800 residential lots. Western Power has adopted this approach to minimise commercial exposure to single projects without losing economies of scale; it has indicated that, in the absence of funding constraints, MRPs of around 2,000 lots would be optimal.

As part of this Technical Assessment, it was recognised by Western Power that the current selection process and funding arrangements adversely impacted SUPP costs. If funding constraints were to be removed (ie. if the respective annual contributions of the State Government and Western Power were not capped at \$5 million), and the selection process allowed for a successive roll-out of the SUPP, Western Power indicated that there is potential to reduce SUPP costs by approximately 15 to 20 percent. While the magnitude of the savings is unclear, there was little doubt on the part of Western Power that significant savings could be achieved.

4.3.4

Successive roll-out of the SUPP

The selection process results in projects being undertaken in geographically separate locations. This is driven by assessment criteria based on community willingness to pay and equitable allocation of Government funding.

It is expected that the geographically piecemeal manner in which the SUPP is being implemented is impacting on economies of scale, principally through increased mobilisation and management costs. The requirement for the Steering Committee to allocate funding equitably across local government areas will also impact on the cost of SUPP projects through significant stakeholder engagement and consultation costs.

4.4

Findings

A review of the SUPP selection processes for MRPs and LEPs indicates that they are consistent with Government's policies and the objectives of the SUPP and, in the case of the MRPs, focus primarily on energy security and power system reliability. A detailed review of the MRP selection process indicates that it is robust and represents an appropriate approach for project selection.

Review of the selection process indicates, however, that there are a number of factors that adversely impact the SUPP costs. In particular:

- the periodic manner in which underground power projects are approved and implemented means that Western Power cannot engage contractors on a continuous basis. This has consequences for mobilisation and standing time costs, which are ultimately born by the underground power projects;
- increasing labour and materials costs, and a need to minimise commercial exposure from single projects has restricted the size of work packages Western Power can offer in each of the construction streams. This reduces the commercial attractiveness of the work packages (particularly for larger contractors), thereby impacting the competitiveness of the tendering process; and
- Western Power's ability to take advantage of economies of scale is hindered by a requirement to spread the geographical coverage of projects and the existing funding arrangements.

Western Power has indicated that if funding constraints were removed, and the selection process allowed for a successive roll-out of the SUPP, there is potential to reduce SUPP costs by approximately 15 to 20 percent. Based on the nature of this Technical Assessment, and the information available at the time of this report, Halcrow is unable to verify this estimation.

5 Assessment of SUPP Costs

5.1 *Overview*

This section provides an overview of the costs that are included in the costs of the State Underground Power Program (SUPP) and discusses the appropriateness of those costs, in particular whether or not any costs that should be included are omitted, or if any costs are included that should not be.

This section also includes a discussion of Western Power's maintenance costs per metre of overhead power lines and underground cables, and benchmarks Western Power's costs with other distribution companies.

5.2 *Examination of SUPP costs*

5.2.1 *General*

Halcrow was provided with the final detailed budget for the Como East Major Residential Project which was approved and implemented during Round 3 of the SUPP; a summary showing the key cost elements is presented in **Table 5.1**. As such, any findings in relation to the appropriateness of the inclusion or omission of any costs are based on the Como East project budget provided by Western Power.

The costs for an underground power project are allocated into three broad categories: project management costs; materials; and labour. A discussion of each cost category, and the appropriateness of the inclusion or omission of any costs, is presented below.

Halcrow undertook a detailed review of the Como East project budget. Overall, Halcrow notes that the Como East project cost estimates appear to be comprehensive and complete, and provide a reasonable and appropriate level of detail, allowing for rigorous analysis and review. It is also noted that the partnership agreement involving the Office of Energy, Western Power and relevant local governments specifically allows a maximum of 93 percent of overhead costs on internal resources to be allocated to the SUPP projects. That is, the agreement provides for 93 percent overhead on base direct labour costs (including annual leave, long service leave, public holidays, payroll tax,

retrospective pay, sick leave, superannuation, workers' compensation, insurance, fringe benefits tax, operational expenses, and corporate in-kind costs).⁵²

Table 5.1 Cost breakdown – Como East MRP

Item	Cost
Project Management Costs	
Project Management	\$1,261,665
Design	\$256,233
DFIS	\$41,462
Project Closeout fund	\$50,000
City of South Perth In Kind Costs	\$228,800
Project Management Costs Contingency	\$183,816
	\$2,021,975
Materials Costs	
Street Services Materials	\$4,011,807
Street Light Materials	\$303,366
Miscellaneous Materials	\$50,000
Interface Material	\$16,436
Materials Contingency	\$438,161
	\$4,819,770
Labour Contract Costs	
Installation Services Contract	\$7,194,306
Installation Services Contract Contingency	\$660,582
Western Power Transmission Works	\$58,119
Western Power Transmission Contingency	\$5,812
	\$7,918,820
Additional Direct Council Costs (Powder Coated Street Lights)	\$56,614
Total Budget (exc. Contingency)	\$13,528,808
Contingency	\$1,288,371
Total Budget (inc. Contingency)	\$14,817,179

⁵² Office of Energy, 2009. *Underground Power Program: Major Residential Projects – Round Five Guidelines*, p. 20.

5.2.2

Project management costs

The project management-related costs for underground power projects involve the following cost categories:

- project management costs relating to the SUPP group's (within Western Power) input into the project costs and management of the projects;
- design costs incurred by Western Power;
- Distribution Facilities Information System (DFIS) costs, involving geographic mapping and information costs and associated labour;
- project close-out fund attached to each project for a period of one year to accommodate any remedial works or defects;
- local government authority in-kind costs incorporating associated local government staff costs to assist in the implementation of the project; and
- project management cost contingency (a contingency of 10 percent was included in the Como East project).

A review of the project management cost components included by Western Power in the project budget indicates that the costs appear to be both reasonable and appropriate. Halcrow notes that the project management costs for the Como East project represent 14 percent of total project costs. This is not unreasonable given the scale and nature of the undergrounding work being undertaken. Halcrow also notes that the project cost estimates are detailed and appropriate for a project of this scale, and that all relevant and obvious project management costs that Halcrow would reasonably expect to find in a detailed project cost estimate appear to be included. There are no obvious project management cost omissions.

Halcrow notes the inclusion of project management cost item relating to "CCTV Inspection Services". Although this item represents only 1 percent of the total project management costs and can be considered immaterial, it is unclear as to the purpose of this particular cost item, and therefore how it relates to project management.

Overall, the breakdown of project management costs provided in the project cost estimates are detailed and reflect what would ordinarily be expected for a project of this nature and scale. This Technical Assessment has not involved a detailed review or verification of the cost estimates, however, Halcrow notes that the total project management costs as a proportion (approximately 14 percent) of the total project costs broadly appear to be reasonable.

5.2.3

Material costs

Material costs for underground power projects relate primarily to street services materials, streetlight materials and interface materials. Western Power categorise the materials costs as follows:

- street services materials including cabling, transformers and switch gear;
- streetlight materials, including streetlight columns and fixtures;
- interface materials relating to the underground and overhead connection;
- miscellaneous materials (eg. steel bolts, fuses, conduits etc); and
- materials contingency (a materials contingency of 10 percent was included in the Como East project).

As part of this Technical Assessment, Halcrow undertook a detailed review of the materials costs included in the Como East project. A review of the material expenses included suggests that it is a detailed and complete list which appears appropriate for the broad installation and commissioning of the underground power cable services and street lighting services. Western Power allocates materials costs into the following broad categories: distribution substation construction; underground construction; underground streetlight installation; and interface materials. These cost categories are discussed briefly below.

Distribution substation construction

The construction of the distribution substation involves the installation of ground mounted high-voltage and low-voltage switchgear, and the installation of ground mounted transformers.

In relation to the ground mounted switchgear, the most significant cost items are the switch assemblies. These included a range of three-way, four-way and five-way assemblies, ranging in price from approximately \$10,000 to \$22,700 per assembly. The review of costs suggests that there appear to be no obvious cost omissions. Furthermore, all cost inclusions in relation to high-voltage and low-voltage switchgear appear to be appropriate.

With regard to the installation of ground mounted transformers, Halcrow's review indicates that the power transformers are appropriate both in terms of rating and costing for a typical distribution network. There appear to be no obvious cost omissions.

Underground construction

Underground construction materials relate to those materials involved in the laying of the underground cable (including the actual cables themselves). Underground construction involves cable supply costs, high-voltage jointing, low-voltage cable jointing and pillar installation, and miscellaneous material expenses.

Cable supply costs represent the most significant individual cost item for the entire Como East project. Total budgeted expenditure on cables for the Como East project was in excess of \$2.5 million. The cables used for undergrounding purposes are a mixture of single-core, triple-core, solid aluminium and stranded copper cables. A review of the listed power cables suggests that the selected cable sizes are appropriate for typical use in distribution power supply. It is noted that significant lengths of the cable were purchased.

High-voltage cable jointing and termination also involved significant materials expenditure. High-voltage cable joints pose a significant operations risk and need to be installed using the appropriate equipment and suitably skilled and experienced personnel. If high-voltage cable joints are not installed properly with the appropriate level of care, these joints can pose a long-term risk to the reliability of the underground distribution network. A review of the high-voltage cable jointing and termination suggests that all cost items appear appropriate and suitable for distribution power.

Costs involved in low-voltage cable jointing and pillar installation were also reviewed. All included materials appear to be suitable and appropriate for the low-voltage cable installation and jointing, termination and pillar installation.

With regard to the included miscellaneous materials costs, Halcrow's review indicates that none of the included cost items appear to be inappropriate.

Underground streetlight installation

Underground streetlight installation materials relate to those materials required for the installation and erection of the streetlight columns and fixtures. A review of the underground streetlight installation material cost components indicates that the listed materials and costs appear to be reasonable for the typical supply and installation of street lighting.

Interface materials

Interface materials relate to the works involved in connecting the underground and overhead network, and the installation of cross arms. A review of the interface material costs indicates that the materials and associated cost rates do not appear to be inappropriate.

Overall, the breakdown of material costs provided in the project cost estimates are detailed and reflect what Halcrow would ordinarily expect for a project of this nature and scale. Halcrow notes that the materials costs represent approximately 33 percent of total project costs. This Technical Assessment has not involved a detailed review or verification of the cost estimates, however, Halcrow notes that the material cost rates do not appear to be inappropriate.

Halcrow also notes that the SUPP Group (responsible for the implementation and delivery of the SUPP) purchases the relevant SUPP materials through Western Power's broader supply contracts. In doing so, the SUPP Group is able to take advantage of Western Power's bulk purchasing capabilities, and exert further constraint over the SUPP project costs.

5.2.4

Labour costs

Labour costs for underground power projects are fixed and reflect the tendered construction work packages contracted out for street services, streetlight services, house services, decommissioning services, and interface services. The installation services contract cost categories included by Western Power include:

- street services contract for the installation of cabling, switch gear and transformers;
- street service contract scope contingency;
- streetlight services contract involving the erection of streetlights and fixtures;
- streetlight services contract scope contingency;
- house services contract for the installation of consumer mains within the property;
- house services contract scope contingency;
- decommissioning services contract for the demolition and removal of redundant overhead power network, in addition to reinforcing existing poles prior to removal;
- decommissioning services contract scope contingency;
- interface services contract for the connection of underground and overhead network, and installation of cross arms; and
- interface services contract scope contingency.

The Western Power transmission works relate to pilot cable jointing, termination, and commissioning and materials expenses, including related transmission line expenses.

A review of the labour cost components included by Western Power in the project budget indicates that the labour cost components appear to be both reasonable and appropriate. Halcrow notes that the project cost estimates are detailed and appropriate for a project of this scale, and that all relevant and obvious labour costs that Halcrow would reasonably expect to find in a detailed project cost estimate appear to be included. There are no obvious labour cost omissions.

In relation to the labour cost rates, the labour costs included in the Como East project example reflect tendered contract prices. Halcrow notes that labour costs account for approximately 53 percent of the total project budget. This is not unreasonable given the scale and nature of the undergrounding work being undertaken. Halcrow also notes that the labour costs have been bundled to protect relevant commercial-in-confidence concerns. As a consequence, Halcrow is unable to comment on the reasonableness of the individual labour contract rates.

5.2.5

Project cost omissions

A review of the project cost estimates for the Como East MRP indicates that there are no obvious direct project management, material or labour cost components omitted from the cost estimates.

Halcrow notes that the project cost estimates do not provide an indication of the level of future operations and maintenance expenditure saved through undergrounding the distribution network.

As to the treatment of tax equivalent payments and their inclusion in project cost estimates, Western Power confirmed that the project cost estimates do not include any tax equivalent payments, such as payroll tax or stamp duty. These payments are rolled-up and paid by Western Power at an organisational level. As noted above, overhead costs on internal resources are capped at 93 percent in accordance with the partnership agreement in place between Western Power, the Office of Energy and local governments.

5.3 *Comparison of Maintenance Costs*

5.3.1 *Overview*

Western Power is responsible for operating and maintaining the South West Interconnected System (SWIS) which reaches from Albany in the south, Kalbarri in the north and Kalgoorlie in the east. Consequently, Western Power’s network maintenance, refurbishment and replacement programs are rolled out across the entire SWIS network. This has made any attempt to estimate Western Power’s maintenance costs per metre for overhead powerlines and underground cables challenging.

5.3.2 *Operating maintenance expenditure*

As part of this Technical Assessment, Western Power provided the information outlined in **Table 5.2** relating to operating maintenance expenditure budgets for planned and unplanned maintenance of the overhead and underground distribution networks in the SWIS.

Table 5.2 2010-11 operating expenditure budgets per kilometre (\$ per km)

Maintenance Activity	Metro	Country	SWIS ⁵³
Overhead – planned	\$2,674	\$816	\$1,181
Overhead – unplanned	\$3,389	\$673	\$1,173
Underground – planned	\$261	\$364	\$280
Underground – unplanned	\$871	\$429	\$869

The operating expenditure data provided by Western Power relates only to preventative and corrective maintenance activities. It excludes capital maintenance expenditure, such as asset replacements and any associated capital expenditure. Accordingly, it was not possible to ascertain the level of capital maintenance expenditure associated with overhead and underground power maintenance activities as part of this Technical Assessment.

From the information provided by Western Power, it can be seen that in all instances (country, metro, SWIS-wide), planned and unplanned operating expenditure on the overhead distribution network is budgeted to be significantly greater than the underground distribution network. However, while Halcrow was

⁵³ Note: weighted average cost per kilometre across the SWIS.

unable to examine Western Power's budgeted capital maintenance expenditure, based on a review of international case studies, any capital maintenance expenditure associated with underground power cables is likely to be greater than for an equivalent overhead system.

Key points of interest from the information provided by Western Power are summarised as follows:

- for the metro region, budgeted operating expenditure for planned maintenance on the distribution network is approximately ten times greater than for the underground distribution network;
- across the entire SWIS network, planned maintenance expenditure on the distribution network is more than four times greater than for the underground distribution network;
- combined planned and unplanned maintenance expenditure is more than five times greater on the overhead distribution network (\$6,063 per km combined) than the underground distribution network (\$1,132 per km combined) for the metro region;
- combined planned and unplanned maintenance expenditure for the overhead distribution network (\$1,489 per km combined) is approximately 85 percent greater than the underground distribution network (\$793 per km combined) for the country region; and
- combined planned and unplanned maintenance expenditure for the overhead distribution network (\$2,354 per km combined) is approximately double the expenditure for the underground distribution network (\$1,149 per km combined) for the entire SWIS region.

While a detailed analysis of Western Power's operating expenditure was not a focus of this Technical Assessment, Western Power's budgeted maintenance expenditure reflects a range of factors. These include:

- Western Power's overhead distribution network has, largely, a much greater age profile than the underground distribution network, impacting on maintenance and refurbishment regimes;
- the older overhead distribution systems are being replaced with newer, modern underground systems; and
- underground power cables, by their very nature, are expected to have a lower maintenance expenditure profile than overhead systems.

As part of this Technical Assessment, Halcrow has not been able to verify the operating expenditure data provided by Western Power.

5.3.3

Comparison of maintenance costs with other distribution businesses

This Technical Assessment did not allow for a detailed benchmarking exercise of Western Power's maintenance costs with other distribution companies in Australia. In particular, it was not possible to benchmark Western Power's maintenance costs for its overhead and underground distribution networks with other Australian distribution businesses.

However, as part of this assessment, Halcrow undertook a brief desktop review of operational expenditure efficiency amongst distribution companies in Australia, in particular drawing on a benchmarking investigation undertaken by Meyrick and Associates (on behalf of Western Power) in 2005.⁵⁴ The findings of the Meyrick and Associates benchmark comparison, in relation to operating and maintenance expenditure, are summarised as follows:⁵⁵

- in a comparison of thirteen distribution businesses across Australia, Western Power ranked fifth best in terms of operating expenditure per MWh (ie. fifth lowest operating expenditure per MWh). It should be noted that urban-based distributors generally perform well on this measure, while predominantly rural-based distributors incur higher operating expenditure per MWh;
- in a comparison of thirteen distribution businesses across Australia, Western Power had the third lowest (third best) operating expenditure per distribution network kilometre. Rural-based distributors generally perform well on this measure while predominantly urban-based distributors generally incur higher operating expenditure per network kilometre;
- in a comparison of operating costs per customer across thirteen distribution businesses, Western Power ranked third best; and
- in a comparison of operating and maintenance costs per kW of maximum demand, Western Power ranked fourth best out of thirteen businesses. This measure generally favours more urban-based distributing businesses.

Overall, Western Power ranked in the top five of distribution business for each of the operating and maintenance expenditure measures from 1999-2003. While the study was conducted some time ago, it is noted that Western Power was trending downward for all operating and maintenance expenditure measures.

⁵⁴ Meyrick and Associates, 2005. *Benchmarking Western Power's Electricity Distribution Operations and Maintenance and Capital Expenditure*,

⁵⁵ Ibid, pg28-31.

There are likely a range of factors responsible for Western Power's operating and maintenance expenditure performance. However, it is possible that the increasing size of Western Power's underground distribution network relative to the existing overhead network is a contributing factor.

5.4

Findings

Halcrow undertook a detailed review of the Como East project budget to ascertain the appropriateness of those costs, in particular whether or not any cost items that should be included have been omitted, or if any cost items are included that should not be.

Overall, Halcrow notes that the project management, material and labour cost components and cost estimates appear to be comprehensive and complete, and provide a reasonable and appropriate level of detail, allowing for rigorous analysis and review. Additionally, Halcrow's review, which is based on detailed knowledge of the scope and cost of power supply systems, indicates that:

- there are no obvious omissions in relation to particular cost items;
- the cost estimates are detailed and reflect what Halcrow would ordinarily expect for individual projects of this nature and scale; and
- the breakdown of cost by expenditure category is generally in line with expectations, specifically:
 - project management costs account for approximately 14 percent of the total project costs;
 - material costs account for approximately 33 percent of the total project costs; and
 - labour costs account for approximately 53 percent of the total project costs.

It is noted that benchmarking of these costs against those incurred by other organisations would be difficult, and not necessarily informative, for the following reasons:

- Halcrow understands that Western Power is the only Australian power supply organisation that is retrospectively installing underground power supply systems on a large scale basis; and
- international (and for that matter, interstate) cost benchmarking would be of limited benefit due to the different cost bases that prevail.

Halcrow notes that the project cost estimates do not provide an indication of the level of future operations and maintenance expenditure saved through undergrounding the distribution network.

In relation to Western Power's maintenance costs, it was not possible to establish a cost per metre for overhead powerlines and underground cables with the information available. Western Power did provide 2010-11 operating maintenance expenditure budgets for planned and unplanned maintenance of the overhead and underground distribution networks in the SWIS. In all instances (country, metro, SWIS-wide), planned and unplanned operating expenditure on the overhead distribution network is budgeted to be significantly greater than the underground distribution network.

With regard to comparing Western Power's maintenance costs with other distribution business in Australia, this Technical Assessment did not allow for a detailed benchmarking exercise. In particular, it was not possible to benchmark Western Power's maintenance costs for its overhead and underground distribution networks with other Australian distribution businesses.

A brief desktop review of a previous benchmarking study indicates that Western Power's past performance across a range of operating and maintenance expenditure measures has been in the top half (higher performing) of comparable distribution businesses. It is possible that the increasing size of Western Power's underground distribution network relative to the existing overhead network is a contributing factor to its performance relative to other distribution businesses.

6 Alternative Options

6.1 *Overview*

This section outlines a range of alternative options to meet the objectives of the State Underground Power Program (SUPP), and discusses the cost and project feasibility implications of these alternatives on the objectives of the SUPP.

6.2 *Alternative Options to Meet the Objectives of the SUPP*

6.2.1 *Alternative options*

As part of its submission to the Authority's 'Inquiry into the State Underground Power Program Cost Benefit Study', Western Power identified four potential alternatives to undergrounding power that could improve energy security and reliability of the power supply. These alternatives are:⁵⁶

- undergrounding main feeders (typically 22kV);
- aerial bundled cable – insulation of overhead distribution lines;
- maintenance of existing overhead distribution system; and
- pole to pillar – undergrounding of house services only.

In discussing the relative merits of the above alternatives, Western Power noted that SUPP objectives extend beyond improving energy security and reliability. Other issues of importance include:

- meeting the government target of having 50 percent of the distribution network undergrounded by 2010;
- improved storm protection;
- power reliability improvement;
- power quality improvement;
- reduced energy loss;
- lower maintenance costs;
- safer environment (wires, poles removal, no tree pruning, and better lighting);

⁵⁶ Western Power, 2010. Submission to Economic Regulation Authority's 'Inquiry into the State Underground Power Program Cost Benefit Study', pg3.

- public amenity improvement; and
- shared funding arrangements.

As part of this Technical Assessment, Halcrow has also identified the Hendrix spacer cable distribution system as a possible alternative. The alternatives identified by Western Power, and the Hendrix system, are discussed further below.

6.2.2

Undergrounding main feeders

Western Power indicated that undergrounding the 22kV main feeders had the potential to deliver the biggest reliability improvements of any of the possible alternative options. However, undergrounding the main feeders attracts a significant cost disadvantage as the low voltage system was not included.

Of significance to Western Power (and by extension the Steering Committee), undergrounding the main feeders would not provide the same level of amenity, streetlight, pole removal and tree pruning benefits. These benefits are a key driver for community contribution to funding.

6.2.3

Aerial bundled cable

Aerial bundled cables are overhead power lines using several insulated phase conductors bundled tightly together, usually with a bare neutral conductor.

The advantages of aerial bundled cables over traditional uninsulated overhead wires include:

- relative immunity to short circuits caused by external forces (wind, fallen branches);
- can stand in close proximity to trees and will not generate sparks if touched;
- simpler installation, as crossbars and insulators are not required;
- less cluttered appearance;
- can be installed in a narrower right-of-way; and
- reduced transmission losses (on AC lines), due to closer spacing of the conductors.

The disadvantages of aerial bundled cable include:

- additional cost of the cable itself over traditional uninsulated wires;
- insulation can degrade due to sun and weather exposure; and
- insulation thickness makes aerial bundled cables economical for low voltage powerlines only.

In relation to the SUPP, Western Power indicated that the use of aerial bundled cable would improve energy security and reliability, and would be cheaper to retrospectively install than underground power cables. On the other hand, while some improvement to tree pruning risk would be realised, there would be a limited improvement in amenity and little to no improvement in house service safety.

6.2.4

Maintenance of existing overhead system

In Western Power's submission to the Authority's inquiry, it noted that an ongoing and enhanced maintenance regime of the existing overhead distribution system would be the lowest cost option in terms of meeting the objectives of the SUPP.

Western Power indicated that an enhanced maintenance regime would provide some improvement in energy security, reliability, power quality and local amenity, in addition to some improvements in streetlight, pole removal, and tree pruning risks. However, Western Power stated that this option would result in higher ongoing operating expenditure. No further information was provided by Western Power; consequently, it remains unclear as to the quantum of the impact on operating expenditure.

6.2.5

Pole to pillar – undergrounding of house service only

Undergrounding the residential service lines only would improve the safety, reliability and reduce tree pruning risks. However, Western Power indicated that underground house services would result in a work bundling cost disadvantage as the low and high-voltage street services are not included.

With regard to localised amenity, a pole to pillar approach would provide a partial improvement with the undergrounding of individual residential service lines. However, under such an option, the overhead distribution network would remain in place. It is Western Power's view that a pole to pillar approach would not provide equivalent level in improvement in local amenity as the SUPP; Halcrow supports this view.

6.2.6

Hendrix spacer cable distribution system

The Hendrix spacer cable distribution system is similar to the aerial bundled cable option. The Hendrix system involves an overhead distribution system using insulated conductors in close triangular configuration. The triangular configuration provides additional mechanical strength over conventional overhead systems, providing further protection against storm event damage and contact with falling trees and tree branches.

As with the aerial bundled cable, the insulated conductors provide relative immunity to short circuits caused by external forces (wind, fallen branches), and can stand in close proximity to trees and will not generate sparks if touched. The

Hendrix system also has a compact configuration, reducing the need for tree pruning, and improving localised amenity (when compared to traditional overhead distribution systems).

In relation to the SUPP, the use of the Hendrix spacer cable system would improve energy security and reliability, and would be cheaper to retrospectively install than underground power cables. While an improvement in local amenity would be realised, it would be less than that achieved by the SUPP.

6.3

Findings

There are a range of alternative options to meet the objectives of the SUPP. Each of the options provides an improvement in energy security and reliability, meeting a core objective of the SUPP. In many instances, these alternative options would be cheaper to retrospectively install, however, none of the alternative options identified as part of this Technical Assessment would provide the level of local amenity value as that achieved by the SUPP.

Whilst the primary drivers of the SUPP are improved security and reliability of the power supply network, under the current arrangements the program is heavily dependent upon significant (50 percent) financial support from the community; such support is predicated on perceived amenity (and associated) benefits. A more detailed assessment would be required to ascertain whether any of the identified alternative options would be financially viable in the absence of community financial support.

7 Conclusions

7.1 *Overview*

In undertaking this Technical Assessment, Halcrow has sought to:

- examine and provide recommendations on the accuracy of Western Power's reliability data for areas with and without underground power, and, for areas undergrounded as part of the SUPP, the reliability data before and after the projects were completed;
- examine the impact the existing process for selecting potential SUPP projects has on costs;
- examine the costs that are currently included in the SUPP, and identify Western Power's maintenance costs per metre of overhead power lines and underground cables; and
- identify any alternative options that adequately meet the objectives of the SUPP.

The information provided by Western Power as part of this Technical Assessment was in some respects limited in terms of detail and breadth. Consequently, Halcrow's ability to undertake a detailed examination of information and provide recommendations was to some degree constrained.

The findings and conclusions of this Technical Assessment are presented in this Section.

7.2 *Reliability*

Undergrounding generally results in improved reliability, expressed as lower SAIDI and SAIFI. Maintainability is normally reduced due to underground cables being harder to access for repair. This results in a higher value of CAIDI.

The reliability data presented by Western Power follows this pattern but gives superior results for reductions in SAIDI and SAIFI to those typically obtained. The probable reason for this is that the Western Power SUPP project involves the selection of older overhead areas with high SAIDI and replacing them with new underground systems. It is expected that the reliability of the underground system will deteriorate to some extent as it ages, however, it is also expected that the improvement in reliability will be sustained over the average projected life of the underground systems.

Other positive factors are that improvements in the reliability of cables have occurred in recent years, and Western Power has developed particular expertise in cable selection and installation. In addition, improved reliability and safety in regard to storms, bushfires, danger from fallen wires and pole-top fires are significant factors favouring undergrounding.

It is also noted that, in respect of the accuracy of reliability data, Halcrow has not undertaken a detailed audit of the information provided by Western Power. An analysis of a sample of data has, however, confirmed that Western Power has correctly analysed the data to determine the reliability performance characteristics (SAIDI, SAIFI and CAIDI).

7.3 *SUPP Selection Process*

A review of the SUPP selection processes for MRPs and LEPs indicates that they are consistent with Government's policies and the objectives of the SUPP and, in the case of the MRPs, focus primarily on energy security and power system reliability.

The review of the SUPP selection process indicates that there are a range of potential impacts on cost efficiency. These impacts, which are also influenced by the level of Government/Western Power funding (ie. overall program funding), include:

- the ability to maintain cost competitiveness through continuity of work at an appropriate level;
- project size/economies of scale; and
- the successive roll-out of the program.

Western Power has indicated that if funding constraints were removed, and the selection process allowed for a successive roll-out of the SUPP, there is potential to reduce SUPP costs by approximately 15 to 20 percent.

7.4 *Assessment of SUPP Costs*

7.4.1 *Examination of SUPP costs*

A review of the Como East project budget indicates that, overall, the project management, material and labour cost components and cost estimates appear to be comprehensive and complete, and provide a reasonable and appropriate level of detail, allowing for rigorous analysis and review. Additionally, the review indicates that there are no obvious omissions in relation to particular cost items, and that the

cost estimates are detailed and reflect what Halcrow would ordinarily expect for a project of this nature and scale.

The project cost estimates do not provide an indication of the level of future operations and maintenance expenditure saved through undergrounding the distribution network.

7.4.2

Comparison of maintenance costs

It was not possible to establish a cost per metre for overhead powerlines and underground cables with the information available. Western Power provided 2010-11 operating maintenance expenditure budgets for planned and unplanned maintenance of the overhead and underground distribution networks in the SWIS. In all instances (country, metro, SWIS-wide), planned and unplanned operating expenditure on the overhead distribution network is budgeted to be significantly greater than the underground distribution network.

This Technical Assessment did not allow for a detailed benchmarking exercise, however, a brief desktop review of a previous benchmarking study indicates that Western Power's past performance across a range of operating and maintenance expenditure measures has been in the top half (higher performing) of comparable distribution businesses. It is possible that the increasing size of Western Power's underground distribution network relative to the existing overhead network is a contributing factor to its performance relative to other distribution businesses.

7.5

Alternative Options

A range of alternative options to meet the objectives of the SUPP were identified as part of this Technical Assessment. Each of the options provides an improvement in energy security and reliability, meeting a core objective of the SUPP. In many instances, these alternative options would be cheaper to retrospectively install, however, none of the alternative options identified as part of this Technical Assessment would provide the level of local amenity value as that achieved by the SUPP.

Appendix A Information Requested for Review

In order to assist Halcrow’s input into the Authority’s *Inquiry into State Underground Power Program Cost Benefit Study*, Halcrow requested the information outlined in **Table A.1** from Western Power.

Table A.1 Halcrow request for information

Requested Information
Reliability Data
<ul style="list-style-type: none"> • What are Western Power’s adopted standards in relation to: <ul style="list-style-type: none"> ○ Short/instantaneous interruptions (eg. momentary interruptions up to 5 minutes?); ○ Longer term interruptions, such as major events (eg. SAIDI major event threshold); and ○ Normal interruptions (eg. in between). • Can Western Power provide the following reliability information in relation to power interruptions in Undergrounded and Overhead-powered areas: <ul style="list-style-type: none"> ○ Number of interruption events; ○ Event date/time; ○ Number of customers interrupted for each event; ○ Duration of interruption for each event; and ○ Total number of customers in area serviced. • For service areas that have been successfully ‘undergrounded’, can Western Power provide the following reliability information ‘before’ and ‘after’ those areas were undergrounded: <ul style="list-style-type: none"> ○ Number of interruption events; ○ Event date/time; ○ Number of customers interrupted for each event; ○ Duration of interruption for each event; and ○ Total number of customers in area serviced. • In relation to corrective maintenance data, for each of High Voltage Feeders, Low Voltage Feeders, and Service Connection Lines, Halcrow would be interested in: <ul style="list-style-type: none"> ○ The total number of faults per kilometre for ‘undergrounded’ and ‘overhead’ areas; ○ Amount of outage time per kilometre for ‘undergrounded’ and ‘overhead’ areas as a result of faults; and ○ Restoration (historical) cost per kilometre for ‘undergrounded’ and ‘overhead’ areas.

Requested Information

Other Technical Information

- Can Western Power provide a breakdown of all costs included in the SUPP costings? This includes (but is not limited to):
 - Installation;
 - Maintenance;
 - Operation;
 - Removal of overhead powerlines and poles;
 - Underground cable;
 - Overheads; and
 - Tax equivalent payments.
- Can Western Power provide a breakdown of the costs included for the installation of underground cables in Greenfield developments? Can Western Power provide an explanation for differences in installation costs (if any) between Greenfield and SUPP works?
- Can Western Power provide clarification with respect to the costs involved in the removal of overhead powerlines and poles in areas that have been undergrounded?
- In relation to the roll-out of the SUPP, can Western Power provide copies of information it supplied to the SUPP Committee regarding the prioritisation process? That is, what was the basis for selecting service areas for underground installation? For example, were service areas selected on the basis of:
 - Existing risk?
 - Cost per kilometre?
 - Ease of access?
 - Local government cooperation and assistance?
 - Geographic location?
- What were the key business drivers for the prioritisation of the selection process above?
- Can Western Power provide indicative costs in relation to the costs of power outages? For example, does Western Power estimate the direct costs of a power outage within a particular area?
- Can Western Power provide information in relation to corrective **'underground'** and **'overhead'** maintenance costs? Specifically, Halcrow would appreciate information relating to:
 - Maintenance cost per kilometre for underground cables;
 - Maintenance cost per kilometre for overhead wires; and
 - Breakdown between maintenance expenditure for 'planned' versus 'reactive' maintenance for both **'undergrounded'** and **'overhead'** areas.

Requested Information
Alternative options
<p>Can Western Power provide all information relating to alternate options that could be considered in order to achieve the SUPP objectives? For example, alternate options may include:</p> <ul style="list-style-type: none">• Operation of reclosers;• Upgrade of existing overhead lines;• Retrospective installation of service lines; and• Running underground cables in parallel with the overhead lines (leaving the overhead lines in place).

Table B.2 Publicly available information reviewed as part of this Technical Assessment

Document Title/Description
2009 Victorian Bushfires Royal Commission, 2010. Final Report. See: www.royalcommission.vic.gov.au .
Amended Proposed Revisions to the Access Arrangement for the South West Network owned by Western Power. See: www.erawa.com.au
Entergy, 2008. Should Power Lines be Underground? See: www.energy.com/2008_hurricanes/underground-lines.pdf .
Economic Regulation Authority, 2010. Inquiry into State Underground Power Program Cost Benefit Study – Issues Paper. See: www.erawa.com.au
Institution of Electrical and Electronic Engineers, IEEE Standard 1366-2003, Guide to Electric Power Distribution Reliability Indices. See: http://standards.ieee.org/findstds/standard/1366-2003.html
Meyrick and Associates, 2005. Benchmarking Western Power’s Electricity Distribution Operations and Maintenance and Capital Expenditure See: www.westernpower.com.au
Naylor, Paul 2007. Medium Voltage Cables Life Expectancy. See: www.eea.co.nz
Office of Energy, 2007. Underground Power Program: Localised Enhancement Projects – Round Four Guidelines. See: www.energy.wa.gov.au
Office of Energy, 2009. Underground Power Program: Major Residential Projects – Round Five Guidelines. See: www.energy.wa.gov.au
Praks, P. et al. 2009. Wearout characteristics of underground cables by one- and two-mode models, Electric Power Engineering.
Town of Vincent, 2006. General Information on the State Underground Power Program. See: www.vincent.wa.gov.au
Western Power, 2010. Public Submission to the Economic Regulation Authority’s Inquiry into the State Underground Power Program Cost Benefit Study. See: www.erawa.com.au



Halcrow Pacific Pty Ltd

Melbourne

Level 1, 542 Station Street, Box Hill, Melbourne, VIC 3128
Tel +61 3 9899 9777 Fax +61 3 9899 1214

Sydney

Level 22, 68 Pitt Street, Sydney, NSW 2000
Tel +61 2 9250 9900 Fax +61 2 9241 2228

Brisbane

Level 19, 215 Adelaide Street, Brisbane, QLD, 4000
Tel +61 7 3169 2900 Fax +61 7 3169 2999

www.halcrow.com