21, rue d'Artois, F-75008
http : //www.cigre.org

C1-305

CIGRE 2016

Overcoming barriers to the use of alternative and innovative solutions such as stand-alone power systems as an alternative to replacement of end-of-life network assets

O. ARTEAGA NOVOA
Western Power
Australia

M. CHUNG
Western Power
Australia

P. HOWE
Anser Consulting
Australia

P. NEWITT
Western Power
Australia

J. THOMAS
Western Power
Australia

T. FAIRFIELD*
Western Power
Australia

SUMMARY

In Western Australia, significant sections (about 40,000 km) of the fringe-of-grid assets were constructed under rural electrification policies of the State Electricity Commission of Western Australia between the late 1950s and the 1980s. Today, the age of network in these regions typically exceed 30 years of age and will progressively be scheduled for replacement or refurbishment over coming years.

The historical challenge that "a vast area of the State of Western Australia, when taken together with the relatively small population and large rural holdings in the arable South Western region…distances are great and electrification loadings are light when compared to most situations encountered elsewhere in Australia" [1] remains essentially unchanged in the 21st century. Similar challenges exist throughout Australia, in particular in remote and regional areas, both with respect to the current and looming asset renewal investment requirement, low loads, and long distances.

Local generation supply options, for example, stand-alone power systems (SPS) have evolved considerably in recent years and, in some circumstances present a safer, more reliable and more economically efficient alternative to network rebuild for some customers at the edge of the distribution network, where there is low customer density and customers have low electricity consumption.

Postage stamp electricity tariffs have applied in Western Australia since 1975, resulting in an ongoing cross-subsidy from metropolitan to regional electricity consumers. While the "Uniform Tariff Policy", has been considered a policy instrument to achieve social equity, it has resulted in the ratio of network revenue (based on uniform tariffs) to network replacement cost in these areas typically being very low – between 4-11% over a 50 year period over most of the South West Interconnected System (SWIS). In combination with the difference in Net Present Value of SPS compared with network rebuild in some of these situations, there is a significant incentive to consider the deployment of SPS.

Regulatory frameworks in both Western Australia and the Australian National Electricity Market (NEM) intend for demand management or non-network solutions to be used wherever they are the most economically efficient option for network investment. Failure to consider these options brings

tristy.fairfield@westernpower.com.au

the risk of penalties, rejection of expenditure requests and consequential inability to recover investments.

Jurisdictional statutory and regulatory barriers exist that currently prevent Western Power[1] from deploying SPS as an alternative to network replacement even where it is the most economically efficient option. In addition, limitations to the deployment of SPS exist under the proposed application to Western Power of the National Electricity Rules (NER)[2].

Analysis on the SWIS indicated a potential net benefit of at least AU$100 million, and potentially greater than AU$500 million (in net present cost terms) over 50 years, if SPS were deployed as an alternative to rebuilding networks on a like-for-like basis.

This paper describes Western Power's considerations and processes in resolving key statutory, regulatory, cultural and other barriers to the potential deployment of SPS as an alternative to network replacement or refurbishment, as well as recent developments in market design and regulation that may make this approach more feasible.

KEYWORDS

Remote, Rural, Renewable Energy, Stand-alone Power System, Remote Area Power System, Fringe-of-Grid, Edge-of-Grid.

DEFINITIONS

Southwest Interconnected System (SWIS) – is the interconnected transmission and distribution systems, generating works and associated works located in the South West of Western Australia.

Stand-alone Power System – SPS are a modular, hybrid electricity supply that are not connected to the electricity network, and typically supply electricity to single premises. A SPS typically consist of: a renewable generator (e.g. solar PV), electrical energy storage system (e.g. batteries), inverter, battery charger/regulator; dispatchable (e.g. diesel generator), fuel storage, communications and housing. Some of these elements are optional. Hence, a SPS may be provided in a variety of configurations.

Fringe-Of-Grid/ Edge-Of-Grid -'Fringe-of-Grid' or 'Edge-of-Grid' typically refers to the parts of the network at the end of long and often weak feeders or spurs, rather than the geographical fringe/edge (boundary) of the grid supply area.

---

[1] Western Power ('Electricity Networks Corporation') is a Western Australian State Government owned network service provider. It builds, maintains and operates the electricity network in the southwest corner of Western Australia. The Western Power Network forms the vast majority of the South West Interconnected Network (SWIN), which covers 261,000 square kilometers and serves approximately 1 million customers.

[2] Western Power is in the process of transferring its regulation from the Western Australian Economic Regulation Authority to the national Australian Energy Regulator, and from 2018 the National Electricity Rules will apply.

1.0 BACKGROUND

Stand-alone Power Systems (SPS) have been utilised for many years in areas with no electricity network connection. Improved performance and reduced costs mean that, in some cases, it may be preferable for SPS to be installed as an alternative to the extension or replacement of network assets.

In 2009 Western Power installed a SPS[3] at a customer site with an average daily load of 23kWh/day in York, Western Australia, to understand the relative performance of the SPS compared with a traditional network connection. While this technical trial was a success, it did not consider or address the statutory, regulatory and other barriers that would face a Business-As-Usual (BAU) deployment of SPS as an alternative to traditional network infrastructure and the removal of the network infrastructure. Critically, the network infrastructure remained in place, meaning that the customer was still part of the South-West Interconnected System (SWIS)[4].

In 2013, following a bushfire, Western Power considered deploying SPS as an alternative to replacing 6km of network infrastructure that connected to only one relatively low-use customer.

It established that, despite being required to consider non-network alternatives to network augmentation, it did not have the statutory or regulatory scope to deploy SPS as an alternative to rebuilding end-of-life network assets. A key statutory restriction was the fact that, unlike the trial in York, the customer would not be 'interconnected' and therefore not form part of the SWIS.

Many areas of Western Power's network, predominantly at the fringe-of-grid, have a very low customer density and revenue to cost ratio. Western Power recognised that the inability to implement the most economically efficient solution to provision of electricity could have considerable economic consequences, and could potentially create a risk of asset write down.

2.0 INTERJURISDICTIONAL DEPLOYMENT OF SPS

Western Power has considered the experience of other organisations in deploying SPS as an alternative to network rebuild, including the 2010 SPS Ausnet, Powercor and EnergySafety Victoria trial [2] and Powerco's "Basepower" program in New Zealand [3].

It also considered the experience of the Australian federal Government's Remote Renewable Power Generation Program (RRPGP)[5] and Bushlight program[6] through interviews with project managers and reports.

Western Power contributed to and considered the findings of the Electricity Supply Association of Australia (ESAA) report, *Assessment of edge of grid regulatory and policy framework* (January 2015) [4].

3.0 ASSESSMENT OF NET BENEFIT

---

[3] 6kW PV, 120V 600Ah/C10 lead acid (sealed gel) battery, 16kVA diesel generator.

[4] The definition of 'interconnected' was a key issue in determining Western Power's ability to utilise SPS, and was determined to mean physically interconnected via the electricity network infrastructure.

[5] The Australian Government's Remote Renewable Power Generation Project (RRPGP) was implemented between 2001 and 2009. Its objective was to displace diesel generation systems that provided off-grid power and water pumping services in remote areas of Australia with stand-alone power systems.

[6] The Australian Government's "Bushlight" program provided 148 renewable energy systems to 130 remote indigenous communities between 2012 and 2012.

Prior to seeking any statutory or regulatory changes, Western Power sought to understand the potential net benefit that may be able to be realised as a consequence of having the SPS option available.

Western Power's initial analysis was restricted to parts of the South-West Interconnected System (SWIS) classified as "Outer Regional Australia", "Remote Australia" and "Very Remote Australia".

The cost of network replacement and other attributes at the meter level were assessed using data from various sources, including meter consumption and design estimates.

Meter level data was extracted and analysis undertaken to establish:

- The number of SPS candidate customers (meters) downstream of switchable sections.
- The cost to rebuild the distribution line for each customer connection (meter) up to the upstream isolating point of the switchable section.
- The cost to supply candidate customers with SPS (for comparison).

The analysis made the following assumptions:

- Where the SPS deployment cost was calculated to be less than or equal to 50% of the network replacement cost, it was considered to be a candidate for SPS deployment.
- Only switchable sections of the network in which five or fewer meters (customers) were connected at the end of a spur ('network segment') were considered.

It was observed that there were a large number of meters (approx. 40%) with very low average daily consumption (<2kWhr/day). In these situations it would be uneconomic to install a complete SPS and therefore a modest capital allowance was assumed to provide alternative options such as solar pumps (for dam pumps) or portable generators and fuel vouchers for infrequently used facilities (e.g. sheds).

3.1 Network Replacement Cost

To calculate the network replacement cost, each meter was identified against a network segment. Each network segment can be comprised of one or more switchable sections at the end of a distribution spur.

The assets in each network segment were extracted from the Western Power Geographical Information System (GIS) and the individual network replacement cost determined using current replacement rates (poles, conductor, crossarms, switches, conductors etc.). The cost per network segment was then shared evenly between all meters supplied by the network segment.

3.2 SPS Capital and Operating Costs

The cost to procure and deploy an SPS was estimated from tender bids received through an earlier Request-For-Information process, actual costs incurred in the York project and supplemented with information from other sources. These were updated in subsequent analysis.

The estimates were based upon a standard configuration (utilising a containerised solution) and were not adjusted for price discounts which may be obtained from large volume purchasing.
Using a HOMER[7] modelling and simulation, four different SPS configurations (10, 20, 30 and 40kWh/ day average consumption) were considered with optimised sizing of batteries, inverter, generator and solar PV for each energy category.

[7] HOMER (Hybrid Optimization of Multiple Energy Resources) is an established industry software modelling system used to size stand-alone electricity systems and micro-grids.

SPS options were not considered where the requirement exceeded that of the 40kWh/day system (i.e. demand exceeded 13kW or daily energy exceeded 50kWh/d) although it may be possible to cater for some larger loads.

This initial process identified approximately 1400 rural connection points in the "Outer Regional Australia", "Remote Australia" and "Very Remote Australia" areas of the SWIS where installation of a SPS is likely to be a significantly lower cost option than replacing existing network assets.

3.3 Net Present Cost Assessment – SPS vs network

The Net Present Cost of a 10-year SPS deployment program was modelled with operating expenditure evaluated over fifty years to correspond with expected network asset life using the assumptions of the "Most Likely Scenario".

A scenario in which 360 SPS are installed over a 10-year period was considered. In addition, 269 very low use electricity connections (<2kWh/day) were assumed to be removed by mutual consent with customers at a modest cost to Western Power per meter. Under this scenario the financial benefits were estimated to be in the vicinity of $190 million over 50 years, with a range of between $80 million and $380 million under an initial sensitivity analysis.

3.4 Revision and Sensitivity Analysis

Western Power subsequently undertook a further sensitivity analysis and updated earlier SPS cost inputs. The sensitivity analysis included:

- discount rate ranging between 2.5% and 10.2%.
- high and low capital costs based on costs from an Expression of Interest (extrapolated for large systems).
- uptake of SPS systems on a feeder or network section of up to 20 customers.
- no upper limit on SPS size.

This analysis found that the order of magnitude net benefit of deploying SPS as an alternative to network asset replacement over the next 50 years could range from $100 million to greater than $500 million (in net present cost terms) based on current SPS costs and current network replacement costs.

4.0 INTERSECTION WITH PLANNED NETWORK INVESTMENT

Western Power has continued to develop increasingly sophisticated tools to enable the identification of suitable SPS candidates and their intersection with Network Investment Plans.

These tools have built on the previous analysis, creating a dynamic model by spur (within the project defined as being a sub-section of network where the number of customers downstream of a switching device form less than 10% of the total number of customers on the electrical feeder) which enables analysis by criteria such as average daily consumption, maximum daily consumption, number of customers, line length, SPS vs network rebuild cost.

Predictably, overlaying theoretical SPS candidates, which are based on an assumption of full life cycle network costs being incurred, with actual Network Investment Plans results in a reduction of viable SPS candidates.

In addition to identifying suitable alternatives to BAU network replacement or significant refurbishment, these will be used to "flag" meters that may be more suitable to have SPS installed than rebuild the network after events (e.g. bushfire) that remove the entire spur.

5.0 STATUTORY AND REGULATORY BARRIERS

Despite the positive results from the strategic analysis, Western Power identified a number of statutory and regulatory barriers to its deployment of SPS. Key issues identified are:

Electricity Corporation Act 2005 (WA) - All of Western Power's functions under this act relate to operating a network and it has not been granted the legislative power to "supply" electricity.

Electricity Industry Act 2004 (WA) - SPS would not be considered part of the South West Interconnected System (SWIS) within the definition contained within the *Electricity Industry Act 2004 (WA)* and consequently capital expenditure (capex) would not be considered part of the "covered service" for the purposes of the Electricity Networks Access Code 2004. Consequently it would not be able to be added to the Regulated Asset Base nor would operating expenditure (opex) be recovered through Western Power's regulatory process.

Energy Operators Powers Act 1979 (WA) - Western Power has statutory power to access land under the *Energy Operators Powers Act 1979 (WA)* only where that access is necessary in the performance of its functions. As noted above, "supplying" electricity is not one of Western Power's functions and accordingly Western Power does not have any statutory land access powers enabling it to install, run and maintain SPS equipment.

The Western Australian Government's Public Utilities Office is considering options to enable the deployment of SPS where they are a more economically efficient alternative to network replacement.

6.0 WESTERN POWER'S SPS PILOT

Western Power recognises that ultimately, the customer perception and experience, will determine whether their deployment is able to be a viable alternative to network replacement.

Consequently, Western Power is undertaking a 12-month pilot project of six SPS, to determine whether stand-alone power systems will achieve better outcomes for electricity consumers at a lower cost than the replacement of end of life electricity network infrastructure and to inform the regulatory and statutory changes required to enable their deployment.

Western Power is delivering the pilot project in partnership with the other Western Australian electricity Government Trading Enterprises (GTEs), Horizon Power and Synergy, in order to ensure that lessons learned are shared across the GTEs and that the ultimate resolution achieves the best outcomes for Western Australian electricity consumers.

The SPS pilot will inform Western Power's consideration of SPS, improving its understanding of:

- capex and opex of SPS compared with network rebuild or refurbishment;
- the most effective processes to identifying SPS candidate customers and the inclusion of SPS in network planning processes;
- the reliability of SPS compared with network connection;
- potential commercial model and market designs;
- key stakeholder views with respect to existing roadblocks and potential treatment;
- the customer experience, particularly in relation to the key aspects of the customer value proposition: reliability and safety; and;
- other deployment barriers.

6.1 SPS capex and opex accuracy

As noted previously, SPS technology is well established, as are the costs associated with most aspects of the technology (battery costs being the notable exception).

Early indications, based on responses to the pilot project Requests for Tender, have indicated that costs will likely be higher for utility-owned and maintained SPS than for systems installed and owned by the property owner.

The intention is for SPS to replicate the customers' existing electricity supply arrangements, and there should be no requirement for their electricity consumption or load profile to change. Eventually, there is likely to be merit in incentivising behaviour change or retrofits to reduce SPS costs, however, in the early stages, the customer must be satisfied that there is no disadvantage to them.

Consequently, neither customer behaviour change, nor energy efficiency is a component of the pilot project. This is in contrast to a usual SPS design process, which, to minimise costs, would identify opportunities for customers to reduce both demand (kVA) and consumption (kWh). There is a small budget for any high-return retrofit opportunities, such as upgrading old electric hot water systems, but this is not a key element of the SPS design process.

Similarly, Western Power's Rural Distribution Design Guidelines specify a maximum demand capacity of 32A (~8kVA) per phase. Many of Western Power's rural customers have split phase electricity supply arrangements. Replicating this supply arrangement requires using a split phase transformer, two inverters or a multi-phase inverter.

Battery sizes (approx. 2 days equivalent usable capacity), while not excessive, are larger than an individual may choose to install.

SPSs installed to date have largely used lead-acid battery storage. From a utility perspective, the advent of lithium-ion chemistries as a longer life, smaller footprint alternative creates an incentive to pursue lithium-ion chemistries rather than lead acid. While up-front costs remain higher, life-cycle costs are projected to be more favourable for lithium-ion chemistries.

The majority of the Western Power meter fleet does not have the capability to record and store interval data. To accurately assess candidate suitability and suitable SPS sizes, consumption and demand data over 12 months or more is highly desirable.

For the purposes of the pilot, interval meters were installed, however, only limited data was available prior to the finalisation of the SPS design. Consequently, there is a higher reliance on energy audit and discussion with the property occupants.

6.2 Reliability and Power Quality

The SPS will be remotely monitored, enabling simple comparison with network performance.

Number and duration of outages, and voltage will be compared with network-connected customers connected to the same feeder as the SPS Pilot participants.

6.3 Customer receptivity and experience

Western Power commissioned market research to inform its understanding of likely community and customer amenability to SPS. This research found that:

> *In general, amenability to Stand Alone Power systems was high, with around 80% of those interviewed at least partially open to the idea of having such a system.*
>
> *All participants who were open to SPS's however, would still require reassurance as to its viability, both in terms of cost and electricity supply capacity.*

Respondents largely fell into one of three segments, as described in Figure 1, below.

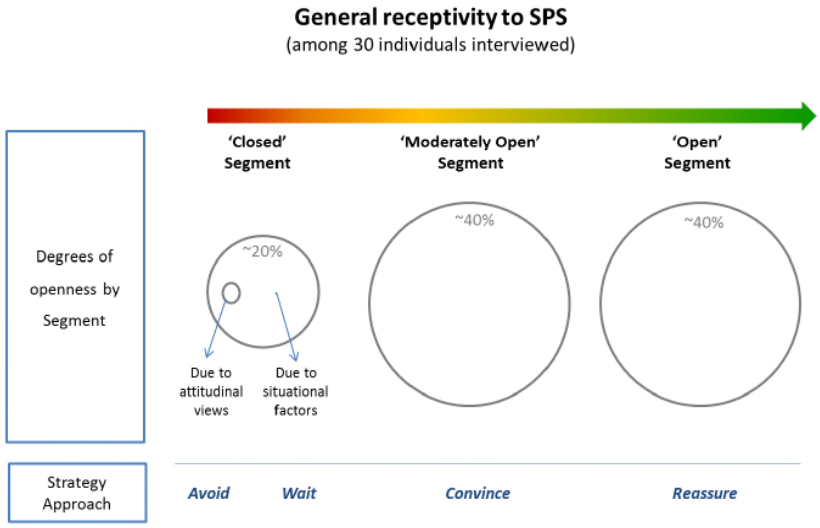

Figure 1: General receptivity to SPS (among 30 individuals interviewed)

There are significant benefits to users of SPS, including safety and reliability, which are likely to encourage public acceptance. However, while an SPS may offer a more reliable and safer electricity supply for customers, they will not experience a direct financial benefit, as they will continue to be charged the regulated tariff.

The pilot will expand on this preliminary qualitative research to understand the sentiment of the participants before, during and after the 12-month period.

Receptivity and acceptance is likely to be strongly influenced by the engagement strategy and customer experience in pilot programs. Accordingly, the engagement has been designed to ensure customers are chosen for the pilot that are willing with work through issues, for example, in relation to SPS performance, operations and maintenance or customer service aspects and the perceived and actual benefits for the customer of the SPS are captured. These lessons will be used to inform the future engagement strategy.

6.4 Stakeholder views

In relation to the potential deployment of SPS, Western Power has undertaken significant engagement with the majority of its key stakeholders, including the Minister for Energy, the Public Utilities Office PUO), the Economic Regulation Authority (ERA), the Western Australian government-owned retailer, Synergy and Western Australia's Regional Power Corporation, Horizon Power. Additionally, it has sought the views of local governments in the areas where the pilot project is being implemented.

Each of these stakeholders expressed support for the investigation of the feasibility of utilising SPS as an alternative to network treatment.

7.0 OTHER BARRIERS

7.1 Transition to the Australian Energy Regulator

Regulatory frameworks in both Western Australia and the National Electricity Market (NEM) intend for demand management or non-network solutions to be used wherever they are the most economically efficient option for network investment. Failure to consider these options brings the risk of penalties such as asset write-down.

In addition to the current restrictions to the deployment of SPS on the Western Power Network, limitations to the deployment of SPS exist under the proposed application to Western Power of the National Electricity Rules (NER).

The ability for a DNSP to use a SPS as a means of providing a reference service in the NEM regime (or standard control service as they are termed) is not explicitly catered for in the National Electricity Rules (NER) ("the Rules"). Noting jurisdictional legislative barriers already identified, the ability to deploy an SPS requires an expanded interpretation of the service classification and definitions of key terms (i.e. definition of a distribution system) as currently provided for under the Rules.

Consideration of the treatment of generation within the wholesale and retail markets is also required.

The Australian Council of Australian Governments (COAG) Energy Council resolved in December 2015 to "examine the regulation of standalone and non-interconnected systems under the national energy frameworks, where appropriate"[8].

7.2 Customer Protection Framework

In addressing the identified barriers and establishing the ability to deploy SPS as a legitimate Reference Service, it must be ensured that customers are adequately protected from a service quality and access perspective. The existing Western Australian *Small Use Customer Code* could be used, and could act as the customer protection instrument in line with physically connected customers. However, additions may be required to include specific SPS related customer protections such as opt-in/opt-out provisions.

7.3 Technical Rules and Standards

The Technical Rules are specified for technical conditions on the network and the impact of interconnection. While the Technical Rules specify requirements for performance at the point of supply, they do not make provision for standards and requirements for SPS performance. The Technical Rules and other applicable guidelines would need to be amended to include appropriate standards to ensure reliability, quality, safety, and security of the installation.

8.0 CONCLUSION

In conclusion, Western Power confirmed many instances where SPS is an economically viable alternative to replacing aging network assets in areas of low customer density and where all the customers have relatively low electricity use. Realising these opportunities can create benefit to metropolitan customers via tariffs due to the avoided replacement capital expenditure.

The substantial scale of the potential economic net benefit, in combination with potential customer benefits, should provide the incentive for policy makers to remove regulatory barriers to BAU deployment of SPS both within the SWIS, and in other jurisdictions.

[8] COAG Energy Council, Meeting Communiqué, 4 December 2015.

BIBLIOGRAPHY

[1] Booth, R.R and Coulter, T.E., *A Review of Rural Electrification Policies in Western Australia* (Electric Energy Conference Sydney, 13-17 October 1980, p1).

[2] Powerline Bushfire Safety Taskforce *Final Report*, (September 2011, pp 77-78) and Chant Link & Associates, *ESV Bushfire Start Minimisation Research* (30 June 2011, pp 9-64).

[3] Whaley and Pattie, *Stand Alone Power Systems for Remote Rural Areas* (C6-305, CIGRE 2012).

[4] Electricity Supply Association of Australia, *Assessment of edge of grid regulatory and policy framework*, January 2015.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the following Western Power colleagues for their contribution to this paper: Michael Chapman, Neil Chivers, Andrew Cook, Margot Hammond, Annabel Keogh, Andy Kondola, and Brad Smith.