

13 April 2018

To:

Dr David Worth
Principal Research Officer
The Economics and Industry Standing Committee,
Legislative Assembly of WA, Parliament House

Subject:

Response to 'Inquiry into Microgrids and Associated Technologies in WA'

This letter is a response to the "Inquiry into microgrids and associated technologies in WA", by the Economics and Industry Standing Committee of WA parliament.

A group of academics and researchers at the School of Engineering & Information Technology of Murdoch University are currently engaged in researching in the field of microgrids and its associated technologies. This team has an extensive experience in conducting projects in the following terms of reference of this Inquiry:

- The potential for microgrids to contribute to the provision of affordable, secure, reliable and sustainable energy supply, in both metropolitan and regional WA;
- Development of raw material resources/primary commodities; and
- Key enablers, barriers and other factors affecting microgrid development and electricity network operations.

We have provided our comments on the above terms of reference in the attached Appendix.

Should you have queries on our comments or require additional information, we are happy to appear before the committee to present our case.

Regards,

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Appendix

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Overview of Microgrid

The concept of microgrids was first proposed in 2001 in the IEEE Power and Energy Society's general meeting, and the first guideline for the interconnection of distributed energy resources to microgrids and microgrid's control was developed by IEEE in 2010. Microgrid refers to a small-scale electricity generation and distribution network and its main character is the possibility of operating in off-grid mode, which is often referred to as islanded, isolated or standalone modes of operation. Such a character is very attractive for those power distribution companies and utilities that are responsible to supply electricity to regional, remote and very remote areas customers or those located at the edge of grid such as WA.

The key difference of a microgrid with standalone or isolated power systems, which have been used for several decades throughout the world, including all regional towns of WA, is to proliferate the number of distributed energy resources. The ultimate goal of microgrids are realising 100% of the electrical demand being supplied by renewable sources. However, we are currently in the transition stage of converting our fossil dominated electricity grids into sustainable microgrids.

Some of the key benefits of microgrids to the utilities are:

- improvement in the network's power losses
- reduction in the levelised cost of electricity generation, and
- reduction in the level of greenhouse gas emissions

As of today, 160+ pilot microgrid projects are under operation around the world varying from a few kilowatts up to a few megawatts. Almost 70% of these projects are scattered in Northern America and the rest in Europe, Asia and Australia. Altogether, they have a total generation capacity of 1.2 GW.

Along with the vast research and developments in both universities and industries around the world, Horizon power and Western Power in WA, are also moving towards changing their current business models from a conventionally pole and wire-focused industry to a power generation-distribution type in which some customers can be supplied from the national electricity grid as before, while some areas, suburbs or neighbourhoods can be supplied by the indigenous renewable-based energy along with the energy storages and the national grid while some other customers can be fully off the grid and supplied by an appropriate combination of renewable sources, energy storages and a small scale diesel or gas-driven generator to minimise the levelised cost of electricity generation. Microgrid pilot projects in Onslow, Kalbarri, Carnarvon and Rottnest Island are the key projects currently under development/operation in WA.

Our Research on Microgrids

A group of academics and researchers at the School of Engineering & Information Technology of Murdoch University are engaged in researching in the field of microgrids and its associated technologies. The team has experience in conducting research projects in these fields sponsored by Australian renewable energy agency (ARENA), Australian research council (ARC) and some local industries such as

- an ARC Linkage project on “stand-alone renewable energy microgrids for remote area power systems” (ARC Linkage Project \$326k, 2014-17), and
- an ARENA Advancing Renewables Programme on “monitoring & control of photovoltaic and energy storage systems” (\$1.9M, 2017-19).

Our studies generally fall under the following terms of reference of this inquiry. For each term of reference, we have identified those key areas of research that we are experts in and over the past 5 years, we have collectively published 100+ scholarly journal articles in these areas.

a) *The potential for microgrids to contribute to the provision of affordable, secure, reliable and sustainable energy supply, in both metropolitan and regional WA*

- **Conducting techno-economic analysis** for microgrids at several remote towns and islands in WA
- **Developing roadmap** for renewable energy application in Australia and WA
- **Developing the investment, implementation and operation policies and frameworks** for electrification of remote areas based on renewable energy resources

b) *Development of raw material resources/primary commodities*

- **Mapping environmentally friendly materials** like cathode and anode for static storage to reduce energy consumption
- **Developing new technologies of energy storage systems** to minimise the carbon footprint
- **Applying lithium and sodium-based supercapacitors** using a novel oxide and phosphate materials instead of the existing expensive technologies for energy storage

c) *Key enablers, barriers and other factors affecting microgrid development and electricity network operations*

- **Designing, modelling and techno-economic analysis** of photovoltaic-diesel-battery based microgrids
- **Developing new operational mechanisms** to overcome the key technical challenges of operating islanded microgrids
- **Developing controllers for energy storages** and more specifically batteries in microgrids to efficiently compensate the unexpected variability of the solar and wind energies
- **Developing an effective dynamic mechanism of power sharing** among multiple energy resources within a microgrid

- **Developing strategies for reliable power sharing** among neighbouring microgrids
- **Applying forecasting tools** to improve photovoltaic integration into WA's remote electricity networks
- **Developing a short-horizon predictive controller** to take proper actions to avoid any technical issues such as outages
- **Orchestrating multiple energy storages within a microgrid** considering their different internal characteristics
- **Developing suitable corrective control mechanisms for microgrids** to maintain the voltage and frequency within acceptable boundaries

Summary of Our Findings

We have determined several key enablers, barriers and factors that can affect development of microgrids and the associated technologies in WA based on our findings from conducting research in the above areas. The key enablers for microgrid development can be summarised as:

- Remoteness factor is found to be a key factor for developing microgrids in WA's remote areas.
- Expansion of electricity grid network in WA's remote areas is found economically infeasible because of the low density of customers
- Microgrids are found to have the potential to play a significant role in WA's future given the state's unique geographic characteristic
- WA utilities are facing challenges from fuel price volatility and therefore, microgrids are attractive solutions
- Microgrids are found to have the potential to reduce WA customers' electricity bills and their concerns regarding the rapidly increasing costs of electricity by avoiding network expansion and upgrade costs being passed to customers
- Microgrids are found to have the potential to motivate WA's regional and edge of grid customers and utilities to reduce their energy costs by generating their own energy locally in the form of a small-scale microgrid, referred to as the behind-the-meter scheme
- Proper operational techniques are found for maximising the footprint of renewables in microgrids while satisfying utility's technical, economic and reliability constraints.

while the key barriers for microgrid developments and electricity networks in WA are found as:

a) Technical Barriers

- Increased complexity of the system and the difficulty in its operation and management
- Optimisation and orchestration of various components and sources within a microgrid
- Voltage and frequency deviation and stability margins
- Power quality issues including harmonics

b) Institutional and Policy Barriers

- Government policy level is important for developing microgrids and therefore, a lack of policy makes the uptake of microgrids harder
- Absence of clear incentives for microgrid development

- Lack of suitable regulations, legislation and historic market design for microgrids
- Absence of an active involvement from all stakeholders (i.e., consumers, manufacturing companies, utilities and retailers) in decision-making to enhance the trust and cohesiveness

The solution for the above barriers are achievable though research, and we have to continue conducting research in the above areas but the institutional and regulatory barriers also require Government intervention.

Sample of Our Related Published Journal Articles

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