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ARENA

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**ARENA submission to Australian Energy Regulator (AER) on Assessing Distributed Energy Resource (DER) Integration Expenditure**

This submission provides background information on projects funded by the Australian Renewable Energy Agency (ARENA) as relevant to the AER's Consultation Paper on Assessing DER Integration Expenditure.

Attachment A provides a summary of the progress of 11 projects being implemented under ARENA's Network Hosting Capacity funding round in their first year. These demonstrate innovations that may form part of expenditure proposals in the coming years as network businesses seek to integrate a greater range, and higher penetrations of DER.

I look forward to ARENA and the AER collaborating this year through the Distributed Energy Integration Program (DEIP), especially with regard to the DEIP Access and Pricing work package which we hope will provide a pathway to enhanced regulatory frameworks for DER integration into electricity networks.

Please contact Jon Sibley, Principal Policy Advisor [redacted] if you would like to discuss any aspect of ARENA's submission.

Yours sincerely

Darren Miller

Chief Executive Officer

## Attachment A

## Network Hosting Capacity Projects

## Year One Summary - 2019

In February 2019, the Australian Renewable Energy Agency (ARENA) awarded $9.6 million in funding to further integrate distributed energy resources (DER) into the electricity system.

The term DER commonly refers to small-scale, flexible resources connected to the distribution network. This includes behind-the-meter technologies (such as rooftop solar PV, small-scale battery storage, electric vehicle charging points), residential and commercial-industrial controllable loads, smart devices (such as some air conditioners, hot water heaters and pool pumps), and relevant enablers like smart meters and data services.

Australia's investment in renewable DER assets continues to grow, with more than 14 million kW of total installed capacity currently connected to electricity systems across the country[1]. Queensland and South Australia are at the forefront with over 30 per cent of residential homes owning solar PV, while some local areas across the nation have solar PV penetration rates of over 50 per cent[2]. While DER has many benefits, it can also create technical challenges for distribution network service providers (DNSPs), primarily local network voltage rise, thermal constraints and reverse flows, as well as other issues such as harmonic disturbances. There is also emerging evidence that DER can create both benefits and issues in transmission.

Traditional network responses to managing high levels of DER in the system tend to focus on asset augmentation and fixed export limits. In order to accelerate the integration of renewable DER into the system, ARENA is supporting four pilot projects led by Jemena, SA Power Networks, Solar Analytics and Zeppelin Bend, and seven studies led by the Australian National University, CitiPower & Powercor, CSIRO, Dynamic Limits, Oakley Greenwood, University of Melbourne and University of Tasmania. These projects and studies are investigating innovative

[1] *Australian PV market since April 2001,* Australian PV Institute, https://pv-map.apvi.org.au/analyses
[2] *Mapping Australian Photovoltaic installations,* Australian PV Institute, https://pv-map.apvi.org.au/historical#7/-27.635/153.129

ways to increase network hosting capacity of DER assets while maintaining optimal system security and reliability.

This report provides a summary of the progress made by the studies and projects in year one of the initiative (2019).

### Australian National University: Community Models for Deploying and Operating DER

*ARENA Funding:* $498,000
*Total Project Cost:* $1.37 million
*Location*: Australian Capital Territory, Queensland, Tasmania, Victoria

Community energy models (CEMs), including community-level storage, may be a way to reduce energy costs and allow a higher penetration of DER into the grid and into the energy market, including ancillary and network service markets. For the purposes of this study, CEMs are defined as models in which the load, generation and storage are not co-located behind a single metering point. The ANU are investigating the key technical, economic, social and regulatory barriers associated with establishing CEMs in the distribution system, and identifying possible solutions to remove barriers and incentivise CEM deployment. In addition to increasing network hosting capacity, the study will also investigate the benefits and value that CEMs can provide to DNSPs, retailers and customers, including how the benefits can be shared with vulnerable customers, renters, and apartment owners.

ANU's social research has found that community energy groups strongly value local energy generation linked to local consumption - the term "energy sovereignty" was used to capture this concept. Networks also appear willing to engage in local storage models, however, there are some challenges including current regulations. ANU's simulations show that community energy storage (CES) may allow increased DER penetration, compared to residential storage.

For one scenario based on a combined group of 55 households, rooftop solar generation was increased up to 7kW per house, and CES reduced export power to the wider grid by 50 per cent compared to equivalently-sized residential storage. To fully access the benefits of CES, however, a local use of service (LUOS) reduced energy transport tariff might be required to incentivise the local exchange of energy between customers and the storage asset.

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**CitiPower & Powercor: Distributed Energy Resources Hosting Capacity Study**
*ARENA Funding:* $164,000
*Total Project Cost:* $353,000
*Location:* Victoria

The CitiPower and Powercor Project aims to demonstrate the issues faced by Australian distribution networks in maintaining security and quality of supply in the context of increasing penetrations of DER. The project will provide the industry with a replicable methodology to assess both DER hosting capacity and the potential options to increase DER penetration. This methodology will use publicly available analysis tools in combination with smart-meter data at a 30-minute level, and other network, customer and weather data sets to assess limitations and the most cost-effective opportunities for increasing hosting capacity on the network. The project will engage with CSIRO on their experience in the development of the network models published by in the medium-voltage National Feeder Taxonomy Study, and will also provide insights for their development of low voltage models to ensure consistency with the current CSIRO National Low Voltage Feeder Taxonomy Study. Once the methodology has been completed, CitiPower and Powercor will be able to identify and assess a broad range of customer and network level mitigation options currently available to distribution networks in some key growth areas of the network.

During year one of the round, CitiPower and Powercor gathered and cleansed input sources, including 30-min smart meter data, network supervisory and operational data, to develop 10 low voltage (LV) network topologies comparable to LV networks across the CitiPower and Powercor networks. This was an increase from the originally proposed 5 topologies due to the greater range of customer types and supply areas covered by the network. A methodology has been created to assess DER hosting capacity and value capacity increases against the costs of various remediation options, and five wider area network models have been developed to test and verify the representative LV network topologies against the real systems operation. CitiPower and Powercor have been working with industry partners to develop a modelling approach to address limitations in the publicly available analysis tool. This primarily focused on the limitations in assessing unbalanced LV networks and single phase systems, as the tool is limited to assessment of balanced three phase systems at this time. Finally, CitiPower and Powercor are working on delivering hosting capacity assessment results, to a 30-minute resolution, for five key remediation options focused on the LV networks including both customer side or network side strategies.

For more information, contact: adinning@powercor.com.au

**CSIRO: National Low Voltage Feeder Taxonomy Study**
*ARENA Funding:* $485,000
*Total Project Cost:* $2.7 million
*Location:* National

Through this study, the CSIRO are developing the first nationally representative taxonomy of low-voltage (LV) networks. The aim is to clearly describe and better understand the real-world characteristics of Australia's distribution systems, which will simplify the assessment of new innovative network management technologies that can contribute to the stability, reliability and performance of networks and simplify the assessment of national benefits from such technologies. The study involves working with DNSP partners to gather and summarise key characteristics of Australian LV networks at a regional level, and then identify LV network types with common design and deployment characteristics. The National LV Feeder Taxonomy will provide users with a concise description of the technical characteristics of the identified network types, as well as their common application in the national distribution system. The final stage of the study is to integrate DER models (PV, battery energy storage systems, and demand response) into custom-built power-flow models unique to each LV network type.

The CSIRO continues to work closely with DNSP partners via regular working groups and workshops to drive collaboration and knowledge sharing. CSIRO has also engaged with a non-project partner DNSP to include them in the workshops and gather data from them to be included in the LV Feeder Taxonomy study. Work continues on defining the data requirements and gathering data from the LV feeder networks across Australia. Common formats and tools have been identified from the LV feeder data, which will be used to develop the taxonomy.

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**Dynamic Limits: Distributed Energy Resources Feasibility Study**
*ARENA Funding:* $292,000
*Total Project Cost:* $798,000
*Location:* New South Wales and South Australia

Dynamic Limits is investigating the feasibility of applying principles of distributed control to create dynamic DER operating envelopes on radial feeders on distribution networks. The study consists of a general technical feasibility study, as well as two site-specific feasibility studies examining feeders with both rural and voltage constraints. The approach has the advantage of removing the need for network models used to calculate the point of constraint by measuring relevant constraints directly. This approach has the additional advantage of also creating a more robust system that is both able to withstand a loss of communications and does not have a single point of failure.

The study made good progress in 2019 - the general technical feasibility study has been conducted and indicated that through the implementation of the dynamic control scheme, DER hosting capacity can be increased by as much as six times without the need for network augmentation and only a minimal need for curtailment. Several workshops with subject matter experts were held in 2019 to discuss and uncover potential roadblocks for the implementation of the system and any critical tasks that any system needs to achieve. Site-specific studies are now underway, with data for an urban feeder currently being analysed.

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### Jemena Electricity Networks: Demonstration of Three Dynamic Grid-Side Technologies

*ARENA Funding:* $1.12 million
*Total Project Cost:* $2.61 million
*Location:* Victoria

Jemena and project partners, AusNet Services and University of NSW, are demonstrating how increasing the visibility of LV networks can help manage grid power and voltage fluctuations. Three grid-based technologies are being assessed:

1. Dynamic phase switching of customer loads on LV feeders to help mitigate localised over-voltage challenges caused by concentrated DER assets.
2. Dynamic power compensation to adjust the output voltage and mitigate load unbalance challenges at distribution transformers.
3. Battery energy storage with Virtual Synchronous Generator (VSG) capability to mitigate potential power quality and network stability challenges caused by very high DER penetration.

By the end of the first year, Jemena and it's project partners have developed the equipment specifications and completed bench testing of the effect of phase shifting operation on common household appliances (e.g. the impact of momentary power loss across the switching cycle). Data has been collected from two demonstration networks to feed into network modelling. Computer modelling for optimal placement of the new network technologies and operating parameters has been completed. Jemena and AusNet Services have worked closely with local residents and councils and have successfully installed and begun field trials of pole-mounted phase shifting devices, a power compensation device and central controllers. A containerised battery energy storage system (BESS) is scheduled to be installed by Jemena in early 2020, and Jemena will continue sharing progress of their project via round tables, seminars, presentations and publications.

For more information, contact: peter.wong@jemena.com.au

**Oakley Greenwood: Pricing and Integration of Distributed Energy Resources**
*ARENA Funding:* $207,000
*Total Project Cost:* $569,000
*Location:* NEM-wide

Oakley Greenwood is investigating the optimal way to provide price signals that reflect the value that DER services can provide to the electricity supply chain. The intention is that appropriate market signals can incentivise stakeholders to invest in locations and at scales where DER is most needed, and to deploy DER when and how it is of most value. This will maximise the value provided by DER assets through the provision of the correct price signals at all levels of the supply chain and the various levels of markets to create opportunities for customers, industry and third parties.

The study has examined the regulatory and economic environment of DER, both in the National Electricity Market (NEM) and internationally, and undertaken consultation with representatives from across the industry. Oakley Greenwood has identified a series of technical and economic services that DER assets can provide to different parts of the electricity value chain, and has developed a suite of pricing options to optimally price DER services.

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**SA Power Networks: Advanced VPP grid integration**
*ARENA Funding:* $1.03 million
*Total Project Cost:* $2.48 million
*Location:* South Australia

The Advanced VPP Grid Integration Project aims to demonstrate how higher levels of energy exports from customers' solar and battery systems could be enabled through the use of dynamic, rather than fixed, export limits, and to test the additional value this could create for customers and Virtual Power Plant (VPP) operators. To achieve this, SA Power Networks has implemented an interface (API) to exchange real-time and locational data on distribution network capacity between SA Power Networks and Tesla, enabling Tesla's 1,000-customer SA VPP to increase its output when there is available network capacity. This concept is being tested in a field trial that commenced in July 2019.

During the first year of the project, SAPN have established a DER integration API working group, which brings together several related ARENA projects to collaborate on API design and development, and a separate VPP technical reference group (now convened by AEMO). In collaboration with the API working group, SAPN have developed a distribution network API specification to support DER registration, monitoring and the publication of network constraints. The API has been integrated with Tesla's VPP management and market trading systems,

including global updates to Tesla's Powerwall firmware to support the dynamic export limit function, and commenced live field trials in July 2019. The project is on track and SAPN are on target to complete the 12-month trial mid-2020.

For more information, contact: bryn.williams@sapowernetworks.com.au

### Solar Analytics: Enhanced Reliability through Short-Time Resolution Data

*ARENA Funding:* $491,000
*Total Project Cost:* $1.28 million
*Location:* NEM-wide

Solar Analytics are working with AEMO and Wattwatchers to improve the monitoring capabilities of voltage disturbances, as well as automating short-time data capture transfer triggered by grid events. This will allow for increased visibility, predictability and/or potential control of DER for AEMO, network service providers and other relevant entities, as well as provide a better understanding of the system security and reliability challenges caused by increasing DER penetration in certain areas across the grid. One of the benefits of the project is to optimise power system operation within secure technical limits and enable the market operator to manage the power system with a high share of DER while maintaining reliability and system security.

During the first year of the project, Solar Analytics provided several datasets to AEMO. Analysis of the high-resolution data enabled AEMO to identify specific behaviours of small-scale PV systems during frequency and voltage disturbances that are critical to predicting overall network response and preparing appropriate responses. AEMO is currently preparing public reports on these findings. Wattwatchers have also delivered a firmware upgrade that enables the regular reporting of voltage statistics, which provides more useful information around such disturbances. Wattwatchers and Solar Analytics are currently working on rolling out these upgrades across the Solar Analytics fleet of over 20,000 monitoring devices.

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### University of Melbourne: Advanced Planning of PV-Rich Distribution Networks Study

*ARENA Funding:* $203,000
*Total Project Cost:* $497,000
*Location:* Victoria

The University of Melbourne study is a three-stage investigation to understand how Distribution Network Service Providers (DNSPs) can make the most of their networks to accommodate residential solar PV. The study starts with the development of detailed full three-phase

integrated HV-LV network models to quantify the impacts of various solar PV penetrations on network performance. Then, using these models, the University will explore how to quickly estimate PV hosting capacity without the need for complex and detailed network studies. The aim is to develop innovative analytical techniques to assess network hosting capacity of solar PV by using readily available HV network and customer (smart meter) data. Finally, The University of Melbourne will investigate planning options to assist DNSPs in increasing network hosting capacity. Recommendations for DNSPs will be drawn from a techno-economic assessment of traditional solutions (e.g. network augmentation and existing voltage regulation devices) and non-traditional solutions (e.g. new voltage regulation devices, PV inverter capabilities, and battery storage systems).

The first two stages of the study were successfully completed during 2019 and the corresponding reports made available to the public. Stage one involved the HV-LV modelling of HV feeders selected in collaboration with AusNet Services. Detailed three-phase network models from the head of the HV feeder down to the connection points of residential customers were produced for four significantly different HV feeders (long/short rural and long/short urban), each supplying electricity to 3,000 to 5,000 customers. In stage two, an innovative analytical technique was defined to calculate the solar PV hosting capacity of a residential area (LV customers connected to the same distribution transformer). Using the developed detailed network models, growing PV penetrations in a horizon of five years were simulated to create a large realistic smart meter data set. The analytical technique was then applied to this data and tested for different PV penetrations. The findings show that the proposed analytical technique provides adequate estimations of PV hosting capacity, making it possible for DNSPs to have a faster and simpler alternative to time-consuming approaches that require full network models.

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**University of Tasmania: Optimal DER Scheduling for Frequency Stability**
*ARENA Funding:* $527,000
*Total Project Cost:* $1.18 million
*Location:* Tasmania

The University of Tasmania aims to demonstrate, via detailed modelling, the frequency response capabilities of a range of inverter-interfaced DER and flexible loads, and the extent to which they can assist with frequency stability in power systems with decreasing conventional generation. The project will also develop optimisation software that enables fleets of DER in distribution networks to be operated so that this frequency response can be enabled while simultaneously respecting the physical constraints and limitations of distribution networks. Finally, the project will establish methods for and thus provide insights into how fleets of aggregated DER might actively participate in energy and FCAS markets in Australia so as to allow their frequency response capabilities to be harnessed in
future.

During 2019, the project team developed detailed models of inverter power electronics control for a number of DER types – photovoltaic systems, battery systems, electric vehicle chargers, inverter-based heat pumps (for space heating and cooling and for hot water heating) and inverter-based resistive loads (for hot water systems). These models have been included in simple power system frequency response time-domain simulations, operating alongside different types of conventional synchronous generators, and variously demonstrated to be capable of providing faster response with less frequency deviation and smaller settling time, particularly in power systems with decreasing levels of physical inertia. Models are currently being developed to demonstrate the value of this DER frequency responses in NEM power system frequency response simulations with a range of different generation mix scenarios, including with pumped hydro energy storage capacity. We also assessed some of the conditions for and capability of inverter-based DER alongside flexible loads to still provide adequate frequency response when exposed to network fault conditions.

The project team has been developing network-constrained bidding optimisation strategies to support and coordinate the participation of aggregators of DER in the electricity (wholesale energy and frequency reserve) markets. The approach being pursued consists of a decentralised optimisation approach, where aggregators negotiate with distribution system operators to define network-constrained energy and reserve bids. The optimisation method breaks down the network-constrained bidding optimisation problem into aggregators and DSO problems. Multiple aggregators are able to operate in the same distribution network, with each aggregator optimising the flexibility of its fleet of DER, and with the flexibility at the same time 'aggregated' at the distribution network MV substation level. This optimisation software has been implemented and tested but is undergoing further development. In order to demonstrate possible integration of such an approach into NEM energy and reserve markets, a simplified dispatch engine (NEMDE equivalent) has been built and tested for energy bids and is being extended to incorporate reserve bids and thus DER aggregator dispatch.

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### Zeppelin Bend: *evolve* DER Project

*ARENA Funding:* $4.29 million
*Total Project Cost:* $12.94 million
*Location:* ACT, NSW and Queensland

Zepben's project is developing mechanisms to orchestrate the operation of DER assets by continuously providing 'operating envelopes' to the DER via integration with aggregator systems. The project includes integrating Zepben's existing Energy Workbench platform with DNSP partner systems to obtain medium- and low-voltage network models and measurement data that will be used as inputs into the algorithms to calculate the operating envelopes. Such

operating envelopes will ensure that the secure technical limits of electricity distribution networks are not breached, and will allow for greater integration of DER assets into the grid.

The project has made considerable progress in the first year.  A common information model (CIM) standard based data platform (designed to marshal network asset models and data) has been developed and made available via open source:

https://bitbucket.org/zepben/cimbend/src/master/

https://zepben.bitbucket.io/docs/cim/zepben/

The initial versions of agents that will integrate with DNSP systems have been completed and are pending deployment within a DNSP partner's IT infrastructure. An AZURE-hosted instance of the *evolve* data platform, including associated authentication and security mechanisms, has been created and penetration testing for cyber security assurance is about to be performed. Zepben's principle project partner, the ANU, is building the aggregator-facing API that will be used to register DER assets with the *evolve* platform, as well as designing the operating envelope engine. The first end to end testing is scheduled for July 2020.

For more information, contact: bill.tarlinton@zepben.com