Australian Government
Australian Renewable Energy Agency

ARENA

ARENA submission

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Senate Committee into the Resilience of Electricity Infrastructure in a warming world

This submission provides background information on the Australian Renewable Energy Agency's (ARENA) projects relevant to the *Senate Committee into the Resilience of Electricity Infrastructure in a Warming World.*

The Inquiry terms of reference include investigation into 'the role of storage technologies and localised, distributed generation to provide Australia's electricity networks with the resilience to withstand the increasing severity and frequency of extreme weather events driven by global warming'. To assist the Committee with its investigation, this submission outlines ARENA's project portfolio and relevant experience with distributed generation, storage, and its interaction with the electricity network, and demand for electricity from consumers and industry. The submission also outlines ARENA's broader approach to enabling affordable, reliable electricity supply with a high proportion of renewable energy. ARENA's projects are generally not designed specifically with weather-related risks to the electricity system in mind, however, they are relevant to the inquiry in so far as they show the potential for reliable and affordable supply using new technologies.

About ARENA

ARENA was established with the aim of improving the competitiveness and increasing the supply of renewable energy and enabling technologies in Australia.

ARENA provides financial assistance for research, development, demonstration and deployment of renewable energy and enabling technologies. This assistance is designed to accelerate the commercialisation of these technologies by helping to overcoming technical and commercial barriers.

A key part of ARENA's role is to collect, store and disseminate knowledge gained from the projects and activities it supports for use by the wider industry.

To date, ARENA has invested $1.1 billion in support of 232 projects (including 190 active and 42 complete) with a total value of $2.7 billion.

Flexible capacity and solutions for grid security and reliability

As the mix of electricity generation changes to a higher level of renewables, Australia's electricity system will need to continue to provide secure, reliable power with more diverse, variable and distributed energy sources. This will involve a higher level of integration with flexible capacity, smart control systems, demand management, and improved technical standards to help withstand unexpected and extreme events.

Flexible capacity includes storage, demand response, and generation that can be ramped up and down to help balance supply and demand. As renewables like wind and solar PV get cheaper, ARENA is placing an increased focus on flexible capacity technologies to balance out variability in supply and demand.

Technical innovation and market evolution has already allowed Australia to move to higher levels of intermittent renewable generation than thought possible in past decades. This trend is expected to continue. For example, there is the potential for a wide range of technologies (both established and emerging) to provide ancillary services (such as frequency and voltage control) and inertia, both of which were traditionally provided by large, centralised generators.

ARENA's project portfolio includes activities that facilitate greater penetration of renewable energy into low voltage grids, develop customer-focused or behind-the-meter solutions, and address knowledge gaps to help develop market rules, regulations and network practices. One of ARENA's investment priorities, Integrating Renewables and Grids (IRG), aims to support industry in developing, testing and commercialising a range of solutions that help to integrate increasing levels of variable generation.

ARENA supports a number of projects that aim to address these challenges including through:

- studies, models and tools that allow for technology and cost optimisation of the whole energy system (for example, through the Australian Renewable Energy Mapping Infrastructure);
- tools for renewable energy resource forecasting (for example, Fulcrum 3D's cloud prediction technology, also used at Karratha Airport Solar Farm). This is especially relevant to the present inquiry given potential challenges in predicting renewable energy resources as a result of climate change.
- distributed and utility-scale renewable energy storage (e.g. batteries, Concentrated Solar Thermal - CST), pumped hydro) to improve system-wide energy reliability and security (for example, through the AGL Virtual Power Plant);
- enabling distribution and transmission networks to accommodate high penetrations of both utility-scale and distributed energy resources (for example, through the TransGrid Renewable Energy Hub); and
- new market designs that help realise the full value of renewable energy (for example, through the Institute for Sustainable Future's study into local electricity trading and local network charges).

Integrating renewables into the grid requires whole-of-system change across technology, markets and regulation. ARENA's 'A-Lab' is a new, collaborative innovation laboratory with a focus on distributed renewable energy resources. A-Lab aims to facilitate the whole-of-system energy change by:

- bringing together a variety of stakeholders such as consumer representatives, generators, network service providers, retailers, technology developers, market operators and regulators, researchers, government and non-government organisations;
- enabling these stakeholders to use a variety of workshop techniques to facilitate creative thinking to generate new capacities, approaches and initiatives to drive systemic innovation; and
- developing project proposals and funding projects that tackle the major challenges of renewable energy grid integration.

ARENA has recently completed the pilot stage of A-Lab and will be announcing successful projects and future stages in the coming months.

Microgrids, fringe-of-grid and off-grid

ARENA's project portfolio also supports the development of microgrids. Microgrids are discrete energy systems, usually comprising distributed generation (such as solar PV), energy storage (such as from batteries) and demand management, which can be operated either independently of or in conjunction with the main grid. Applications include fringe-of-grid (for example, Lakeland Solar and Storage), remote off-grid (for example, Hydro-Tasmania's King Island project) and new residential developments (for example, Brookfield Energy Australia's Huntlee development).

Amongst other benefits, microgrids can allow communities and large energy consumers to continue operating as separate or 'island' networks, and so preserve power supply in the event that supply on the main grid is interrupted, for example, as a result of a loss of the network connection caused by a storm. The benefits of this kind of approach is highly dependent on the particular situation: for example, whether the location in question is particularly susceptible to network disruption, and how a microgrid solution would compare in cost and reliability. Microgrids will often work as a complement to a larger grid to maximise reliability, especially when the renewable resource within the microgrid is low (e.g. very occasional extended periods of cloud cover and/or low wind).

While advances have been made in the research, development and demonstration of off-grid, fringe-of-grid and microgrid technologies, there are still barriers that need to be addressed, particularly in relation to economic and regulatory requirements. Identifying sites where a stand-alone system could be cost-effective can also be difficult, as this will depend on the characteristics of the electricity network in a particular location. ARENA's microgrid and off-grid portfolio seeks to inform these issues by showing the potential for high penetration, affordable renewable energy systems integrating generation, demand and network requirements.

Please refer to Attachment A for a list of ARENA-supported microgrid, fringe-of-grid and off-grid projects.

Energy storage

A wide range of storage types are available, each with different characteristics suiting different applications. ARENA is investing significantly in a variety of storage projects to test a range of technologies and new business models for provision of grid services that will enable a higher penetration of variable renewable generation.

ARENA's current investment priorities in storage includes:

- demonstrating new business models and control systems for end-user applications, to maximise the value and benefit of distributed renewable generation;
- overcoming barriers and improving access to information;
- reducing real and perceived risks;
- grid-scale storage applications, to allow for higher penetration of renewables in Australia in future;
- pilots and demonstration activities to address barriers to higher penetration of renewables or grid stability constraints; and
- research and development of technology and other solutions, particularly where relevant to Australian conditions.

ARENA has invested over $77.6 million across 20 projects involving storage (see Attachment A). These include:

- off-grid demonstration projects that aim to prove reliability and control benefits of storage paired with renewables;
- a focus in some projects on new business models to facilitate the integration of renewables and grids;
- the allocation of a significant proportion of existing storage-related funding to concentrating solar thermal research and development, studies, and demonstration projects;
- a small number of projects focused on battery technology development; and
- projects investigating broader regulatory and consumer issues, such as the Future Proofing the Distribution Industry project led by the Clean Energy Council.

Pumped Hydro Energy Storage

Pumped Hydro Energy Storage (PHES) technology has the potential to provide cost-effective large-scale energy storage to complement high levels of renewable energy in the national electricity grid. ARENA is supporting the Australian National University (ANU) to produce an atlas of potential sites for pumped hydro utility-scale storage. This will be accompanied by new information on the cost structures of 'off-river' pumped hydro systems and their integration into local and state grids. Off-river pumped hydro provides utility-scale, short term energy storage, with the potential to be constructed wherever there is

suitable geographic elevation difference. Unlike traditional large-scale hydro electricity sources it does not need a large water supply and can operate independently of river systems.

By providing large-scale, rapid response energy storage, off-river pumped hydro can support electricity system reliability, for example to cover very occasional periods of extended cloud cover and low wind. Additionally, because it uses water flows to power a turbine, pumped hydro energy storage can provide the same grid stability services (such as grid inertia and frequency response services) as provided by traditional generators.

The ANU study seeks to illustrate pathways for renewable energy to provide a larger share of generation to the national electricity grid. It will also investigate the cost, efficiency and efficacy of pumped hydro systems in providing large-scale, reliable, clean energy storage that can feed into the grid on demand, in a range of suitable locations across Australia.

Concentrating Solar Thermal

ARENA continues to provide significant funding to a range of projects that are developing cost effective ways to collect and store heat from sunlight (solar thermal energy) to increase user confidence in solar energy, provide options for affordable and reliable electricity supply and heat for direct use.

ARENA supports research and development (R&D) of technologies that can store solar thermal energy and discharge it on demand to meet user needs. Concentrating Solar Thermal (CST) involves solar radiation being concentrated by lenses or mirrors onto a single point or receiver, which can then be converted directly into electricity or transferred as heat energy, through a heat transfer fluid, to an electricity generation system. Generation of electricity can use traditional steam turbines, typically used in existing coal-fired power plants.

While the levelised cost of CST is still comparatively high and bankability challenging, technology development shows promise for long term cost reductions. The business case for CST in electricity generation is likely to depend on its potential to provide a broader range of services beyond clean energy, such as dispatchable power using thermal energy storage, or ancillary grid support services. Similar to pumped hydro, these characteristics mean it could enable a high proportion of variable renewable generation with a high degree of electricity network reliability and security. CST is likely to be more efficient and competitive at larger scales (tens to hundreds of MW), meaning it is most likely to be part of a larger grid rather than the distributed resources of particular interest to the Inquiry. There is some potential for direct use at larger facilities, as illustrated by Sundrop Farms.

ARENA funds a number of R&D projects aimed at improving the efficiency and effectiveness of CST systems. One such major project is the Australian Solar Thermal Research Initiative (ASTRI). ASTRI provides an institutional framework for a coordinated, strategic, national approach to CST research in Australia. ASTRI coordinates a range of high-priority research activities, across CSIRO, the Australian National University, Flinders University, Queensland University of Technology, University of South

Australia, the University of Queensland and the University of Adelaide with the aim of improving the competitiveness of CST systems.

ARENA is also funding the Vast Solar CST pilot plant, at Jemalong NSW, which is expected to be commissioned in 2017. It will demonstrate the reliable and safe operation of the Vast Solar CST system as a fully functioning pilot-scale power generation facility.

ARENA is committed to reducing the cost of CST through R&D and demonstration to enable dispatchable electricity, by taking next generation R&D to an attractive point of commercial investment. This will provide a potential technology option for supporting grid security and reliability with a higher level of renewable energy.

Demand response

Demand response refers to energy users actively controlling when they use energy to help balance the overall supply and demand of electricity, making it another potential source of flexible capacity. Some ARENA projects use demand response as part of an overall integrated solution to enabling more renewables. For example, the Rottnest Island project includes active control of a desalination plant to make use of high levels of wind and solar energy.

Attachment A: List of relevant ARENA-supported Microgrid, off-grid and energy storage projects

Company/ Project	Sub-category	State	Description	Link
Lakeland Solar and Storage Pty Ltd	Hybrid/enabling technologies	QLD	Construction of large-scale solar plant with battery storage in a fringe-of-grid location, tested in 'island' mode, where the local distribution network is disconnected from the main transmission line.	https://arena.gov.au/project/lakeland-solar-storage-project/
Carnegie Wave Energy Ltd - Garden Island Microgrid Project	Hybrid/enabling technologies	WA	Demonstration of how wave energy can be integrated into a microgrid to produce both energy and desalinated water. The microgrid will serve the needs of a navy base.	https://arena.gov.au/project/garden-island-microgrid-project/
ANU	Solar thermal	ACT	High-temperature solar thermal energy storage via manganese-oxide based redox cycling.	arena.gov.au/project/high-temperature-solar-thermal/
Barbara Hardy Institute	Solar thermal	SA	Development of high temperature phase change storage system and test facility.	arena.gov.au/project/development-of-a-testing-facility-for-storing-heat-from-solar-energy-at-high-temperatures/
CSIRO	Solar thermal	NSW	Advanced solar thermal energy storage.	arena.gov.au/project/advanced-solar-thermal-energy-storage-technologies/
CSIRO	Solar thermal	NSW	Australian Solar Thermal Research Initiative (ASTRI)	arena.gov.au/project/astri-australian-solar-thermal-research-ini

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CSIRO	Tool development	NSW	Virtual Power Station 2: pilot-scale testing of load, generation and energy storage coordination.	arena.gov.au/project/virtual-power-station-2/
Abengoa Solar Power Australia	Solar thermal	WA	Dispatchable Solar Thermal Power Project – feasibility study.	arena.gov.au/project/feasibility-study-for-perenjori-20mw-dispatchable-solar-tower-project/
AUSTELA	Solar thermal	NSW	Potential Network Benefits of Solar Thermal Generation in the NEM.	arena.gov.au/project/potential-network-benefits-of-csp-in-the-nem/
Vast Solar	CST demonstration project	NSW	Vast solar 6MW (thermal) grid connected multi-module CST plant with thermal storage.	arena.gov.au/project/vast-solar-6mw-concentrating-solar-thermal-pilot-project/
ANU STORES	Pumped Hydro Energy Storage	ACT	Feasibility study to map potential short-term off-river pumped hydro energy storage (STORES) sites.	https://arena.gov.au/files/2016/11/161102_-JOINT-MEDIA-RELEASE-ARENA-ANU_Old-dog-new-tricks.pdf
Genex	Pumped Hydro Energy Storage	QLD	Kidston Pumped Storage Project.	arena.gov.au/project/kidston-pumped-storage-project/

UTS	Battery technology	NSW	Develop lithium-sulphur batteries for large-scale electrical energy storage.	arena.gov.au/project/lithium-sulfur-batteries-for-large-scale-energy-storage/
Smart Storage (Ecoult)	Battery technology	NSW	Distributed Solar PV Support and UltraBattery for remote area power systems.	arena.gov.au/project/ultrabattery-distributed-pv-support-and-ultrabattery-for-remote-area-power-supply/
First Solar (Australia)	Off-grid hybrid power project	QLD	Weipa Solar PV Project.	arena.gov.au/project/weipa-solar-farm/
Hydro Tasmania	Off-grid hybrid power project	TAS	Hydro Tasmania King Island Renewable Energy Integration.	arena.gov.au/project/king-island-renewable-energy-integration-project/
Hydro Tasmania	Off-grid hybrid power project	TAS	Flinders Island Energy Hub.	arena.gov.au/project/flinders-island-hybrid-energy-hub/
Lord Howe Island Board	Off-grid hybrid power project	NSW	Lord Howe Island Renewable Project.	arena.gov.au/project/lord-howe-island-hybrid-renewable-energy-system/
Ergon Energy	Residential battery roll-out	QLD	Trialling a new residential solar PV and battery model.	arena.gov.au/project/trialling-a-new-residential-solar-pv-and-battery-model/
Reposit Power	Battery and energy trading system	ACT	A commercially viable application of electricity storage	arena.gov.au/media/storage-so

			for Australia's national electricity grid.	lution-to-enhance-rooftop-pv
Synergy	High penetration PV and battery storage solution	WA	Alkimos Beach Energy Storage Project.	arena.gov.au/project/solar-and-storage-trial-at-alkimos-beach-residential-development/
Clean Energy Council	Renewable energy Integration	VIC	Study into future-proofing Australia's electricity industry (includes work on battery storage safety and standards)	arena.gov.au/project/future-proofing-in-australias-electricity-distribution-industry/
Sunverge Energy #	Storage	QLD	Deployment of solar integration system into the Australian market.	www.sunverge.com
Octillion Power Systems #	Storage	QLD	Development of advanced lithium-ion battery storage solutions for Australian and global markets.	www.octillion.us
IT Power (Australia) Pty Ltd	Storage	ACT	Testing the performance of lithium ion batteries	https://arena.gov.au/project/testing-the-performance-of-lithium-ion-batteries/
AGL	Storage	SA	Installation of 1,000 centrally controlled batteries in homes and businesses to provide storage to operate as a virtual power plant through centralised monitoring and management software.	https://arena.gov.au/media/battery-storage-set-strengthen-south-australian-grid/
AGL	Storage	SA	Energy Storage for Commercial Renewable Integration (South	arena.gov.au/project/energy-storage-for-com

			Australia) – feasibility study of grid-scale storage.	mercial-renewable-integration/
Clean Energy Council	Storage and enabling technologies	VIC	Consultation with industry, government, regulators and consumers with the aim of enhancing the flexibility and resilience of Australia's electricity distribution systems.	https://arena.gov.au/project/future-proofing-in-australias-electricity-distribution-industry/
Moreland Energy Foundation Limited	Microgrid	VIC	Virtual trial that examines how a grid connected solar PV and storage system could provide behind the meter needs for users.	https://arena.gov.au/project/moreland-micro-grid-investigation/
UTS Institute for Sustainable Futures - Kangaroo Island	Microgrid	SA	Cost-benefit analysis and technically feasibility study of establishing a microgrid on Kangaroo Island.	http://newsroom.uts.edu.au/news/2016/06/towards-100-renewable-energy-kangaroo-island-new-study-under-way
Curtin University	Microgrid	WA	Development of governance models to allow shared solar PV, battery, and monitoring systems in apartments and testing on units in the White Gum Valley Development.	https://arena.gov.au/project/increasing-the-uptake-of-solar-photovoltaics-in-strata-residential-developments/

Brookfield Energy Australia - Huntlee Residential Microgrid	Microgrid	NSW	Feasibility study to explore the commercial viability of installing a microgrid utilising renewable energy, energy storage and other enabling technologies for the new Huntlee housing developments to be built in the NSW Hunter Valley.	https://arena.gov.au/project/delivering-higher-renewable-penetration-in-new-land-and-housing-developments-through-off-grid-microgrids/

Note: Investment by the Renewable Energy Venture Capital Fund managed by Southern Cross Venture Partners