Innovation Frame 1: Show me the customer driven distributed energy market in action

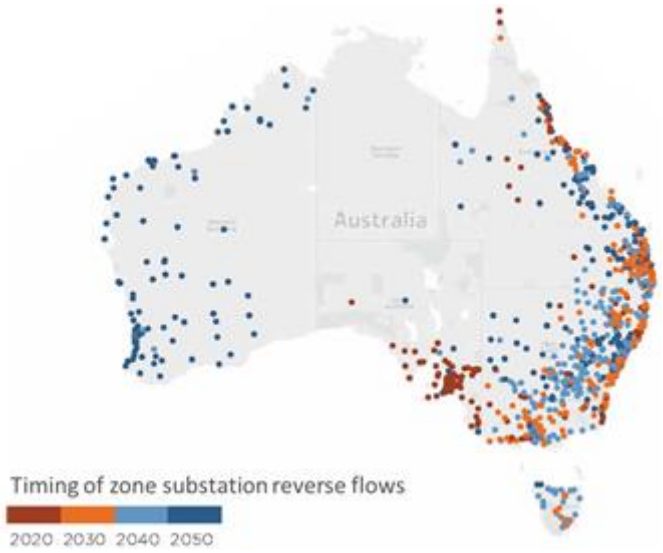
Ideate Event supporting the Electricity Network Transformation Roadmap Implementation Grid Orchestration Approach

Background

Earlier this year Energy Networks Australia and CSIRO reported[1] how "a future where up to 45% of all electricity is generated by the customers in 2050 – at the opposite end of the system from its original design – presents a very significant range of technical, economic and regulatory challenges".

Figure 1 below shows some of this impact unfolding across the network, with reverse flows beginning to manifest at zone substations in many areas by 2020 – particularly in South Australia.

Figure 1: Timing of reverse flows



Source: Electricity Network Transformation Roadmap, Final Report

The rise in distributed energy resources (DERs) will continue - fuelled by historically high electricity prices and declining technology costs. DER costs will continue to decline driven by scale efficiencies, further technology innovation, deeper delivery capability and competitive pressures. Customer bundles of solar, storage and demand response technologies will become increasingly valuable as they gain access to additional markets and value streams via aggregation and orchestration technologies or DERMS – Distributed Energy Resource Management Systems.

Customers will continue to drive grid edge innovation as they search for greater control over their energy costs and more value from their investments in DERs. This includes opportunities for owners of distributed energy resources to sell output back to the grid as an alternative to networks building their own infrastructure. Analysis by CSIRO for the Roadmap predicts that with the right pricing structures incentive frameworks and markets, networks could pay up to $2.6 billion per annum from 2050 to

[1] CSIRO and Energy Networks Australia 2017, Electricity Network Transformation Roadmap, Final Report.

MHC

Energy Networks Australia

customers for the use of distributed energy resources and in doing so reduce network charges by around 30%.

However, these new opportunities do not come without risk.

AEMO forecasts that by as early as 2026, rooftop solar PV in South Australia could be sufficient to supply 100 percent of demand at minimum demand periods. This level of penetration, whether un-orchestrated or coordinated, risks widespread overload or breach of distribution network technical constraints, leading to disconnection of generators and potentially whole sections of the distribution network. Given the likely magnitude of the volume of DERs in question, breaches of distribution network constraints might also trigger constraints at the transmission level, presenting wider system security risks.

Failure to address the problem of completely unmanaged flows across an electricity system is bad for any market and its participants. In the wholesale market, where generators bid supply against demand identified by AEMO, prices alone are not sufficient to maintain a secure operating state. Constraint equations additional to this market ensure that the dispatch of bidding generators is aligned with the physical constraints on the transmission system. A similar approach is even more necessary at the distribution level, where the inability to rely solely on price signals to coordinate potentially millions of small generators to guarantee supply is even more significant.

Opportunity for Innovation: ***How to operate the distribution system to facilitate customer choice and access to value from DER investments AND ensure that the efficiency, security and reliability of the network is maintained?***

(A version of) The distributed energy ecosystem of the future

Figure 2 below, outlines one possible example of how the distributed energy ecosystem might be organized to solve this challenge. Wherever possible we have tried to use the terms outlined in the Electricity Network Transformation Roadmap[2] to ensure consistency with the emerging nomenclature surrounding these new concepts. This is only one option for a possible future – there are many, but it is provided as a straw man for point of reference.

[2] CSIRO and Energy Networks Australia 2017, Electricity Network Transformation Roadmap. Synthesis Report: Future Market Platforms and Network Optimisation.

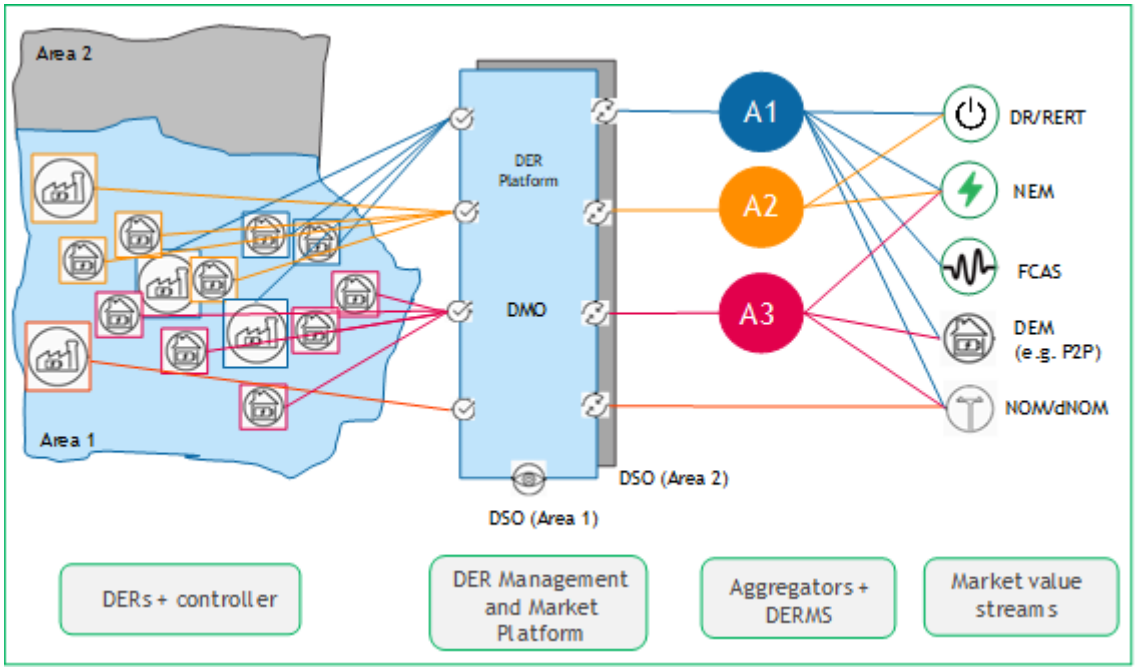


Figure 2: An overview of a potential future distributed energy ecosystem

- DERs – The distributed energy resources such as PV and battery systems and controllable loads purchased by customers and installed behind the meter. These DERs can be consolidated into an aggregated source of flexible capacity (e.g. additional supply, reduced demand) to support the balancing of supply and demand on the grid.
- Controllers - DERs need to be integrated with a controller unit which enables remote control and acts to optimise the operation of the system in response to remote communication signals. For DERs to be integrated into the DER platform they need to provide defined power products, be visible on the platform, and be remotely scheduled and dispatched.
- Aggregators (A1-A3 above) – Organisations who have a contractual relationship with a customer that allows them to interact with the customer's DER under certain circumstances, in return for financial compensation. They would do so in order to bid these resources into the wholesale market in aggregate.
- DERMS – Distributed Energy Resource Management Systems which enable aggregation and orchestration of the DERs in the Virtual Power Plant (VPP), sending signals to the DERs to influence their behaviour in order to provide value for customers and the system. Each Aggregator will have one or more DERMS to manage the DERs in their fleet.
- Market value streams – There are an increasing number of markets that DERs can access via their aggregators. Some may ultimately be accessible without the need for an aggregator (e.g. for very large customers), but in the main we assume the need for some sort of intermediary to provide sufficient scale for economic trading activity. These value streams could include:
    - Reliability and Emergency Reserve Trader (RERT) payments from AEMO to customers for demand response capability during emergency activation events. This source of market value has recently been supplemented by additional funding via the ARENA Demand Response Competitive Round.
    - The wholesale electricity market (NEM) which provides a strong price signal to customers based on the supply and demand situation in each jurisdiction.

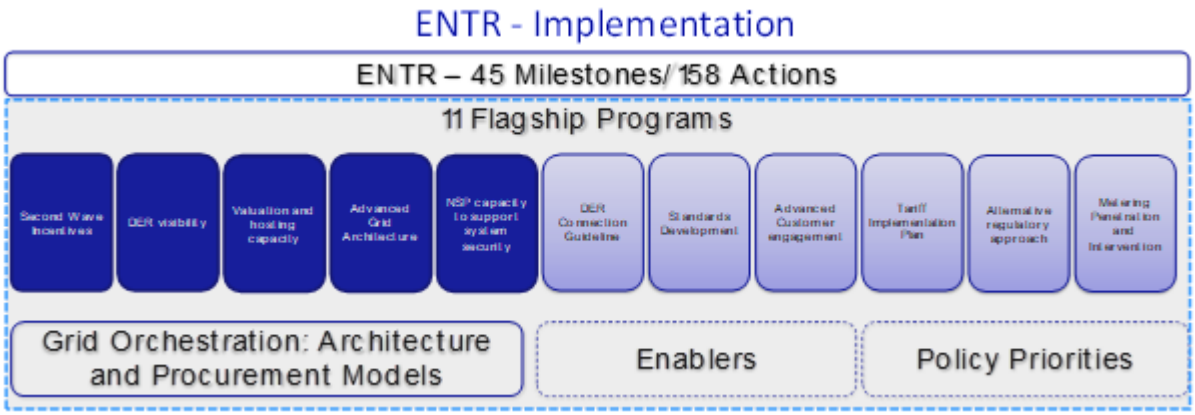
    - The frequency control and ancillary services (FCAS) market, which has been recently made accessible to bidding by aggregators. In future this could also include a market for Fast Frequency Response services.
    - The network optimisation market (NOM). Currently this market is in the form of the RIT-T and RIT-D which have only recently seen the involvement of DERs. GreenSync's non-network solution to a United Energy RIT-D in the Mornington Peninsula is one example. In the future it is envisaged that this market could increasingly become digitised to become a digital network optimisation market (dNOM) where a range of network services can be provided by aggregated DERs responding to more granular locational and temporal price signals in near real time (Second Wave Incentives).
    - Another emerging market is being referred to as the distribution-level energy market (DEM) where DERs ultimately trade with other customers via many-to-many or peer-to-peer relationships. These arrangements could be facilitated in the near term by a retailer arranging for energy trading within their customer group. Powershop's "Your Neighbourhood Solar" is an example of this market.
- DER management and market platform – A digital platform providing a standardised link between multiple aggregators and their DERs and multiple value streams to optimise the performance of the system. The platform can be thought of as having two layers:
    - A physical management layer, or DER Management Platform; provides for and details registration and visibility of the DERs, a communication link to enable the DERs to respond to market signals, and details of the physical constraints of the network to ensure DERs act in a way that maintains the reliability and security of the network.
    - A commercial trading layer; contractually connects the DER to a buyer, defines the service agreement between a buyer and seller. This layer also confirms that the DER acted in accordance with its instructions and facilitates reconciliation through market settlement.
- Distribution System Operator (DSO) – The DSO is responsible for safe, reliable and efficient operation of a high DER distribution system. In this ecosystem the DSO is an information provider - providing details of the physical constraints of the network to the DER Management Platform to ensure the market operates effectively. It would provide information upstream to the Transmission System Operator (TSO) about the activity on the distribution network to manage the operation of the Transmission and Distribution system interface. A DSO would:
    - Maintain distribution network resilience and security
    - Support whole system stability
    - Provide fair and cost-effective distribution network access
    - Provide capacity in an efficient, economic, coordinated and timely manner
    - Support whole system optimisation
    - Enabling and facilitating competition in energy markets
    - Provide and maintain systems, processes and data to facilitate markets and services
- Distribution Market Operator (DMO) – The DMO operates and manages the platform to ensure that participants meet registration requirements, information transparency, dispatch reconciliation and market settlement.

A pathway to the future: ENTR Roadmap Flagship Programs relating to distributed energy ecosystem functions

Since the delivery of the Electricity Network Transformation Roadmap (ENTR) in May, 2017, Energy Networks Australia has been exploring how to progress key Roadmap actions and priorities.

To identify key priorities Energy Networks Australia has shaped a Roadmap Implementation Program and identified Flagship programs. These are critical activities that are essential to Roadmap success, require immediate action, and collective leadership. Most require close collaboration with a wide range of stakeholders.

The diagram below illustrates how ENTR Flagship programs have been grouped as Enablers, Policy Priorities and Grid Orchestration. The programs have been grouped as follows to allow for alignment of Grid Orchestration – Architecture and Procurement Models that require a cohesive approach to program design and execution.



It is expected that these programs will contribute towards a Distribution System Operator (DSO) Strategy that will be developed as the Roadmap Implementation progresses.

These 5 Roadmap Implementation Flagship programs now form the basis of an ARENA innovation lab program to:

- Explore Distribution System Operator (DSO) design requirements
- Explore what is required for DSO interface and how to best utilise data
- Identify how a system with a high penetration of distributed energy resources (DERs) can be operated efficiently for the future we need
- Encourage industry alignment to accelerate network transformation and consider opportunities to create projects and trials to explore these issues in real world settings

Grid Orchestration Approach

Second Wave Incentives

Program Objectives:

- Establish how networks would implement locational and dynamic incentives which would allow networks to procure operational access to DER and would allow proponents to compete for these service requests
- Establish how these procurement arrangements would relate to customer facing products
- Allow open trials of these procurement frameworks across the NEM being funded by 2020 to test viability of different operational access platforms

- Ensure these procurement arrangements can be catered for in the next round of tariff structure statements

DER visibility

Program Objectives:

- Determine and develop effective data sharing frameworks to provide the Australian Energy Market Operator (AEMO) with greater visibility of DER at a distribution network level.
- Determine minimum data requirements for provision of information from DSO to IMO, and improved processes around TSO/DSO services and operation
- This will include specification of options for DSO/IMO/TSO interface which will define how IMO and DSO will interact
- Develop new DER adoption forecasting tools which model the forward impacts of DER growth across different levels of the network
- Determine the level of visibility and forecasting requirements required by AEMO to manage the system (determined in collaboration with AEMO)
- Establish roles, spec data required, likely cost, find optimal balance between cost and benefit and develop detailed specifications for data sharing and communication and control protocols
- Develop a more detailed view of the required transition from DNO to DSO & required intelligence & decision making tools at interface with IMO/TSO

Advanced grid architecture

Program Objectives:

- Define and establish the minimum technical architecture, for either decentralised or wide area scale, future power system requirements including sensing, core algorithm requirements, measurements and data exchange, and communications.
- Establish minimum requirements to deliver coherent open source architecture for to enable the needed step change in capability to integrate, manage and optimise distributed technologies and services, including cross vector issues;
- Designed-in flexibility & agility for identifying and responding to change requirements.

Valuation and hosting capacity

Program Objectives:

- Evaluate the techniques tools and solutions that could be deployed to provide greater visibility of DERs, future drivers of costs to networks which could be impacted or addressed by DER and options for integrating DER into network operations
- Develop network strategy to support effective integration of DER into network operations
- Develop and test valuation frameworks that would assist with the integration and orchestration of DER with other network flows

NSP capacity to support system security

Program Objectives:

- It is suggested that this program could provide inputs to define the central and transformed role for the transmission system to support power system security and would leverage off recommendations in Power System Security Reviews being undertaken by AEMO, AEMC and Finkel Blueprint recommendations.

Further details regarding these programs, the Roadmap milestones addressed by each and the proposed actions and timeframes are provided in Appendix A.

Existing Projects

The ENA has identified a number of projects which are either completed, in progress or planned which will make a meaningful contribution to the progress against the program objectives listed above. Details of some these projects are provided in Appendix B, and they are mapped against the 5 ENTR Grid Orchestration Program in the table below. Note: this mapping has been undertaken based on limited information and will be further explored with the group at the Ideate workshop.

	Second Wave Incentives	DER Visibility	Advanced Grid Architecture	Valuation & Hosting Capacity	NSP Capacity to support system security	Comments
SAPN – Salisbury VPP						Further details in Appendix B
SAPN – Greenfield Community Microgrid						Further details in Appendix B
SAPN - confidential						Further details to be discussed at the workshop
United Energy – deX trial (TGCP)						Focus on network augmentation deferral, Mornington Peninsula
UQ, EQ, EE United – MV visibility						Further details to be discussed at the workshop
EQ-Optimal Incremental Pricing (OIP)						Further details in Appendix B
EQ - VPP						Focused on C&I customers
Consortium – Open Network Data Gateway						A current A-Lab project

Key

	At least one Roadmap Objective addressed		Most Roadmap Objectives addressed
	Multiple Roadmap Objectives addressed		All Roadmap Objectives addressed

Gap Analysis - Opportunities for Innovation

While this will be explored further in the A-Lab workshop, the preliminary analysis detailed above has identified a number of potential gaps in the suite of existing projects and the objectives identified by the Roadmap to progress the Grid Orchestration approach. These gaps represent opportunities for innovation and will likely be priority areas for project ideas generated in the A-Lab ideate workshop.

Key gaps include:

- Second wave incentives:
    - **Test more dynamic pricing arrangements:** Although there have been trials identifying locational based price incentives, there is opportunity to test targeted and localised pricing arrangements and how these might be calculated in areas identified with some type of emerging constraint, signalled to the market, responded to by DERs and organised into a customer offering.
- DER visibility:
    - **Interface management**: Significant opportunity exists to explore the options for DSO/IMO/TSO interface management and how IMO and DSO will interact
    - **DER forecasting tools;** Particularly as they relate to the DSO/IMO/TSO interface, the impacts on broader wholesale markets, system planning and operation
    - Intelligence & decision making tools at interface with IMO/TSO
- Advanced Grid Architecture
    - **Defining minimum technical architecture:** Although work has been progressing (particularly on the deX project) on open source architecture, the opportunity exists to explore the minimum technical architecture, for either decentralised or wide area scale, future power system requirements including sensing, core algorithm requirements, measurements and data exchange, and communications
    - Defining **minimum technical requirements** for real-time identification and communication of Network Support Requirements
    - Using these technical requirements will help to provide **functional capability** to support an emerging DSO function.
    - Requirements for **control systems** and **protection systems**
    - Requirements for **DER forecasting below the zone substation level**
- Valuation and Hosting Capacity
    - **Develop and test valuation frameworks:** Further work is needed to develop strategies to support effective integration of DER into network operations and to develop and test valuation frameworks that would assist with the integration and orchestration of DER with other network flows
- NSP Capacity to support system security
    - **Enhance system security:** This area is particularly lacking in existing projects and, given the recommendations of the Finkel Review, presents a significant opportunity for innovation.

Appendix A: ENTR Grid Orchestration Programs

Roadmap Flagship Program	Second Wave Incentives	DER Visibility	Advanced Grid Architecture	Valuation & Hosting Capacity	NSP Capacity to support system security
Roadmap Milestones Addressed by the Program	• **Incentives and Network Regulation - Milestone 4:** By 2027, network orchestration using DER on a dynamic, locational basis, results in one in three customers selling their DER services to networks on a dynamic, locational basis, directly or through their agents: – **Action 1:** By 2018, develop an appropriate framework for procuring operational access on a dynamic and locational basis that would allow proponents to compete for the service requests – **Action 3:** Between 2018 and 2021, networks **develop** frameworks to implement locational & dynamic incentives which act in competition to traditional network augmentation/replacement expenditure or non-network solutions under RIT-T frameworks • **Network Optimisation and Markets - Milestone 1**: By 2018, networks with very high distributed energy resources levels are	• **Power System Security - Milestone 3:** By 2019, an initial approach has been developed for coordinating and optimising decisions across the power system as a whole, which includes more effective interfacing between the Independent Market Operator and the distribution network connection points. – **Action 1:** By 2018, Specifications have been developed and agreed for scope and access to information at the interface between the transmission and distribution networks – **Action 2:** By 2019, Capability for real-time communication and controls between the IMO and distribution system – **Action 3**: By 2019, Enhanced intelligence & decision making tools at interface between AEMO and transmission and distribution networks • **Power System Security – Milestone 4:** By 2020, new tools and models have been developed to provide better	• **Grid Transformation – Milestone 3:** By 2019, an integrated suite of distributed grid intelligence and control architectures and tools have been agreed as foundational to the safe, reliable and efficient operation of a high distributed energy resources distribution system. – **Action 1:** By 2018, identify the technical priorities for distributed Grid Intelligence and Control – **Action 2:** By 2018, develop a framework to facilitate Demand Side Response and appropriate monitoring – **Action 3:** By 2019, establish minimum technical standards for LV system sensing & measurement – **Action 4:** By 2019, minimum technical requirements established for DER & microgrid interoperability • **Grid Transformation - Milestone 4:** By 2020, an integrated suite of advanced network operation	• **Intelligent Networks and Markets – Milestone 2:** By 2019, an integrated suite of advanced network planning models, techniques and distributed energy resources services valuation methods have been established as foundational to the mainstreaming of distributed energy resources services as non-network alternatives. – **Action 1:** By 2018, develop tools for evaluation of cost-benefits of the range of technological and commercial solutions that will be deployed – **Action 2:** By 2018, Procure DER resources with the capability and expectation of being utilized with automatic optimization processes, with appropriate incentives to motivate their participation – **Action 3:** By 2020 some networks establish trials to test the technical operation of the optimization processes to	• **Power System Security – Milestone 1:** By 2018, the central and transformed role for the transmissions system to support power system security has been defined. – **Action 2:** By 2018, Develop new tools to assess, test and extend power system planning approaches – **Action 3:** By 2018, Transmission businesses have commenced detailed evaluation and trials into the feasibility of employing synthetic inertia such as electrical energy storage, SVCs and flywheels – Action 4: By 2018, Develop transmission operating techniques for dealing with intermittent generation resources, including any changes required to market rules

Roadmap Flagship Program	Second Wave Incentives	DER Visibility	Advanced Grid Architecture	Valuation & Hosting Capacity	NSP Capacity to support system security
	implementing basic NOM functions to procure locational distributed energy resources services for network support, either directly from customers and/or through their agents. – **Action 1:** By 2018, many network businesses have identified the key locations where DER may result in short term savings in network augmentation. – **Action 2:** By 2019, establish and collate information to allow participants to assess available opportunities for DER provision. – **Action 3:** By 2019, establish simple procurement mechanisms that encourage DER development from DER providers or aggregators.	forecasting to better anticipate where environmental and system constraints could lead to system security issues. – **Action 1:** By 2017, development of new operational techniques for reliable forecasting of future operation of renewable generation and DER – **Action 2:** By 2018, establish appropriate methodologies and processes for providing this information for the market operator control functionality	mechanisms and tools should be agreed as foundational to the safe, reliable and efficient operation of a high distributed energy resources distribution system which also contributes to overall power system security – **Action 1:** By 2020, minimum technical requirements for real-time identification and communication of Network Support Requirements – **Action 2:** By 2020, minimum technical and procedural requirements should be established for enhanced visibility, communication and co-ordination between the IMO and DNSP/DSO	meet a range of system objectives • **Power System Security – Milestone 4:** By 2020, new tools and models have been developed to provide better forecasting to better anticipate where environmental and system constraints could lead to system security issues. – **Action 1:** By 2017, development of new operational techniques for reliable forecasting of future operation of renewable generation and DER – **Action 2:** By 2018, establish appropriate methodologies and processes for providing this information for the market operator control functionality	

Appendix B: Existing Projects Overview

OIP (Optimal Incremental Pricing)

Project Partners	*Ergon Energy*
Project Location	*Queensland*
Project Timing	*Commenced and BAU operational*
Project Funding Source	*NNA*

Project Description

Ergon Energy's Optimal Incremental Pricing (OIP) has been developed to encourage locational market and customer led investment in demand side technologies as alternatives to network investment. The OIP approach to valuing demand side opportunities enables the calculation of locational based non-network alternatives prior to the network investment being fully quantified.

The OIP methodology is built using a self-learning optimisation algorithm with an inbuilt feedback mechanism that includes market response and load growth forecasts. The utilization of the feedback mechanism ensures the valuation of demand side resources self-corrects depending on the network risk and market activity.

Demand management programs that have been run to date within Ergon Energy have shown that demand management can be more efficient when the incentive is used to alter what a customer will buy, not when they will buy. The OIP allows Ergon Energy to engage and incentivise the market earlier providing increased time for the market to respond and enabling greater customer choice.

What areas of the roadmap does this project address? (see next page for more details)

☒ Second Wave Incentives	☒ Valuation and hosting capacity	☐ NSP capacity to support system security
☐ DER visibility	☐ Advanced grid architecture	

Any additional comments?

Project enables second wave incentives in a geospatial manner and directly supports ENA initiatives of:

- *Second Wave Incentives*
- *Valuation and hosting capacity*

The outputs from the initiative can be leveraged through connection to:

- *DER connection guidelines*
- *Tariff Implementation*
- *Standards*
- *Advanced customer engagement*

Salisbury Battery Trial

Project Partners	*SA Power Networks, Reposit Power*
Project Location	*Salisbury, South Australia*
Project Timing	*July 2016 – July 2019*
Project Funding Source	*DMIA*

Project Description

The objective of the Salisbury Battery Trial was to deploy 100 residential battery storage systems in the Salisbury area of South Australia in order to:

- *Validate assumptions about benefits accruing from batteries*
- *Better understand network impacts*
- *Defer a $2.9 million network upgrade*

Customers were offered the purchase or lease of a subsidised battery in exchange for providing SA Power Networks with the ability to:

- *Monitor their system; and*
- *Dispatch energy from their system at certain times when the local network is under stress*

Systems were priced at a level so as to provide a 5 – 7 year payback from retail energy cost savings. The systems were also configured with back-up power as standard and with an option to subscribe to 'grid credits' – allowing an aggregator to utilise their battery to dispatch into the NEM during high price periods.

Customers without solar were also offered panels at a competitive price as part of the package.
The trial has enabled validation of tangible and intangible benefits accruing to battery customers. It has also provided valuable insights into the implications of high penetration 'passive' and 'orchestrated' DER on distribution networks. Finally, it has demonstrated the use of DER as a means to defer network augmentation.

What areas of the roadmap does this project address? (see next page for more details)

☒ Second Wave Incentives	☒ Valuation and hosting capacity	☐ NSP capacity to support system security
☐ DER visibility	☐ Advanced grid architecture	

Any additional comments?

As well as informing issues that may arise in high penetration DER networks, the trial will provide a test-bed for experimenting with new approaches to remediating DER impacts within a reasonable sample of 'typical' customers.

Greenfield Community Microgrid Trial

Project Partners	*SA Power Networks, Property developer, Reposit Power, CSIRO*
Project Location	*Metropolitan Adelaide, South Australia*
Project Timing	*January 2017 – December 2021*
Project Funding Source	*ARENA, regulated opex, partner contributions*

Project Description

The Greenfield community microgrid trial seeks to inform:

- *Optimal network designs in high DER situations;*
- *The ability of centralised control systems to effectively orchestrate resources to manage local network performance & minimise upstream demand impacts;*
- *Savings that might accrue to customers under such a scenario; and*
- *Customers' receptiveness to such models of electricity supply.*

To achieve these outcomes, a 240 home greenfield residential development will be constructed with:

- *Home energy systems as standard: incorporating solar, batteries, intelligent appliances and various feedback mechanisms;*
- *A 'thin' network connection; and*
- *Control systems that seek to orchestrate the resources to meet local network constraints and optimise costs for customers.*

The trial has not yet commenced, pending contract execution between the developer and the SA Government.

What areas of the roadmap does this project address? (see next page for more details)

☒ Second Wave Incentives	☒ Valuation and hosting capacity	☐ NSP capacity to support system security
☐ DER visibility	☒ Advanced grid architecture	

Any additional comments?

As well as informing issues that may arise in high penetration DER networks, the trial could provide a test-bed for experimenting with new approaches to remediating DER impacts within the same local network area.