Project Symphony

Our energy future

Vision and Impact Pathway

Citation and disclaimer

Citation: Alexander, D., Blaver, A. 2021. *Project Symphony: Vision and Impact Pathway*, September 2021

Disclaimer: This project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program. The authors have used all due care and skill to ensure the material is accurate as at the date of this report. The Institute for Sustainable Futures and the authors do not accept any responsibility for any loss that may arise by anyone relying upon its contents. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

Institute for Sustainable Futures (ISF)
University of Technology Sydney
PO Box 123 Broadway, NSW, 2007
www.isf.uts.edu.au

In partnership with:

western power synergy AEMO Government of Western Australia Energy Policy WA

Executive Summary

The purpose of this document is to capture the **collective vision** of Project Symphony, placing it in the context of the suite of Australian DER integration projects, and outline an **impact pathway**, particularly in the context of the Western Australian (WA) energy market, to achieve the project objectives.

The rapid growth in distributed energy resources (DER), while delivering significant financial and environmental benefits for individuals owning DER, is leading to a range of emerging issues for network operators. The WA community is installing DER like rooftop solar at unprecedented rates. However, the high penetration of DER poses a significant risk to the stability of the power system at times of low system demand. Based on advice from the Australian Energy Market Operator (AEMO) the stability of the SWIS may be at material risk as early as 2022, if DER are not efficiently and effectively managed.

In recognition of this risk, in April 2020 the WA Government published a DER roadmap for Western Australia (the DER Roadmap) to support the integration of DER into the South West Interconnected System (SWIS) and the Wholesale Electricity Market (WEM), and support changes to energy policy and regulation stemming from the energy value chain evolution. As the Western Australia's 'flagship' DER aggregation and orchestration pilot, Project Symphony is directly linked to two DER Roadmap activities and has interdependencies with many other DER Roadmap activities.

The overall vision for Project Symphony (the Project) is to progress toward a future where the integration and participation of DER in markets supports a safe, reliable, lower carbon and more efficient electricity system.

Project Symphony is an exciting and innovative project, part-funded by the Australian Renewable Energy Agency, where customer DER like rooftop solar, battery energy storage and other major appliances, like air conditioning and pool pumps, will be orchestrated as a virtual power plant (VPP) to participate in a future energy market and unlock greater economic and environmental benefits for customers and the wider community. As such, Project Symphony encompasses end-to-end transactions that enable a value chain for customer DER assets to participate in the WEM. To achieve its purpose, the four partners of the Project - being Western Power, Synergy, AEMO and Energy Policy WA – will undertake seven work packages, supported by targeted knowledge brokering.

Project Symphony

Our energy future

Roles of Project Symphony partners

Western Power: Project Lead, network operator and Distribution System Operator (DSO)

- Provide a DSO 'platform', in part to identify the maximum renewable energy hosting capacity
- Deploy up to 2MW of front of meter batteries in a location in the Southern River pilot area.
- Install network monitoring within the Southern River region.

Synergy: Residential retailer and responsible for DER valuation and customer acquisition

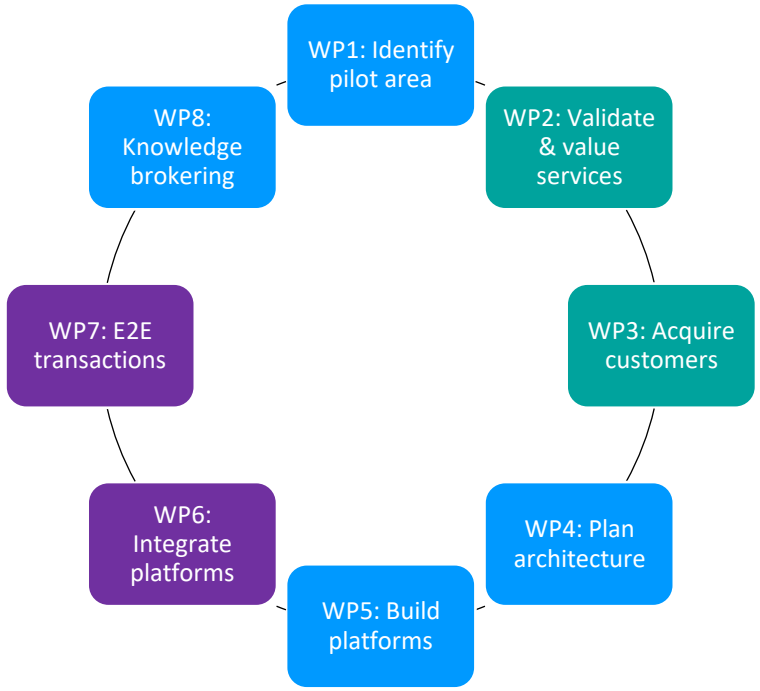
- Lead the customer interactions to achieve a suitable mix and concentration of at least 900 DER assets.
- Procure, design, build, integrate and test an Aggregator platform
- Build an understanding of DER customer sentiment in relation to more active participation in markets.

AEMO: System and Market Operator and the Distribution Market Operator (DMO)

- Provide a two-sided market platform, comprised of wholesale and system support services
- Organise and operate the market and assess all bids and offers and optimises the dispatch of energy resources in consideration of transmission network and distribution network constraints.

Energy Policy WA is the government agency responsible for the delivery of energy policy advice to the WA Minister for Energy and is also responsible for supporting the delivery of the government's Energy Transformation Strategy, including a key partner to Project Symphony providing active guidance and oversight.

Project Symphony work packages



In partnership with:

western power synergy AEMO Energy Policy WA

The **impact pathway** is designed to aid in the monitoring and evaluation of each work package throughout the Project and based on a mutually exclusive and collectively exhaustive life-cycle framework that leverages ARENA's "technology readiness levels" (TRLs) and "commercial readiness index" (CRI). Project Symphony (in parallel with Project EDGE in the NEM) is unique as the first end-to-end pilot of a new energy market, using new and existing assets, rather than an independent and/or incremental trial of specific elements of the technology solution. However, it is actively incorporating the lessons that have been learned through previous DER related trials to incorporate the most up-to-date knowledge and test the best ideas that have been presented. These lessons have been directly mapped to each work package in a way that informs the current state (TRL and CRI) along with the stages needed to reach greater technology and commercial readiness.

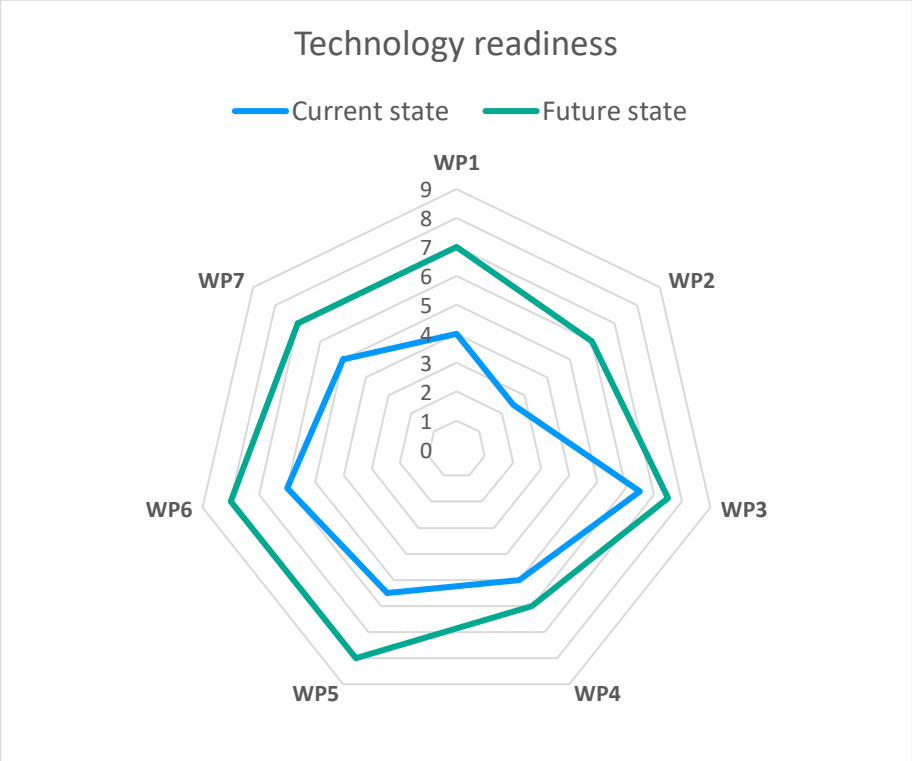
The outcomes of the consolidated work packages over the next two years will determine the viability of Project Symphony as a mainstream option for integrating DER in WA and will substantially inform the policy and regulation requirements to achieve technology and commercial readiness and customer acceptance. This will also assist NEM participants as a live whole-of-system example that could be further implemented across Australia. The expected progress (impact) of Project Symphony is estimated against the TRL and CRI framework to determine a likely future state, working towards mainstreaming DER integration in WA.

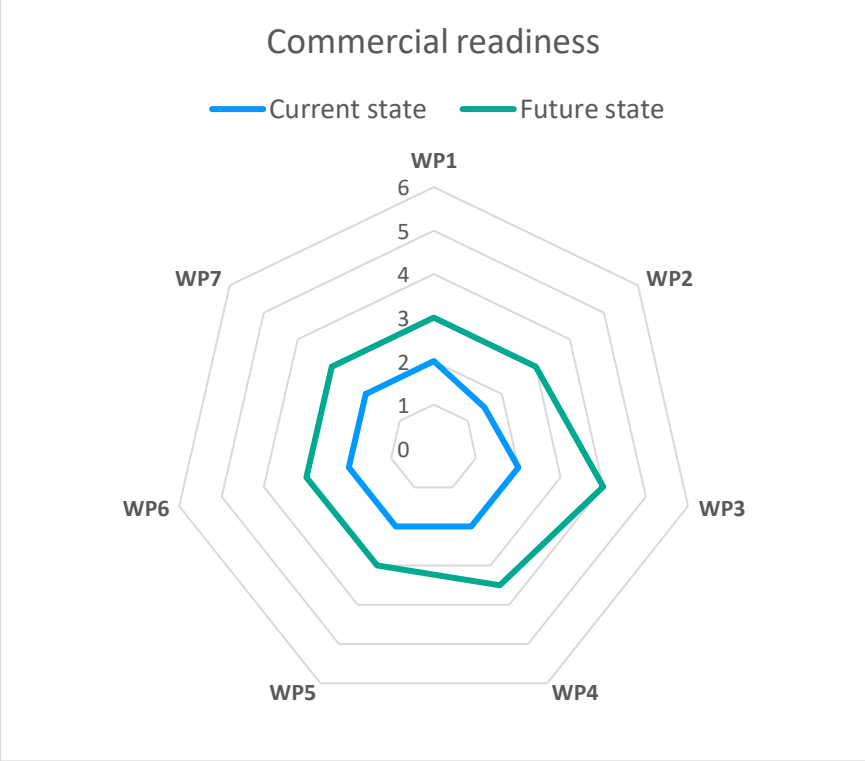
The **preliminary analysis** of the impact pathway is summarised below by work packages 1-7 to represent the life-cycle of DER integration and orchestration. This analysis suggests that Project Symphony will:

- Progress the technology readiness of DER orchestration by between one to four levels across the life-cycle, with the largest shift across Work Package 2 that is expected to move from TRL 2.5 to TRL 6, and
- Generally progress commercial readiness from commercial trial (CRI 2) to commercial scale-up (CRI 3), with greater progress expected towards the acquisition of customers (WP3) which will be demonstrated across multiple jurisdictions (CRI 4).

Further detail of this analysis by work package is provided in the Project Symphony: Impact Pathway section of this report.

This framework will be used to guide the mid-term (Work Package 8.2 Mid-Project Assessment) due in June 2022, and final project evaluation (Work Package 8.4 Project Close Out Report) due in June 2023 to determine whether Project Symphony is meeting its stated objectives and progress against the technology readiness and commercial readiness goals. Project outputs from each work package will be assessed against the technology and commercial readiness framework along with an update to the contextual analysis of concurrent DER integration projects, including Project EDGE. The evaluation will also outline considerations for policy makers and regulators, including EPWA to inform its delivery of the DER Roadmap.





Project Symphony

Our energy future

Acronyms and glossary of terms

Term	Definition
Advanced Distribution Management System (ADMS)	An Advanced Distribution Management System (ADMS) is the software platform that supports the full suite of distribution management and optimisation e.g. fault location, isolation and restoration, volt/volt-ampere reactive optimization, conservation voltage reduction; peak demand management, and support for microgrids.
Advanced Meter Infrastructure (AMI)	Advanced Metering Infrastructure (AMI) typically includes smart meters (that measure bidirectional energy flows, in shorter time intervals), upgraded communications networks (to transmit large volumes of data), and requisite data management systems.
Aggregator	A party which facilitates the grouping of DER to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the system operator(s).
Application Programming Interface (API)	An Application Programming Interface (API) is a set of functions through which two software systems can communicate without any human intermediation.
Australian Energy Market Operator (AEMO)	The Australian Energy Market Operator (AEMO) manages Australia's electricity and gas markets including operating the systems for energy transmission and distribution, and the energy financial markets. NB: AEMO manages the WEM separately to the NEM, under different rules, funding, and governance structures.
Australian Renewable Energy Agency (ARENA)	The Australian Government-funded agency whose purpose "is to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy through innovation that benefits Australian consumers and businesses" (ARENA website, accessed 15 August 2021)

Term	Definition
Behind the meter	Any technology located on the customer's side of the customer-network meter.
Direct Load Control (DLC)	Direct Load Control (DLC) is where utilities provide a payment to customers to control the operation of their equipment e.g. an air-conditioning unit or hot water system.
Distribution Constraint Optimisation Algorithm (DCOA)	The calculation of available network capacity that enables the publishing of the dynamic operating envelope in a given time interval for a given location within a segment of an electricity distribution network.
Distributed Energy Resources (DER)	Distributed Energy Resources or 'DER', are smaller–scale devices that can either use, generate, or store electricity and form a part of the local distribution system, which serves homes and businesses. DER can include renewable generation, energy storage, electric vehicles (EVs), and technology to manage load at the premises. These resources operate for the purpose of supplying all or a portion of the customer's electric load and may also be capable of supplying power into the system or alternatively providing a load management service for customers.
Distribution Market Operator (DMO)	A Distribution Market Operator (DMO) is a market operator that is equipped to operate a market that includes small-scale devices aggregated and able to be dispatched at appropriate scale (Energy Transformation Taskforce, 2020).
Distribution Network Service Provider (DNSP)	Distributed Network Service Providers (DNSPs) are the organisations that own and control the hardware of the distributed energy network such as power poles, wires, transformers and substations that move electricity around the grid.

Term	Definition
Distribution System Operator (DSO)	A Distribution System Operator (DSO) enables access to the network, securely operates and develops an active distribution system comprising networks, demand, and other flexible DER. Expanding of the network planning and asset management function of a DNSP, the DSO enables the optimal use of DER of distribution networks to deliver security, sustainability and affordability in the support of whole system optimisation (Energy Transformation Taskforce, 2020).
Dynamic Operating Envelope (DOE)	A dynamic operating envelope (DOE) is a principled allocation of the available hosting capacity to individual or aggregate DER or connection points within a segment of an electricity distribution network in each time interval. A dynamic operating envelope essentially provides upper and lower bounds on the import or export power in a given time interval for either individual DER assets or a connection point, may also apply at a nodal level.
Electric Vehicle (EV)	Electric vehicles (EVs) refers to cars or other vehicles with motors that are powered by electricity rather than liquid fuels.
Heating Ventilation and Air Conditioning (HVAC)	Heating, ventilation and air conditioning (HVAC) systems are responsible for heating and cooling and include products like furnaces, air conditioners, heat pumps as well as ductwork, thermostats and other comfort controls.
Hosting capacity	DER hosting capacity is defined as the typical amount of DER that can be connected to a distribution network without requiring network augmentation while the network (and the electricity system as a whole) remains within its technical limits.
Geographic Information System (GIS)	A GIS is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface.

Term	Definition
Grid architecture	Grid architecture is the specialization of system architecture for electric power grids. As such, it includes not just information systems, but also industry, regulatory, and market structure; electric system structure and grid control framework; communications networks; data management structure; and many elements that exist outside the utility but that interact with the grid, such as buildings, merchant DER, and microgrids (Taft and Becker-Dippmann, 2015).
Low Voltage (LV) Network	Part of the distribution network which carries electricity from distribution transformers to customers who take supply at the low voltage level (240V)
National Electricity Market (NEM)	NEM is a wholesale market through which generators and retailers trade electricity in Australia. It interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia. Western Australia and the Northern Territory are not connected to the NEM.
Network constraints	When a section of an electricity network approaches its technical limits.
Network support service	A contracted service provided by a generator / retailer / demand side program / DER aggregator to help manage network limitations on the LV network. Services relieving transmission network constraints are provided under the Non-Cooptimised Essential System Services framework.
Photovoltaic (PV)	A photovoltaic (PV) cell, commonly called a solar cell, is a nonmechanical device that converts sunlight directly into electricity.
OSI PI (Process Information)	OSI is a proprietary software product for real-time data management – capturing, processing, analysing and storing – of process information

Term	Definition
Reactive power	The power which flows back and forth meaning it moves in both the direction in the circuit or react upon itself, is called Reactive Power. The reactive power is measured in kilo volt ampere reactive (kVAR) or MVAR.
South West Interconnected System (SWIS)	South West Interconnected System (SWIS) is an electricity grid in the southwestern part of Western Australia. It extends to the coast in the south and west, to Kalbarri in the north and Kalgoorlie in the east.
System architecture	System architecture is a discipline for describing, analyzing, and communicating structural representations of complex systems. Colloquially, a system architecture is a model of a (complex) system, the purpose of which is to help think about the overall shape of the system, its attributes, and how the parts interact (Taft and Becker-Dippmann, 2015).
Telemetry data	Telemetry data is measured at the aggregated or individual device (NMI) level. This dataset consists of a set of key DER system variables at a minimum 4-minute (or real time) resolution
Time-of-use tariff	A retail tariff structure that includes different variable charges for energy depending on the time of day the energy is consumed by the customer.
Virtual Power Plant (VPP)	A virtual power plant (VPP) broadly refers to an aggregation of distributed energy resources (such as decentralised generation, storage and controllable loads) coordinated to deliver services for power system operations and electricity markets.

Term	Definition
Whole of System Plan (WoSP)	The WoSP is a long-term and detailed plan developed by Western Power, the State Government, EPWA and AEMO. It documents how the generation, management and distribution of energy in the SWIS will change over the next few decades, and what needs to be done to respond, such as the investment or infrastructure required.
Wholesale Electricity Market (WEM)	Wholesale Electricity Market (WEM), operated by AEMO, controls the supply and trading of wholesale electricity between retailers and generators on the South West Interconnected System.

Project Symphony

Our energy future

Table of Contents

1. Introduction and context

The purpose of this document is to capture the **collective vision** of Project Symphony, placing it in the context of the suite of Australian DER integration projects, and outline an **impact pathway** particularly in the context of the Western Australian energy market, to achieve the project objectives. The collective vision has been co-developed and agreed by members of the project team and tested with key Australian industry stakeholders. The impact pathway informs a robust and independent monitoring and evaluation (M&E) protocol to assess the viability and performance of different technical and commercial pathways for the duration of the project given the relative immaturity of the solutions. The impact pathway is focused on the context of Project Symphony in the Wholesale Electricity Market (WEM) more specifically, with reference to the National Electricity Market (NEM) more broadly. The document is structured as follows:

- This section further describes the context in which Project Symphony exists
- The collective vision is described along with the project's objectives and activities
- The project's impact pathway is summarised and then detailed by each work package that will be undertaken
- The next steps for the project are outlined, including the policy implications

1.1. Project Symphony in the context of the Western Australian energy transition

The Western Australian Government owns three corporations with active roles in the WA electricity supply chain. Two of these corporations are involved in Project Symphony: Western Power, which is solely responsible for building, maintaining and operating the electricity transmission and distribution network within the South West Interconnected System (SWIS); and Synergy, which sells and generates power within the SWIS. Synergy is the sole retailer available to all customers consuming less than 50MWh/year in the SWIS. Retail and export tariffs are regulated and set by the State Government for these customers as part of the State Budget processes and are subject to varying degrees of subsidisation.

Unlike the NEM, the SWIS is an isolated network that must balance all demand and generation loads internally without reliance on interconnectors. The independent Australian Energy Market Operator (AEMO) has the role of ensuring this balance is maintained at all times as it manages the security if the SWIS and the WEM.

Energy Policy WA (EPWA) is the government agency responsible for the delivery of energy policy advice to the WA Minister for Energy and is also responsible for supporting the delivery of the government's Energy Transformation Strategy, including a key partner to Project Symphony providing active guidance and oversight.

The rapid growth in distributed energy resources (DER), such as rooftop solar, while delivering significant financial and environmental benefits for individuals owning DER, is leading to a range of emerging issues for network operators such as Western Power and challenging the traditional electricity generation and retail business models. The WA community is installing rooftop solar at unprecedented rates. With one in three households in the SWIS already having a rooftop solar PV system, and around 4,000 households adding a new system each month[1], customers with DER are already enjoying the benefits of lower electricity bills while contributing to de-carbonising the power system.

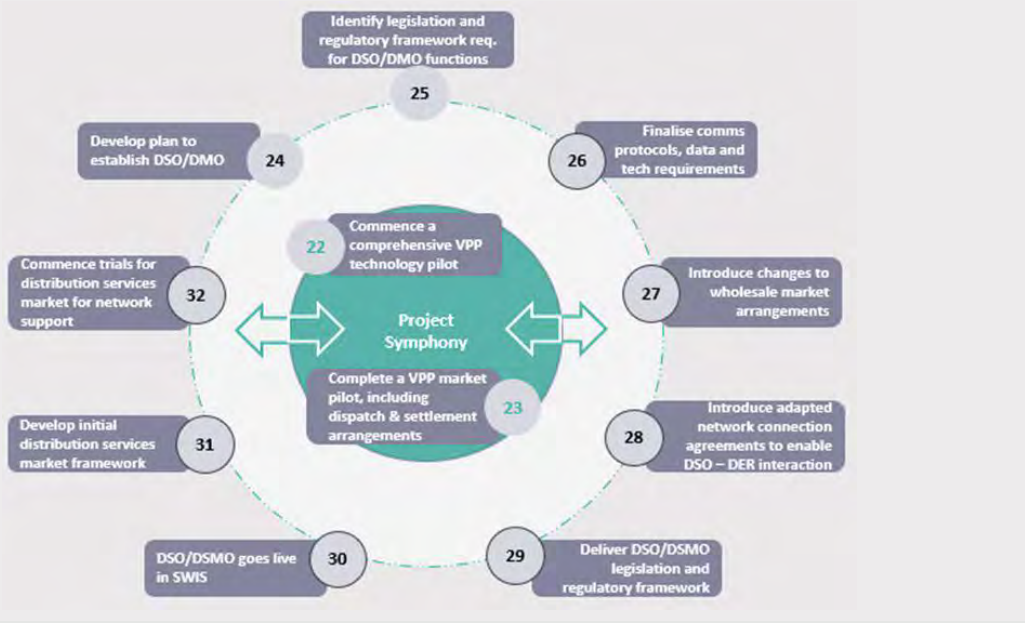
However, the high penetration of DER can pose a significant risk to power system stability, for example at times of low system demand. Based on advice from AEMO the stability of the SWIS may be at material risk as early as 2022, if DER are not efficiently and effectively managed (Australian Energy Market Operator (AEMO), 2019).

In recognition of this risk, in April 2020 the WA Government published a DER roadmap for Western Australia (the DER Roadmap) to support the integration of DER into the SWIS and the WEM, and support changes to policy and regulation stemming from the evolution of the energy value chain. Project Symphony is directly linked to two of the activities in the DER Roadmap (actions 22 and 23) and has interdependencies with many other DER Roadmap activities as outlined in Table 1.

However, rooftop solar PV installation rates have already far exceeded forecasts with over 500MW of new capacity added since the DER Roadmap was published. Other technical issues have also come to light and the risks associated with low load[2] and high levels of DER have further been refined (AEMO, 2021c). While EPWA and AEMO will work with Western Power and Synergy to develop and implement interim solutions to these challenges, including 'last resort' measures to reduce or turn off rooftop solar generation, the Project is still regarded as delivering the best long-term outcomes for customers and the power system via active DER participation through market-based mechanisms. Project Symphony will lay the groundwork for enabling WA consumers to opt-in to aggregated virtual power plants and provide services to the network and WEM, including turning down (or using up) excess output, or managing demand in return for compensation. One of the Project's working hypotheses is that DER can provide cheaper, lower carbon outcomes through network and market services (e.g. load under control, generation under control, frequency, voltage) in a way that shares the most value with customers through their participation, than the alternative of significant network investment and transmission level responses.

[1] Source: Western Power connections
[2] low load is equivalent to low registered generation

Table 1. Project Symphony's relationship to the DER Roadmap

Key actions in the DER Roadmap	Project Symphony DER Roadmap dependencies
Action 22: DER Orchestration Pilot – Technology Demonstration By June 2021, commence a comprehensive VPP technology pilot to demonstrate the end-to-end technical capability of DER in the SWIS **Action 23: DER Orchestration Pilot – Market Demonstration** By December 2022, complete a comprehensive VPP market participation pilot that tests the information of aggregated DER into energy markets, including market dispatch and settlement arrangements from the market operator to individual customer *Note: Following agreement from Project Symphony's Steering Committee, the expected end date of the pilot has been adjusted to mid-2023*	

1.2. Project Symphony is piloting the hybrid model for Western Australia

As the physical electricity network evolves towards a high DER future, the traditional roles and responsibilities of WA market participants change, including the advent of new participants such as DER aggregators, who aggregate customer DER into a single facility to participate in new energy markets.

Energy Networks Australia (ENA) and AEMO jointly led the "Open Energy Networks" (OpEN) project to identify how to best transition to a two-way power grid that allows better integration of customer DER. Project Symphony will be testing a version of the 'Hybrid model' which is a conceptual solution outlined in the OpEN project report (Energy Networks Australia, 2019). This approach evolves the current responsibilities of the existing network operator (Western Power), existing retailer (Synergy) and the power system and market operator (AEMO) to deliver the required functions in the SWIS, shown in Figure 1 below. It also likely evolves or changes the role of customers from once passive recipients of electricity to more active participants as consumers and generators of electricity with access to new energy markets. It is acknowledged that at an operational level, the requirements, value and commercial agreements for transactions between each of the parties has yet to be established, is further explored in Work Package 2.2 Commercial Agreements Summary, and will be further informed as an outcome of the Project and other activities being completed independently within the DER Roadmap.

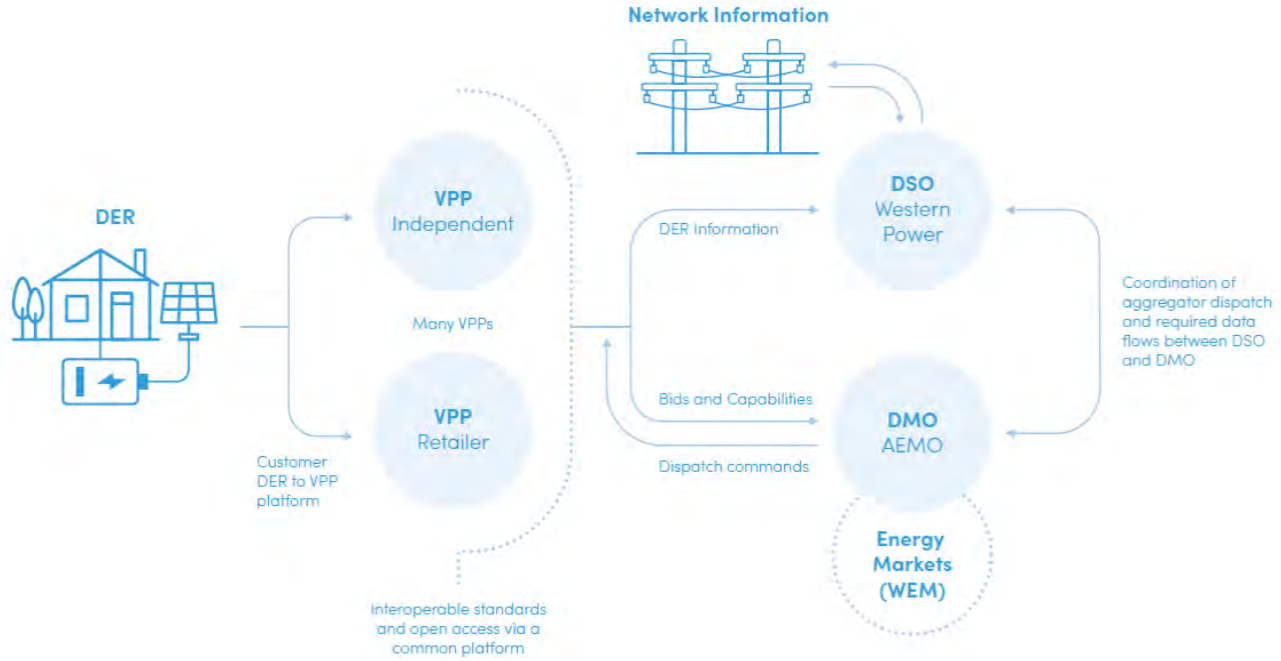


Figure 1 A possible DSO/DMO model for WA (Energy Transformation Taskforce, 2019b)

1.3. Project Symphony within the context of other Australian DER integration projects

It is important to note that Project Symphony is building on a current knowledge base of independent DER integration trials, bringing together the lessons learned into a pilot of an end-to-end DER services market with new rules for participation i.e. what the future will look like for DER customers and their participation in the energy market. A summary of current and recent DER projects in Australia is mapped below, based on publicly available information, and further detail on how Project Symphony will expand on each trial is outlined in Appendix 2. The project will build on the customer experience and engagement approach, and the various technology solutions of the Australian DER integration projects, while adding the relatively new component of the market for DER aggregation and orchestration.

Figure 2. Recent and current DER projects in Australia, relevant to the objectives of Project Symphony

2. Project Symphony: Vision

The overall vision for Project Symphony (the Project) is to progress toward a future where the integration and participation of DER in markets supports a safe, reliable, lower carbon and more efficient electricity system.

Harnessing the rapid uptake of rooftop solar energy generation in WA, Project Symphony will help pave the way for the future security of the network unlocking financial and environmental benefits for customers and the wider community. Project Symphony is an exciting and innovative project where DER like rooftop solar, batteries and major appliances will be orchestrated as a Virtual Power Plant (VPP) to participate in a future energy market unlocking greater economic and environmental benefits for the Western Australian community.

Project Symphony will test the "hybrid model" of the OpEN project, in the context of the WEM. Under this model, a VPP is centrally dispatched but devices within the VPP are locally and independently coordinated by a retailer or aggregator. A graphical overview and interpretation of the hybrid model is outlined in the DER Roadmap (see Figure 1). The project will test this model to: gain a better understanding of its efficiency and effectiveness; and the requirements and performance of the technically complex integration needed between the three platforms. It will also consider non-technical elements of the hybrid model including customer experience and the roles and responsibilities of the key actors (DMO, DSO, retailer and third-party aggregators).

The scope of Project Symphony includes the development, integration and testing of the relatively immature and complex software and systems underpinning pilot versions of the DMO, DSO and Aggregator platforms, and how the combined technological capability enables the participation of DER in the WEM. In addition to considering the customer experience, the Project will secure aggregated DER assets via direct engagement and third-party aggregators. The aggregated DER assets will be orchestrated within the "dynamic operating envelopes" provided by the DSO to provide both market services, dispatched by the DMO, and network services. The Project will secure a minimum of 900 assets, with a target mix as follows:

Asset type	Number of assets	Target capacity
Solar PV (curtailable)	302	• Residential: 300 @ 5kW = 1,500 kW • Commercial: 2 @ 100kW = 200kW
HVAC (controllable)	209	• Residential: 200 @ 3kW = 600kW • Commercial: 9 @ 20kW = 180kW
Hot water (controllable)	250	• 425kW residential • 150 new heat pump systems @ 0.5kW = 75kW • 100 existing resistive electric systems @ 3.5kW = 350kW

Behind the Meter (BTM) storage	158	• Residential: 150 @ 5kW = 750kW
		• Commercial (550kW):
		  ○ 1 large @ 300kW
		  ○ 2 medium @ 50kW
		  ○ 5 small @ 30kW

Front of Meter storage	1	• Up to 2MW to be delivered by Western Power

Project Symphony encompasses end-to-end transactions that enable a value chain for customer DER assets to participate in the WEM and is seeking to achieve the following objectives:

1. **Technical:**

    a. Measure the extent to which DER can address local, regional and system wide challenges in the SWIS. This includes the extent to which DER can provide network support services for the management of local constraints such as peak demand and low load or reverse power flow, which can inform alternative means to defer traditional network augmentation investments.

    b. Measure the extent to which the end-to-end aggregation and orchestration of customer DER is open (non-proprietary), technically viable and can be made cyber secure, while measuring availability, reliability/latency and cost effectiveness of the solution(s).

    c. Inform the standards, processes, planning, systems, interoperability and security frameworks required to maintain system security and reliability.

2. **New Energy Market:**

    a. Measure the functions and services DER can provide to markets, as well as the extent that aggregated DER can be efficiently used to participate in Wholesale Electricity Market (WEM) energy markets, ancillary (essential system) service markets, as well as potentially in capacity markets.

    b. Inform the extent to which the aggregation of customer DER to participate in the WEM, as well as provide essential system services, is capable of creating and sustaining a viable market participation model within the WEM Regulations and Rules where DER aggregators act as the intermediary to customer DER.

3. **The Customer Experience:**

    a. Explore the residential and commercial customer preferences regarding DER, including willingness to engage, level of engagement, value drivers and the customer value proposition.

    b. Pilot the role of the retailer/aggregator in providing products/services to the customer and facilitating customers' involvement in providing DER products and services to the wholesale market and the distribution network.

4. **Roles and Responsibilities:** Test and measure the extent to which the OpEN Hybrid model and the evolved roles and responsibilities of the traditional market participants contained therein, such as Western Power, Synergy and AEMO, is an efficient and effective means of 'unlocking' optimal value from customer DER as it participates in new markets.

5. **Policy and Regulation:** Explore and inform the policy, market design and regulatory reform required for DER integration in the WEM and develop an evidence base for future investments in DER integration within the WEM, including undertaking extensive knowledge sharing and an overarching Cost-Benefit Analysis (CBA).

This vision statement was tested with, and broadly accepted by, industry experts after a presentation at the DER Demonstration Insights Forum hosted by Project EDGE on 24 June 2021.

2.1. Project activities

Project Symphony encompasses end-to-end transactions that enable a value chain for customer DER assets to participate in the WEM. To achieve its purpose, the four partners of the Project – being Western Power, Synergy, AEMO and Energy Policy WA – will undertake seven work packages, supported by targeted knowledge brokering. Energy Policy WA is actively overseeing progress to ensure Project Symphony is consistent with the broader objectives of the WA Government's DER Roadmap.

Project Symphony

Our energy future

Roles of Project Symphony partners	Project Symphony work packages

Western Power: Project Lead, network operator and Distribution System Operator (DSO)

- Provide a DSO 'platform', in part to identify the maximum renewable energy hosting capacity
- Deploy up to 2MW of front of meter batteries in a location in the Southern River pilot area.
- Install network monitoring within the Southern River region.

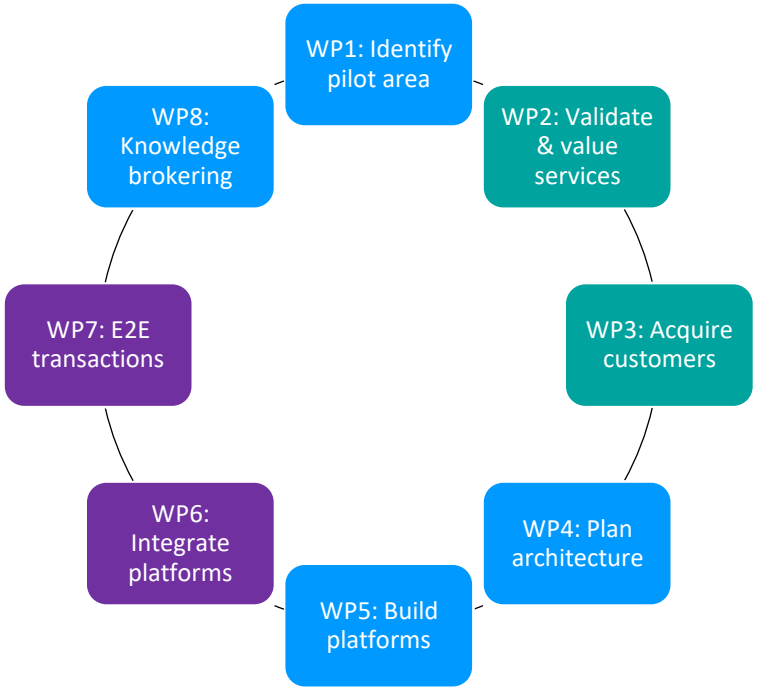
Synergy: Residential retailer and responsible for DER valuation and customer acquisition

- Lead the customer interactions to achieve a suitable mix and concentration of at least 900 DER assets.
- Procure, design, build, integrate and test an Aggregator platform
- Build an understanding of DER customer sentiment in relation to more active participation in markets.

AEMO: System and Market Operator and the Distribution Market Operator (DMO)

- Provide a two-sided market platform, comprised of wholesale and system support services
- Organise and operate the market and assess all bids and offers and optimises the dispatch of energy resources in consideration of transmission network and distribution network constraints.

Energy Policy WA is the government agency responsible for the delivery of energy policy advice to the WA Minister for Energy and is also responsible for supporting the delivery of the government's Energy Transformation Strategy, including a key partner to Project Symphony providing active guidance and oversight.



In partnership with:

western power synergy AEMO Government of Western Australia Energy Policy WA

The overarching goal of these work packages is to design, procure, develop, implement and test software based 'platforms' capable of registering, aggregating and orchestrating customer DER. In particular, work packages 4-7 are focused on delivering an end-to-end solution, with the entire energy system integrated via three platforms: a market or 'DMO platform' (AEMO); an 'aggregator platform' (Synergy); and a 'DSO platform' (Western Power). This will require a significant systems interface and integration effort between the different platforms as aggregated customer DER responds to AEMO dispatch requests via the aggregator platform and within the constraints of the local network including settlement of market transactions off-market.

The end-to-end solution will deliver real value via four 'must have' on-market and off-market services or scenarios:

1. **Energy Services – Bi-directional Energy - Balancing Market.** The balancing market is a mandatory 'gross pool' market for dispatch and 'net pool' for settlement that determines the most economically efficient dispatch of generation to meet system electricity demand at a given time.

2. **Network Support Services.** A contracted service provided by a generator, retailer or DER aggregator to the network operator/DSO (Western Power) to help manage or solve localised network constraints.

3. **'Constrain to Zero'.** To demonstrate the ability of the AEMO Platform to instruct the Aggregator platform to constrain energy output from DER to zero export (net) or zero output (gross). This could be offered as a market service, in the context of reducing the number low load events requiring intervention by the DSO, or incorporated into normal dispatch arrangements if customers are remunerated appropriately.

4. **Essential System Service (ESS) - Contingency Raise.** Market provided response to a locally detected frequency deviation to help restore frequency to an acceptable level in the case of a 'contingency event' such as the sudden loss of a large generator or load.

Data will also flow end-to-end through each of the market participants' platform, from customer to off-market settlement via the DMO (AEMO). This will establish the framework that can be extended beyond Project Symphony to mainstream DER orchestration via an on-market DMO platform.

3. Project Symphony: Impact Pathway

Identifying and measuring the costs and the benefits (the value) of each of these scenarios, individually and cumulatively, will be key to understanding their longer-term viability at scale, along with the technical solutions required to achieve them.

To do this, an **impact pathway** is proposed to monitor and evaluate each work package throughout the project, on a mutually exclusive and collectively exhaustive life-cycle framework that leverages ARENA's "technology readiness levels" (TRLs) and "commercial readiness index" (CRI) (**Error! Reference source not found.** adapted from Australian Renewable Energy Agency (2014)). The detail of each work package is outlined in the following sections and summarised on the following page.

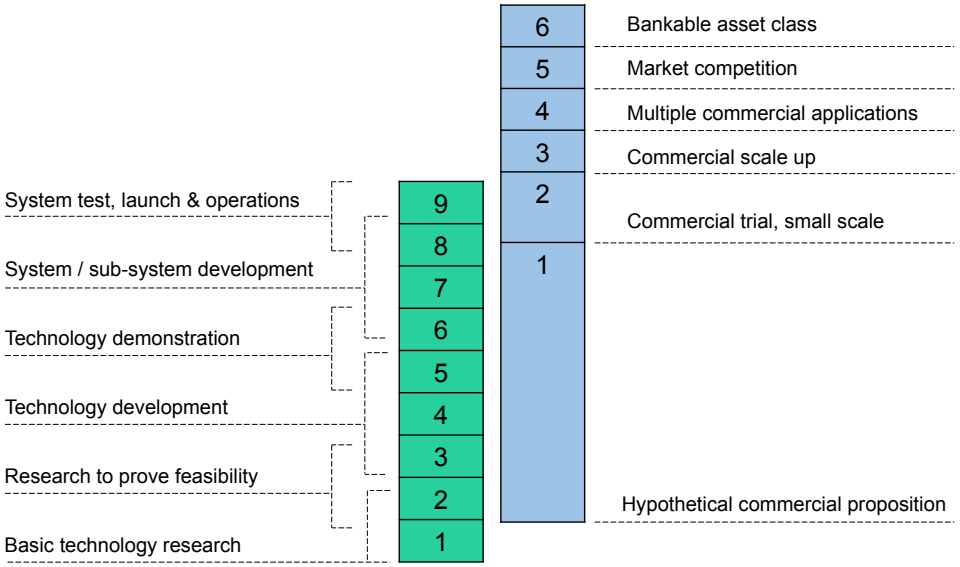


Figure 3 ARENA's Technology Readiness Levels and Commercial Readiness Index

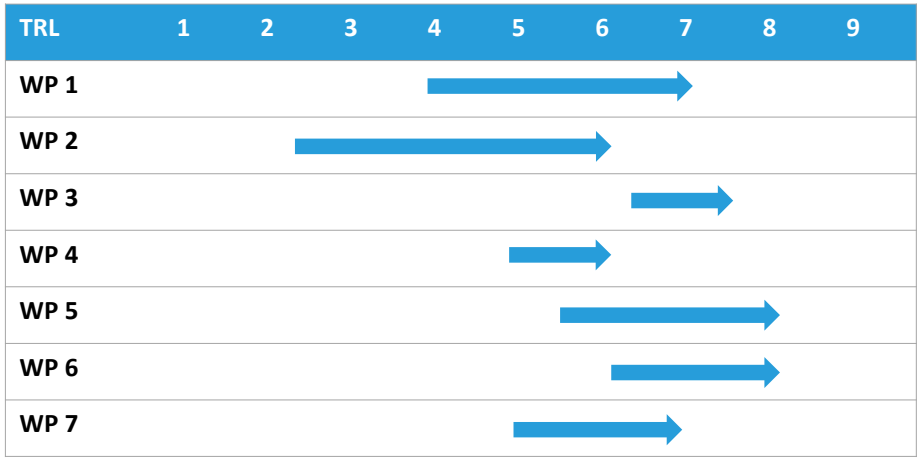
Project Symphony (in parallel with Project EDGE in the NEM) is unique as the first end-to-end pilot of a new energy market, using new and existing assets, rather than an independent and/or incremental trial of specific elements of the technology solution. However, it is actively incorporating the lessons that have been learned through previous DER related trials to incorporate the most up-to-date knowledge and test the best ideas that have been presented. These lessons have been directly mapped to each work package in a way that informs the current state (TRL and CRI) along with the stages needed to reach greater technology and commercial readiness.

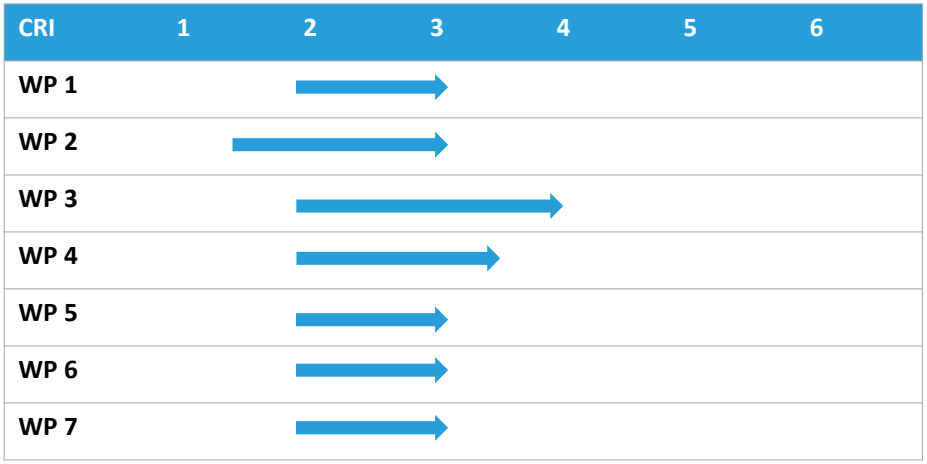
The outcomes of the consolidated work packages over the next two years will determine the viability of Project Symphony as a mainstream option for integrating DER in WA and will substantially inform the policy and regulation requirements to achieve technology and commercial readiness and customer acceptance. This will also assist NEM participants as a live *whole-of-system* example that could be further implemented across Australia. The expected progress of Project Symphony is estimated against the TRL and CRI framework to determine a likely future state, working towards mainstreaming DER integration in WA.

The **preliminary analysis** of the impact pathway is summarised below by work packages 1-7 to represent the life-cycle of DER integration and orchestration. This analysis suggests that Project Symphony will:

- Progress the technology readiness of DER orchestration by between one to four levels across the life-cycle, with the largest shift across Work Package 2 that is expected to move from TRL 2.5 to TRL 6, and
- Generally progress commercial readiness from commercial trial (CRI 2) to commercial scale-up (CRI 3), with greater progress expected towards the acquisition of customers (WP3) which will be demonstrated across multiple jurisdictions (CRI 4).

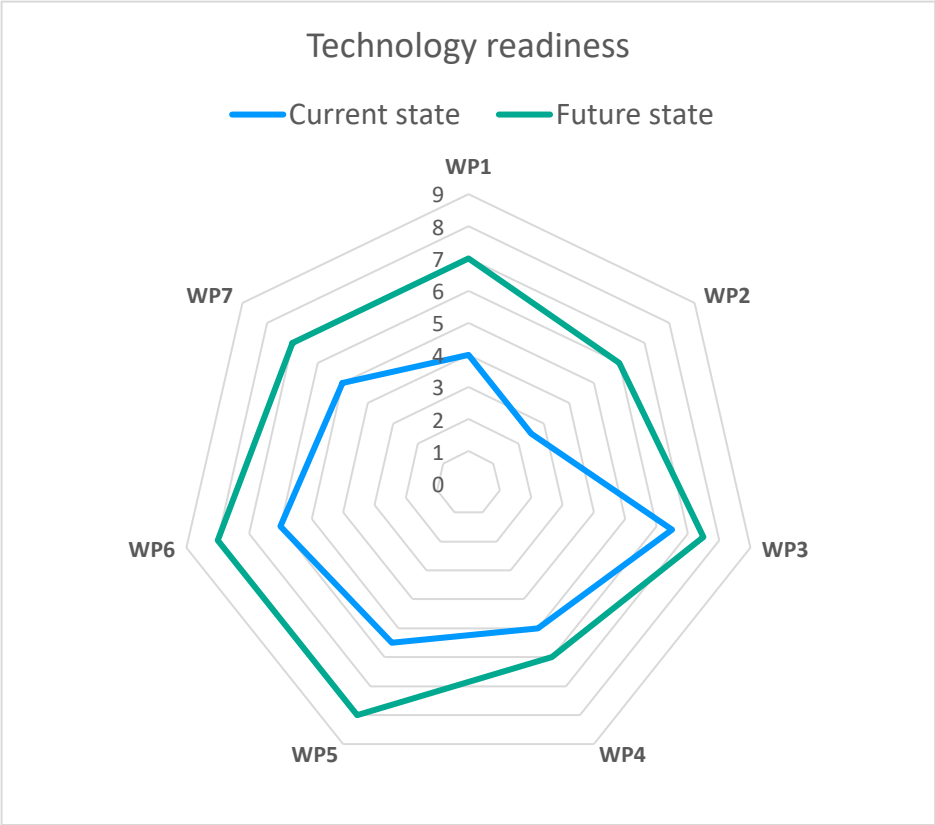
This framework will be used to guide the mid-term (Work Package 8.2 Mid-Project Assessment) due in June 2022, and final project evaluation (Work Package 8.4 Project Close Out Report) due in June 2023 to determine whether Project Symphony is meeting its stated objectives and progress against the technology readiness and commercial readiness goals. Project outputs from each work package will be assessed against the technology and commercial readiness framework along with an update to the contextual analysis of concurrent DER integration projects, including Project EDGE. The evaluation will also outline considerations for policy makers and regulators, including EPWA to inform its delivery of the DER Roadmap.

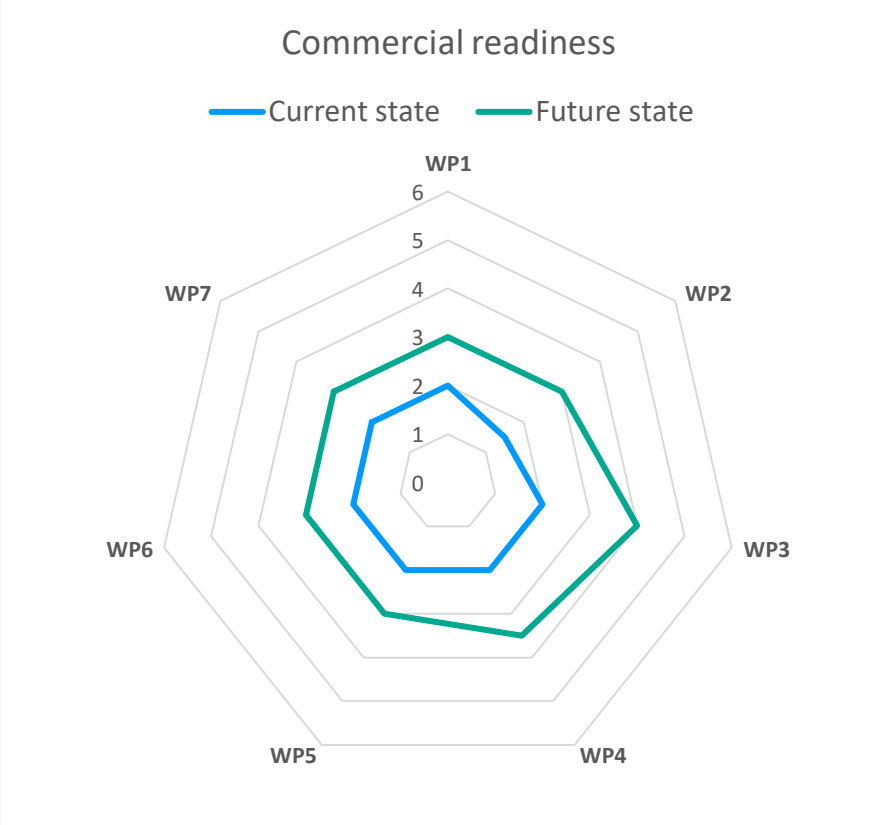




Project Symphony

Our energy future





3.1. Work Package 1: Identify Pilot Area (Western Power)

Description: Identification of a suitable area in WA to use for the pilot confirming the suitability of DER penetration, network constraints, residential and commercial customers connected to the zone substation.

Relevant precedents[3]: Grid Transformation Engine (Western Power), Evolve Project (Zeppelin Bend), Decentralised Energy Exchange (deX, Greensync), AEMO VPP Demonstrations, Peak Demand Reduction using Solar & Storage (United Energy), Trialling a New Residential Solar PV & Battery Model (Ergon Energy), My Energy Marketplace (Wattwatchers), Tesla VPP, Euroa Microgrid, Onslow DER Project (Horizon Power)

Impact pathway:

Activities:

- Confirm the pilot area using available network data, network model, existing feeder SCADA/telemetry and Western Power's proprietary software Grid Transformation Engine (GTEng, which is a strategic planning application that leverages customer profiles, energy forecasts scenarios and distribution network augmentation).
- Determine the hosting capacity of the pilot area
- Evaluate the potential for network services

Key outputs:

WP1.1 Pilot Area Report (confidential) – A report outlining network characteristics, level of renewable energy peak export, evening peak energy demand and a recommended medium voltage (MV) feeder of the selected pilot area for Project Symphony. Network forecasting and planning data using Western Power's Grid Transformation Engine (GTEng) was utilised to develop scenarios for high DER penetration in the SWIS, including where there are existing or emerging network constraints to inform the pilot location. This included a potential transition pathway to optimise network investment by leveraging the benefits of DER as an opportunity to solve local network constraints.

[3] Listed precedents are recent and current DER integration projects in Australia, which are outlined in further detail in Appendix 2. Other important precedents for the design and delivery of Project Symphony include the OPeN Project and the Global Power System Transformation Consortium (G-PST).

Relevant project outcomes[4]:

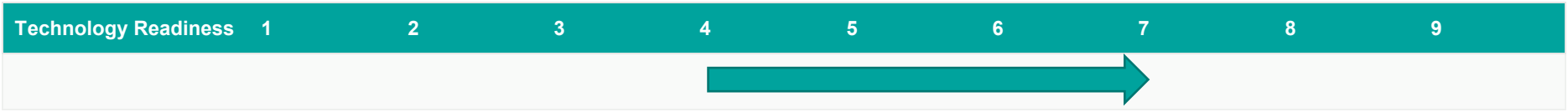
(a) Identify different methodologies for integrating and managing high levels of DER across the SWIS based on testing within the pilot area.

(e) Determine methods to maximise DER hosting capacity in the pilot area.

(f) Identify alternatives to both imposing zero export limits on new DER or continuously augmenting network capacity to accommodate new DER.

(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact:



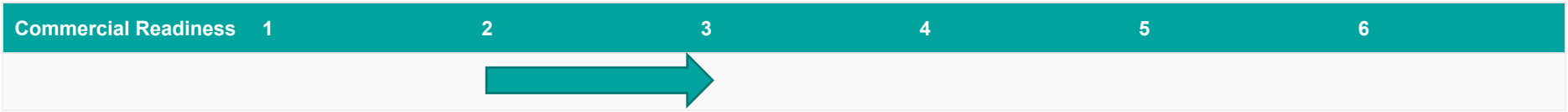
Near real-time network constraint and resource identification on the LV network is currently at TRL 4: Component/subsystem validation in laboratory environment. Western Power delivered a proof of concept "Grid Transformation Engine" (GTEng) in 2019 that included capabilities for customer profiles, energy forecasts and distribution network augmentation (transmission topology, scenario evalution and user interfaces to come). Zeppelin Bend's Evolve project is now testing methods to calculate dynamic operating envelopes for DER to support hosting capacity calculations, along with the software systems to support this.

Other projects have made some progress towards TRL 5: System/subsystem/component validation in relevant environment. deX Vision provides near real-time, dynamic information of DER assets including capability, telemetry and potential impact. Wattwatchers is also providing additional visibility through the My Energy Marketplace trial to deliver greater granularity (between 5 sec to 5 min) of real-time data (including voltage) but these are currently only static "snapshots" rather than living datasets. However, DNSPs do not have automatic visibility of DER assets on the LV network and need to install monitoring themselves or buy the data from third parties (Evolve). Ergon Energy Retail encountered this issue on their trial, where 94% of their real time load measurements had an error margin above 30% which devalued the solution enough to make it non-

[4] The outcomes of Project Symphony are outlined in Appendix 4

commercial. It is also important to note that Victorian DNSPs have better visibility through their access to smart meter data as shown in United Energy's solar and storage trial.

By integrating network monitoring data with forecasting to calculate and publish dynamic operating envelopes in a day-ahead manner, Project Symphony is expected to achieve TRL 7: System prototyping demonstration in an operational environment. GTEng will be used to evaluate the potential for network services to develop scenarios for local distribution areas. The dynamic operating envelope calculator will be hosted by Western Power that has been identified as a key step by the Evolve project for BAU operations (Evolve is using Microsoft's Azure platform). To achieve TRL 7, Project Symphony will need to demonstrate the following minimum functionalities recommended by the deX trial: reliable communications (and a strategy for handling offline devices), at least 5-minute interval monitoring data (not live) and control, a default "safety" mechanism when disconnected, and the ability to be scheduled. Although Horizon Power's Onslow DER project has achieved a similar TRL to this, it is yet to be demonstrated outside of a vertically integrated utility in a market environment.



Near real-time network constraint and resource identification on the LV network is currently at CRI 2: Commercial trials. The four DNSP partners of the Evolve project (Energy Queensland, Essential Energy, Endeavour Energy and Ausgrid) are currently improving the visibility of their static DER asset data and dynamic sensor data, which is in demand from researchers, governments, consultants and technology developers.

Several trials are making progress towards CRI 3: Commercial scale-up driven by specific policy and emerging debt finance. The Evolve project is developing and promoting standards related to network modelling, data measurement and DER asset communications. deX is investigating how best to drive interest and innovation from DER aggregators through developing a Device Registration App and Portal that can be used by installers. Initial requests for data assets in the My Energy Marketplace trial suggest that there could be commercial value of between $10-20,000 for data services. However, it is not yet clear which rules and regulations DNSPs must abide by when sharing the data they have.

Project Symphony expects to achieve CRI 3 by leveraging its unique position of a government-owned DNSP and retailer to access and share distribution network data and voltage studies. It will also extend the commercial applications of dynamic operating envelopes beyond solely battery charging and discharging investigated in the Evolve project. Barriers to achieving a higher CRI including unresolved issues around data access, privacy and cyber-security assurances.

3.2. Work Package 2: Validate and Value DER Services (Synergy)

Description: A three-stage approach to validating and valuing DER services through:

- Identification of DER scenarios (see Project Activities) and use cases for networks, markets and retailers
- Quantification of the value of DER for the different use cases for customers, networks, markets and retailers; and
- Quantification of the risks and role of DER in the WEM wholesale financial markets, including identifying core barriers that may prohibit value capture and opportunities to optimise outcomes across the system.

Relevant precedents: Alkimos Community Battery (Synergy), Alkimos Direct Load Control (Synergy), PowerBank Community Battery (Synergy, Western Power), AEMO VPP Demonstrations, Synergy VPP Technology Trials, AGL VPP Trial, Tesla VPP, Origin Energy VPP, Townsville VPP, Active Hot Water Control (Rheem), Pooled Energy Demonstration, Trialling a New Residential Solar PV and Battery Model (Ergon Energy), CONSORT Trial (TasNetworks), Decentralised Energy Exchange (deX, Greensync), Networks Renewed (UTS – Essential Energy, United Energy, AusNet Services)

Impact pathway:

Activities:

- Develop a valuation and validation model for DER services, considering the four 'must have' on-market and off-market use cases.
- Undertake a rapid Cost Benefit Analysis to quantify the indicative ratios for each use case, including stacking current and potential (benefits that may not be currently available due to regulatory constraints) value streams.
- Describe any barriers that prevent value capture (including regulatory, technical, customer and commercial), and recommendations for how such barriers may be overcome, either in Project Symphony or beyond as part of wider regulatory change.
- Comment on the consideration of conflicts between scenarios in terms of value stacking, value optimisation or direct competition and how much overlap exists, as well as conflict with current price signals.
- Develop a plan for the commercial arrangements to support the provision of DER services as part of Project Symphony, including cases where DER may be owned or aggregated by a third party.
- Undertake a techno-economic simulation (likely a digital replica) to determine the actual value of the DER services deployed or integrated through Project Symphony.

Key outputs:

2.1 DER Services Report (public) – A report outlining network, retail and market use cases for DER, quantifying the potential value of the various DER services, and identifying core barriers and challenges that may prohibit value capture of use cases.

2.2 Commercial Agreements Summary (confidential) – A summary of commercial agreements required for the DER services, as part of Project Symphony, provided by customers, third-party DER owners, and third-party aggregators, considering connection and contractual requirements.

2.3 DER Service Valuation Report (public) – A report outlining the orchestration processes and modelling that validate energy and financial outcomes across the system including the various actors (customer, network, retail, and market actors).

Relevant project outcomes:

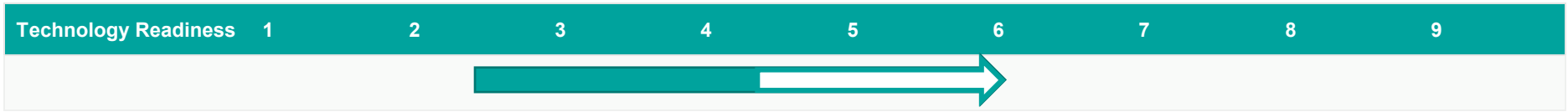
(d) Identify the functions and services DER can provide, and how they can most efficiently be utilised to participate in WEM energy, network support services and capacity markets (and potentially new markets).

(h) Increase customer understanding of DER, including its potential value streams, and define methods to encourage participation in the broader SWIS.

(j) Improve understanding of the cost and benefits of DER integration with key stakeholders and develop evidence base for future investments in DER integration.

(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact: The technology and commercial readiness of valuing DER services must be considered from the customers', network/operator's and retailers/gentailers' perspective. While many trials have explored the benefits of DER orchestration to networks, there has been far less focus on the customer benefit. This is largely due to most trials involving significant grants directed to the DER themselves (e.g. battery subsidies) and large assumptions or proxies being used for customer value, for example one-off payments.

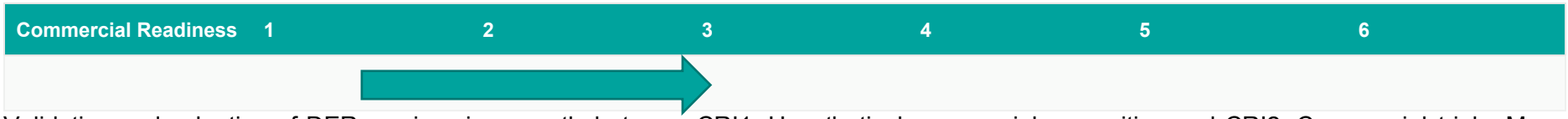


Validation and valuation of DER services is currently between TRL 2 (Technology concept and/or application formulated) and TRL 3 (Analytical and experimental critical function and/or characteristic proof of concept). This is because no project has yet demonstrated the technical feasibility of valuing the suite of DER services from the customers' perspective, including: addressing thermal constraints as well as providing frequency and voltage support services. For DER services to be mainstream in an operational environment, the deX team at Greensync suggests that the resources should be able to simultaneously and non-exclusively participate in multiple markets or schemes to access full value.

Some projects have made some progress to higher TRLs by investigating certain aspects of the DER value stack. For instance:

- United Energy's solar and storage trial found that, in some cases, behind-the-meter solar and storage systems can be used as a viable alternative to traditional network-side solutions i.e. to defer network expenditure. Although network-owned behind the meter assets are viable under the WA Access Code (i.e. not limited by ringfencing rules), Western Power is unable to use these assets to participate in markets which could limit their applications beyond network support services.
- TasNetworks' CONSORT trial tested a "Network Aware Coordination" platform to automatically and fairly award customers for network support services. However, the NAC was not implemented with real customers so still needs to be demonstrated at scale, and further developed under a standard API and to include other services e.g. FCAS.
- Ergon Energy has argued that, to access the other parts of the value stack, additional monitoring and optimisation of the system will also be required to: best size of the system, implement adaptive programming of the system, access to cost-reflective pricing, control of discretionary loads and improve availability in blackouts.

If successful, Project Symphony could achieve a much higher TRL of 6 by implementing a demonstration of the four on-market and off-market scenarios in an end-to-end environment. However, if the valuation is solely a simulation and model, the project is more likely to achieve TRL 4 or TRL 5 where a prototype is validated in either a laboratory (e.g. digital replica) or relevant (solely at the identified site) environment. This is also likely to be constrained by the maintenance of existing tariff regimes and the provision of equipment subsidies in certain cases.



Validation and valuation of DER services is currently between CRI1: Hypothetical commercial proposition and CRI2: Commercial trials. Many trials have provided customers with a one-off payment for monitoring and control e.g. Synergy paid 14 customers $200 to participate in their Alkimos Beach direct load control (DLC) trial of air conditioners and Networks Renewed paid 30 customer $1/KVA for access to solar and battery inverters. However, VPP trials like those in SA have not yet shown a positive business case and still need to be supported by government e.g. the Tesla VPP is expected to cost $800 million by subsidising customer-owned batteries. Similarly, Ergon Energy found that mandatory demand management incentives could leave some customers worse-off than using their storage system for arbitrage.

In terms of CRI 3: Commercial scale up, there are currently no regulatory barriers to wider rollout of direct load control or VPP services. As found in the Alkimos Beach DLC trials and the SA VPP trials, these are largely constrained by customer engagement, technology compatibility and pass-through of value. The deX project is making some progress towards this level by piloting a commercial rollout of DER aggregation with commercially-available registered devices via deX Connect.

While the project will utilise some incentives to achieve initial customer participation, by establishing an 'off-market' system and implementing dynamic operating envelopes as well as valuing multiple value streams for both customer-owned DER (e.g. network services) and a network-connected battery, Project Symphony is likely to achieve CRI 3 by the end of the pilot. This will be driven by the activities leading to the DER Services and DER Services Valuation reports, which hope to identify economic means to incentivise customer participation compared with other trials that have set customer subsidies at higher levels to achieve acquisition thresholds. By investigating, and reporting on, legal, regulatory and market barriers, the project may also make some headway towards achieving CRI 4 where regulatory challenges are addressed in multiple jurisdictions through the DER Roadmap to facilitate multiple commercial applications. This progress towards CRI 4 will also be supported by the Commercial Agreements Summary, which will inform the future commercial agreements that will be initially formed during Project Symphony.

3.3. Work Package 3: Acquire DER Customers (Synergy, University of Tasmania (UTas))

Description: Recruitment of a minimum of 900 DER assets into the aggregation platform and complementary customer attitudinal research to: ensure value for customers; determine a future pathway for DER in WA; and explore support for an ecosystem of emerging business models and broader market participation.

Relevant precedents: Alkimos Community Battery (Synergy), Alkimos Direct Load Control (Synergy), Onslow DER Project (Horizon Power), Smart Sun Broome (Horizon Power), PowerBank Community Battery (Synergy, Western Power), AGL VPP Trial, Tesla VPP, Origin Energy VPP, Active Hot Water Control (Rheem), Project EDGE (AEMO & AusNet Services), Yackandandah Trials (AusNet Services), Euroa Microgrid, Peak Demand Reduction using Solar and Storage (United Energy), Pooled Energy Demonstration, CONSORT Trial (TasNetworks), Networks Renewed (UTS – Essential Energy, United Energy, AusNet Services)

Impact pathway:

Activities:

- Synergy to develop a customer acquisition plan to include analysis on customers within the pilot area, diversity of customers and the phased approach to acquiring customers, as well as DER types including: HVAC control; hot water; behind the meter storage; network-connected storage; and curtailable solar.
- UTas to undertake social research to answer the following questions:
    - Regarding Australian VPP trials, what are the key learnings Synergy, Australian industry, government and academia have identified about customer responses to relevant new energy technologies? What knowledge gaps remain?
    - How do small use residential and commercial customers in different socio-economic situations and locations view, value and respond to the Project Symphony trial technologies, systems, product offerings and pricing? How did incentive types and incentive-related factors, particularly pricing and pricing communications, affect customer acceptance, use and engagement of Project Symphony DER technologies and systems? Did customers perceive prices / incentives as fair? What factors affected these perceptions? What does this understanding tell us about wider deployment of the VPP technologies, systems and processes tested in Project Symphony?

  - What are the social equity implications for residential and small use commercial customers of Project Symphony VPP technologies, systems and pricing? How can understanding of these social equity implications inform larger scale roll-out of VPP's and DER aggregation?
  - What aspects of policy do the findings from the above three questions indicate need to be considered? What new or amended policies, market rules or regulations may be required, at what level and in which organisations, to address the findings and support successful and wider implementation of the VPP technologies, systems and processes tested in Project Symphony?
- Synergy to acquire 900 DER assets from both direct customer engagement, including third-party DER resources, and through third-party aggregators.

Key outputs:

3.1 Customer Acquisition Plan (confidential) – A document outlining the planned customer acquisition process, target DER types and the target mix of commercial and residential customers.

3.2 Aggregator Report (public) – A report outlining the proposed approach to engaging aggregators into Project Symphony including research on how Synergy can facilitate market participation of DER aggregators and/or third-party DER resources.

3.3 Social Science Study (public) – A report summarising the social science research conducted in partnership with the University of Tasmania addressing three key areas:

1. An assessment of policy support required to scale Project Symphony from a pilot to mass market adoption.
2. Customer sentiment towards a variety of DER asset types and offerings.
3. The social equity implications of mass market adoption.

Relevant project outcomes:

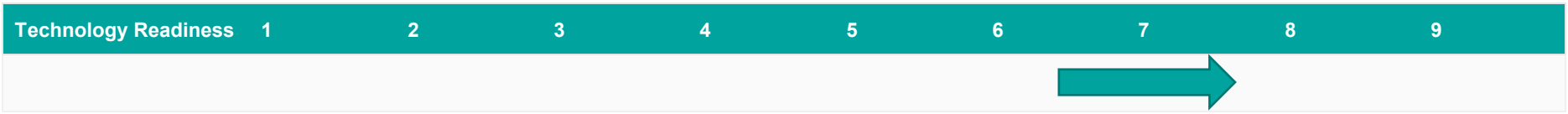
(h) Increase customer understanding of DER, it's potential value streams and define methods to encourage participation in the broader SWIS.

(i) Understand residential and commercial preferences regarding DER, including willingness to engage, level of engagement and value drivers

(j) Improve understanding of the cost and benefits of DER integration with key stakeholders and develop evidence base for future investments in DER integration.

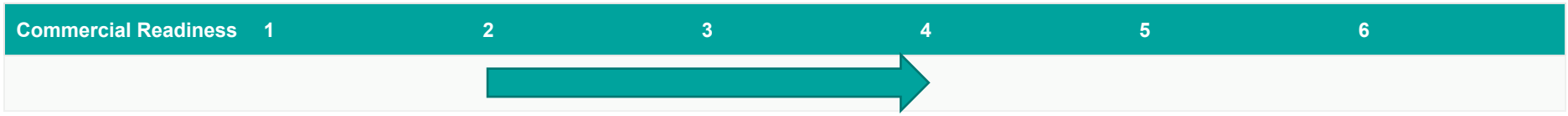
(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact:



The acquisition of DER customers is currently between TRL 6 (System/subsystem model or prototyping demonstration in a relevant end-to-end environment) and TRL 7 (System prototyping demonstration in an operational environment). Although most DER trials to date have experienced difficulty recruiting their target customer base (e.g. in 2017, AGL had only installed 250 of the 700 systems it had sold), with amendments to the recruitment strategies and customer offerings, they have almost all been able to achieve their target. The key barriers to TRL 7 have been related to challenges in installation (e.g. switchboard modifications poor connectivity issues) and drop-out rates i.e. Ergon Energy experienced 45% system availability, which they argue must be increased to 95% for a viable system to operate. An additional barrier to DLC is technical compliance – Synergy found only 35% of applicants had AS4755 compliant air conditioners and customers were also concerned about the impact of the trial on their air-conditioning performance.

For Project Symphony to achieve TRL 7, the pilot will need to undertake a more rigorous site evaluation and system design, particularly if additional equipment needs to be installed to address compliance issues. This will accelerate customer uptake and also reduce the number of dropouts and maintenance calls. If Project Symphony aims to achieve TRL 8: End of system development, additional user training and maintenance documentation will need to be prepared.



The acquisition of DER customers is currently at CRI 2: Commercial trials. Synergy has already successfully recruited participants for several different DER trials. AGL has also had success applying its VPP model across Adelaide since its 2017/18 trial, now providing multiple offerings that accommodate different and flexible rates without lock-in clauses, as well as tailored incentives for DER in place of heavily subsidised batteries.

Current barriers to achieving CRI 3: Commercial scale-up are related to value access and contracting. Further work is required for more of the value of community batteries to be accessible to customers, including via aggregators. Synergy's VPP trials also uncovered a commercial risk that they as the retailer are liable for the technical impact of DER orchestration, even if these are being managed by a third party. A VPP needs to respond in a measurable and reliable way to be considered dispatchable by the DSO, which requires technical progress and cultural acceptance from all participating parties i.e. from customer to DMO. There is tension between behind-the-meter and system outcomes that also needs to be resolved to ensure that DER are dispatched in the right way at the right time. Lastly, Horizon Power also identified customer protections (e.g. privacy) as a risk in its Onslow DER trial.

Project Symphony and Project EDGE are working in parallel to achieve CRI 4: Multiple commercial applications. In addition to addressing the barriers to CRI 3, they will: demonstrate dynamic membership / non-exclusivity i.e. not limited to participating via one aggregator or retailer (recommended by deX); and develop standards for service delivery and "set and forget" functionality to reduce the burden on customers (recommended by Ergon Energy). Project Symphony has engaged the social science team at UTas to develop a better understanding and appreciation of customer motivations as recommended by TasNetworks' CONSORT trial and Wattwatchers' MEM trial. This will inform better customer products that improve on the previously-tested "flat tariff + VPP incentive" structure in order to facilitate much higher levels of VPP participation.

Work packages 4-7 are focused on delivering an end-to-end solution, with the entire energy system integrated via three platforms: a market or 'DMO platform' (AEMO); an 'aggregator platform' (Synergy); and a 'DSO platform' (Western Power). This will require a significant systems interface and integration effort between the different platforms as aggregated customer DER responds to AEMO dispatch requests via the aggregator platform and within the constraints of the local network including settlement of market transactions off market.

The end-to-end solution will deliver real value via four 'must have' on-market and off-market services or scenarios:

1. **Energy Services – Bi-directional Energy - Balancing Market.** The balancing market is a mandatory 'gross pool' market for dispatch and 'net pool' for settlement that determines the most economically efficient dispatch of generation to meet system electricity demand at a given time.

2. **Network Support Services.** A contracted service provided by a generator, retailer or DER aggregator to the network operator/DSO (Western Power) to help manage or solve localised network constraints.

3. **'Constrain to Zero'.** To demonstrate the ability of the AEMO Platform to instruct the Aggregator platform to constrain energy output from DER to zero export (net) or zero output (gross). This could be offered as a market service, in the context of reducing the number low load events requiring intervention by the DSO, or incorporated into normal dispatch arrangements if customers are remunerated appropriately.

4. **Essential System Service (ESS) - Contingency Raise.** Market provided response to a locally detected frequency deviation to help restore frequency to an acceptable level in the case of a 'contingency event' such as the sudden loss of a large generator or load.

Data will also flow end-to-end through each of the market participants' platform, from customer to off-market settlement via the DMO (AEMO). This will establish the framework that can be extended beyond Project Symphony to mainstream DER orchestration via an on-market DMO platform.

3.4. Work Package 4: Architecture Planning (Western Power, University of WA (UWA), AEMO, Synergy)

Description: Design the DMO, DSO and Aggregator platforms and tools required to test and deliver the DMO-DSO-Aggregator roles and responsibilities outlined in the WA DER Roadmap and leveraging the outcomes of the OpEN project.

Relevant precedents: Carnarvon DER Trials (Horizon Power), Onslow DER Project (Horizon Power), Smart Sun Broome (Horizon Power), Grid Transformation Engine (Western Power), Kalbarri Microgrid (Western Power), Perenjori BESS (Western Power), AEMO VPP Demonstrations, Tesla VPP, Origin Energy VPP, Townsville VPP, Active Hot Water Control (Rheem), Yackandandah Trials (AusNet Services), Euroa Microgrid, Birchip Cropping Group Microgrid, Peak Demand Reduction using Solar and Storage (United Energy), My Energy Marketplace (MEM, Wattwatchers), Trialling a New Residential Solar PV and Battery Model (Ergon Energy), Decentralised Energy Exchange (deX, Greensync), Evolve Project (Zeppelin Bend)

Impact pathway:

Activities:

- Agreement between AEMO, Western Power and Synergy on the roles and responsibilities for designing the requirements for the DMO, DSO and aggregator platforms, which will enable the communication of constraints, bids and offers to customers and the market.
- AEMO to develop an off-market DMO Platform – the DER Integration Platform (DERIP) – to test the relevant WEM services and network services from dispatching DER including tests of: market registration; dispatch and settlement arrangements; demonstrated DER capability.
    - Develop the conceptual system architecture design, assessing technology options (e.g. cloud vs software-as-a-service vs on-premises solutions) and evaluating impact to system planners and operators and existing systems within the WEM ecosystem.
    - Refine the design and develop functional and non-functional specifications to enable the DERIP to be developed by an IT partner.
    - Tender and procure services to build or purchase a commercial platform, or repurpose existing architecture being built in other trials across the NEM.
    - Evaluate and report on any changes or exemptions to rules and/or regulations for the trial to be implemented.

- Western Power to:
    - With support from UWA and as part of the Evolve Project platform, develop a Distribution Constraints Optimisation Algorithm to determine the level of, and assess the requirements for, constraints on areas of the distribution network with high DER.
    - Explore the functional need for DER management capability via a hardware and software platform – the DSO Platform – to monitor and request DER services via an aggregator that maintains or improves the reliability, efficiency and overall performance of the distribution system, for example by monitoring DER hosting capacity.
        - Design and develop functional and non-functional specifications to enable the DSO Platform to be developed by a commercial partner.
        - Tender and procure services to build or purchase a commercial platform.
        - Integrate the outputs of the DCOA with the DSO Platform to: calculate constraints dynamically; provide the ability for conducting operational forecasting; and communicate network constraints to both the DMO and aggregator platforms.
- Synergy to share their requirements for a commercial aggregator platform that will support: onboarding resources; managing and dispatching flexibility; and post-event analysis.

Key outputs:

4.1 Distribution Constraints Optimisation Algorithm (DCOA) Report (public) – A report on the network DER DCOA tool including: the function of the tool; how it was developed; and the specifications.

4.2 Provision of DMO Platform Requirements Report (public) – A report on the set of functional and non-functional requirements for the DMO Platform to source the best resource for the development of the market platform, for example via tender or internal capability.

4.3 DSO Platform Requirements Report (public) – A report on the set of functional and non-functional requirements for the DSO Platform, which will be used to undertake a commercial process to develop a DSO Platform.

4.4 Aggregator Platform Requirements Report (public) – A report on the set of functional and non-functional (including cyber security) requirements for Synergy's aggregator platform, summarising the procurement and implementation of the platform.

KS12 Report on DMO, DSO and Aggregator Functional and Non-Functional Requirements (public) – A public report on the functional and non-functional requirements for the DMO, DSO and Aggregator platforms.

Relevant project outcomes:

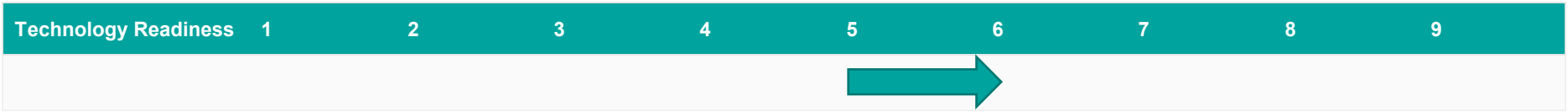
(b) Demonstrate how aggregated DER can support system safety and reliability.

(c) Identify the technical aspects and requirements to enable DER orchestration via DER Aggregators.

(g) Support the delivery of the DER orchestration elements of the WA DER Roadmap.

(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact:



Architecture planning is currently at TRL 5: System validation in the relevant environment. For the DMO and DSO functions, there currently there is no suitable commercial platforms. Although AEMO VPP Demonstrations demonstrated customer participation in the NEM, these did not consider the suite of network and market services that could be delivered i.e. did not include local network services or consider distribution network limits.

The AEMO VPP Demonstrations also found that VPP forecasting is insufficient to be integrated into market systems (i.e. to enable effective dispatch signals to be delivered by the DMO platform), which must be improved by VPP providers and/or DER aggregators to achieve a higher TRL. Alternatively, Project Evolve has suggested DER forecasting should be centralised in the organisation using those forecasts i.e. the DSO.

Similarly, DERMS (which have been proposed for DSO functionality) tend to suit vertically-integrated utilities more that can enact a "command and control" function rather than dynamic operating envelopes. This is unlikely to be suitable across the market as projects like the Mandurah DM Services trial have shown, which required high-levels of communication with service providers to clarify technical requirements and performance expectations that would be too resource intensive for mainstream application.

Project Symphony will be the first, in concert with Project EDGE, to demonstrate a single provider being able to deliver on complete suite of DMO, DSO and aggregator functionality to achieve TRL 6: A system model demonstrated in a relevant end-to-end environment. Project Symphony and EDGE are currently at the leading edge of product development to address this need, having sought proposals from the market for a fit-for-purpose product. Project EDGE has already found that smaller niche vendors seem to have more mature products for DER management (the aggregator and DSO platforms) due to a greater focus on, and adaptability to, developments in this market. Project Symphony will undertake a similar exercise, developing an off-market DMO platform and seeking commercial proposals for the DSO and aggregator platforms. Western Power will integrate the outputs of its DCOA to forecast and communicate network constraints to the market.

For this to become mainstream (TRL 9), Project Evolve further argues that decision-support tools to inform investment decisions will need to be overhauled, which will be explored in Project Symphony by agreeing on roles and responsibilities between AEMO, Western Power and Synergy. Findings not implemented directly in Project Symphony will be shared to inform policy to support mainstream development of the end-to-end solution.

Architecture planning is currently at CRI 2: Commercial trial. However, many of these trials have expressed the challenge of bringing up existing DER to a standard for them to be accessible for mainstream orchestration e.g. the Carnarvon DER trials required replacement inverters for older PV systems and the Alkimos Beach DLC trial found only 35% of applicants had AS4755 compliant air conditioners.

Two key regulatory issues have been uncovered for the DSO:

- challenges recovering OPEX for demand-side solutions compared with traditional network-side CAPEX that is easily recoverable under the regulated asset base, and
- regulatory acceptance will be needed for new network planning approaches e.g. to further develop the GTEng into long-term scenario planning.

AEMO's VPP Demonstrations have also identified three key market issues that must be resolved for the DMO-DSO-aggregator platforms to work together:

- Agreeing and managing power system security risks as DER is relied upon more widely, particularly for network services such as FCAS
- Encouraging customers to adopt flexible connection agreements for DER to both facilitate data for planning and dynamic operating envelopes for management, and
- Updating and maintaining minimum device standards for system security, including best practice cyber security frameworks.

Both Project Symphony and Project EDGE are seeking to concurrently achieve CRI 4: Multiple commercial applications. However, this will require determining standards for DSO offerings for conveying dynamic operating envelopes to both the DMO and third party aggregators. The latter is being progressed by Project Evolve using the IEEE 2030.5 protocol. It is important to note that this protocol does not directly support the concept of dynamic operating envelopes thus the implementation is likely to be non-standard. For this reason, it is likely that Project Symphony's non-standard approach will only achieve CRI 3: Commercial scale-up rather than multiple commercial applications.

3.5. Work Package 5: Build Platforms (Western Power, AEMO, Synergy)

Description: Build the DMO, DSO and Aggregator platforms to orchestrate DER within the pilot area, and facilitate the delivery of energy, network and essential system services.

Relevant precedents: Smart Sun Broome (Horizon Power), Carnarvon DER Trials (Horizon Power), Onslow DER Project (Horizon Power), Project EDGE (AEMO & AusNet Services), Origin Energy VPP, Euroa Microgrid, Birchip Cropping Group Microgrid, Pooled Energy Demonstration, My Energy Marketplace (MEM, Wattwatchers), CONSORT Trial (TasNetworks), DER Integration and Automation Project (Evoenergy), Decentralised Energy Exchange (deX, Greensync), Evolve Project (Zeppelin Bend), Networks Renewed (UTS – Essential Energy, United Energy, AusNet Services)

Impact pathway:

Activities:

- AEMO to:
  - either assess and procure IT services to build DERIP, purchase the licences to a commercial solution or expand existing platforms being developed for other pilot projects within the NEM.
  - ensure the commercial provider or technology developer builds the DMO Platform to receive bids, provide dispatch instructions, test and measure response performance, and publish locational DER capability with the support and input from Western Power and aggregator(s).
- Western Power to:
  - assess and select a commercial provider to build the DSO platform that will interface with the DMO and aggregator platforms, and Western Power's network management.
  - ensure the commercial provider builds the DSO platform system to provide near real-time visibility and monitoring of contracted DER.
  - install advanced meters, SCADA and communications infrastructure as required, and distribution battery storage within the pilot area.
- Synergy to assess, procure, implement and integrate a commercial aggregator (VPP) platform that will support: onboarding resources; managing and dispatching flexibility; and post-event analysis.

Key outputs:

5.1 DSO Platform Report (public) – A report documenting the building of the DSO platform and infrastructure required to communicate with the DMO and aggregator platforms.

5.2 DMO Platform Report (public) – A report documenting the development and implementation of the DMO platform (e.g. DERIP).

5.3 Aggregator Platform Report (public) – A report documenting the implementation of the Aggregator Platform.

KS13 Report on DSO, DMO and Aggregator Platforms (public) – A public report on how the platforms fit together, including integration and communication, and the key learnings from the development and implementation of the platforms.

Relevant project outcomes:

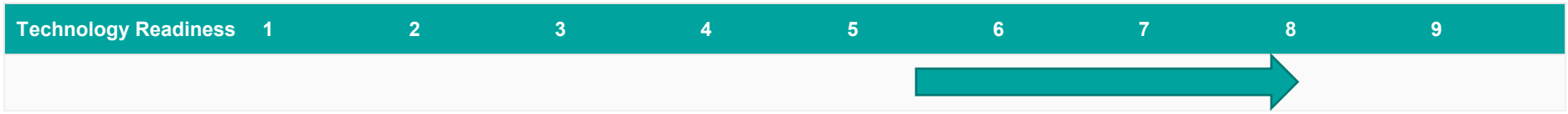
(b) Demonstrate how aggregated DER can support system safety and reliability.

(c) Identify the technical aspects and requirements to enable DER orchestration via DER Aggregators.

(g) Support the delivery of the DER orchestration elements of the WA DER Roadmap.

(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact:



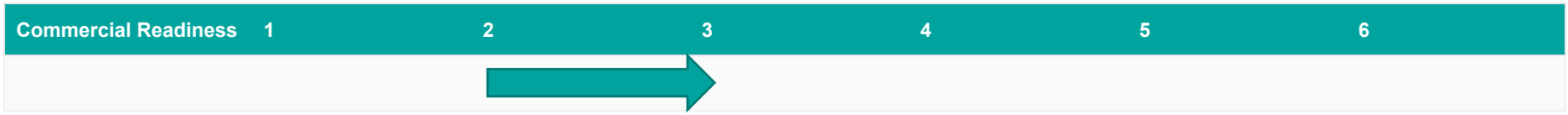
Platforms for DER orchestration are currently between TRL 5 (System validation in the relevant environment) and TRL 6 (System prototyping demonstration in a relevant end-to-end environment). While both the aggregator and DSO platforms have been tested in an operational environment, the DMO platform will start at TRL 5. An example of system validation is Horizon Power's Smart Sun trial which, as a vertically

integrated entity, successfully used SwitchDin's StormCloud to limit solar PV export to 75%, 50% and 0% of capacity, simultaneously promoting charging batteries from the surplus solar, and managing the demand of air conditioners at times of peak demand. As part of the build and end-to-end integration, Horizon Power used the IEEE 2030.5 communication protocol, including the world's first certified, fully functional, IEEE 2030.5 server to control DER inverters in its Onslow DER trial.

Some progress has been made towards TRL 6 for the DSO platform, however commercially-available DERMS platforms have yet delivered on the entire DSO value chain. This is largely because there is no single internationally agreed grid architecture model and supporting standards. Current platforms generally only optimise DER behind the meter rather than making DER available for network management. Partial integration has occurred through the many VPP trials to date.

Similarly, VPP providers have also made technical progress towards developing aggregator platforms, however they have all offered required bespoke integration by DNSPs or retailers i.e. requiring them to be an "aggregator of aggregators". The Evolve and deX projects have made some advances on this bespoke approach. The Evolve project is seeking to integrate with all DNSP systems (including ADMS and GIS) as well as third party providers/aggregators via a consistent API for communication, also using the IEEE 2030.5 data structures. To date, deX Command capability has been demonstrated to: respond to DSO contracts including real and reactive power dispatch; participate in the FCAS market; integrate with AEMO's VPP demonstration API (a precursor to Project Symphony's DMO platform); and produce operational and telemetry data from VPPs. However, deX Connect requires certification of vendors so not all are compatible – nine technology vendors are currently certified – which is limiting its current progress towards technical readiness.

Project Symphony is seeking to make a large step towards technology readiness by achieving TRL 8: An actual system completed and qualified through a test demonstration in an operational environment. This is through the co-development of three platforms for the retailer/aggregator, DSO (leveraging progress towards dynamic operating envelope standards in the Evolve project) and DMO (developing the DERIP). However it may only be possible for the Project to achieve TRL 7 (System prototyping demonstration in an operational environment) given the DMO platform will be off-market, tested in a sandbox environment, and the DSO platform may not achieve scalability. The achievement of technology readiness may also be impacted by parallel market reforms that could have implications for live platform deployment at scale. At a minimum, Project Symphony will make significant progress to inform the requirements to reach TRL 8 for implementation in a transitionary phase once the project is completed.



Platforms for DER orchestration are currently at CRI 2: Commercial trial. Again, platform product maturity is immature or highly variable. While trials have begun to deliver insightful data, data ownership and confidentiality arrangements are still not standard. The deX project has also encountered issues related to operational telemetry not being collected and/or made available (by VPP operators and DER vendors) that are preventing commercial-scale up. This is generally related to the costs for collection, storage and validation.

As mentioned above, the Evolve project has made some progress towards moving beyond the "aggregator of aggregators", which is constraining the ability to achieve mainstream DER orchestration, through the IEEE2030.5 protocol. However, his protocol does not address all use cases, therefore the DER API Integration Technical Working Group is seeking to localise the standard for the Australian market, to be completed in 2021. A standard approach will also need to be expanded beyond solely dynamic operating envelopes.

AEMO has also made progress towards commercial readiness through its VPP Demonstrations in multiple jurisdictions, however none of these were implemented in the WEM.

Project Symphony is aiming to achieve CRI 3: Commercial scale-up, which is likely to be feasible. However, if the project does not align with Australia-wide standard approaches to platform development, given the WEM's different operating environment to the NEM, it is likely to be difficult to move beyond this CRI of bespoke solutions for each network to a mainstream DER orchestration option across Australia. For example, Project Symphony and Project EDGE are pursuing the hybrid model outlined in the OPeN project, and the application of dynamic operating envelopes, to manage inverters. Alternative grid architectures and inverter management methods may be developed that will require the development of different industry structures, platforms and interfaces.

3.6. Work Package 6: Integrate Platforms (AEMO)

Description: Integration, to provide detail of data hosting and sharing agreements and specifications for API's linking the DMO-DSO-Aggregator platforms. These will be developed and finalised during the platform design, build and testing stages.

Relevant precedents: Alkimos Direct Load Control (Synergy), Smart Sun Broome (Horizon Power), Carnarvon DER Trials (Horizon Power), Kalbarri Microgrid (Western Power), Onslow DER Project (Horizon Power), Perenjori BESS (Western Power), PowerBank Community Battery (Synergy, Western Power), Synergy VPP Technology Trials, AGL VPP Trial, Tesla VPP, Origin Energy VPP, Townsville VPP, Active Hot Water Control (Rheem), Project EDGE (AEMO & AusNet Services), Yackandandah Trials (AusNet Services), Euroa Microgrid, Birchip Cropping Group Microgrid, Peak Demand Reduction using Solar and Storage (United Energy), Trialling a New Residential Solar PV and Battery Model (Ergon Energy), CONSORT Trial (TasNetworks), DER Integration and Automation Project (Evoenergy), Decentralised Energy Exchange (deX, Greensync), Evolve Project (Zeppelin Bend), Networks Renewed (Essential Energy, United Energy, AusNet Services)

Impact pathway:

Activities:

- Determine the data visibility requirements and authorisations.
- Develop the appropriate data sharing agreements between AEMO, Western Power and Synergy.
- Develop the APIs (or design for streaming services) to link and interface between the three platforms for the following purposes:
    - The DSO to communicate operating envelopes to the aggregator and DMO as well as requesting the DMO to dispatch any contracted network services.
    - The DMO to: receive available downstream DER availability via the aggregator; receive aggregator facility bids for market services; send out dispatch instructions and settle the market; as well as receving network constraints from the DSO and instructions to dispatch any contracted network services.
    - The aggregator to: receive operating envelopes from the DSO; provide bids into market services; receive dispatch instructions from the DMO; and confirm dispatch for both network and market requirements.

- Test the ability of DER orchestration within the pilot area using the APIs and/or existing arrangements, and enhance the APIs if required, with the aim to develop a standard API requirement that can be published for other aggregators to interface their platforms with the DSO and DMO.
- Develop hosting of relevant DER and weather data on the Data Services Server (DSS) and facilitate agreement on which partner will host the DSS (or equivalent) including regular testing and maintenance.

Key outputs:

6.1 Server Hosting Agreement (confidential) – An agreement which will set out key considerations including data sharing parameters, cyber security requirements and privacy requirements.

6.2 Data Sharing Agreement Report (confidential) – A report summarising the data sharing requirements as identified in WP 6.1, as well as key outcomes of any architecture design workshops between the three parties.

6.3 API Specifications Report (confidential) – A report outlining the specifications of the relevant project APIs, and other methods of data transfer that would be considered, to integrate all parties with the DMO Platform.

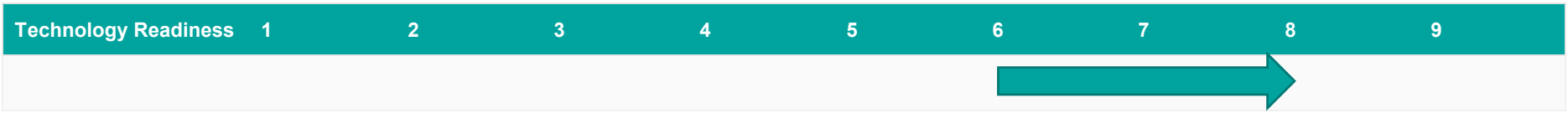
Relevant project outcomes:

(b) Demonstrate how aggregated DER can support system safety and reliability.

(c) Identify the technical aspects and requirements to enable DER orchestration via DER Aggregators.

(g) Support the delivery of the DER orchestration elements of the WA DER Roadmap.

Expected impact:



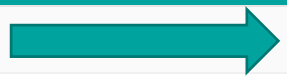
The integration of platforms is currently at TRL 6: System model demonstration in a relevant end-to-end environment. Many VPP trials have demonstrated bespoke integration with VPP or DER aggregator platforms. For example, Networks Renewed, TasNetwork's CONSORT project and United Energy have all integrated Reposit Power's aggregator platform to source network support from DER. However, seamless integration has not always been achieved. For example, during its first stage, the AGL VPP was not able to achieve its 3kW export target due to high grid voltage, low levels of available charge and high customer loads. Approximately 12.5% of systems experienced regular high voltage and a third of systems experienced at least one disconnection.

Several projects are now progressing platform integration to TRL 7: System prototyping demonstration in an operational environment. For instance, the Onslow DER Project by Horizon Power has completed prototyping of an integrated platform in an operational environment albeit as a vertically integrated utility. The deX project has made some progress towards integrating platforms i.e. deX itself, the deX Evaluation Engine and Evoenergy's Internet of Things Hub. This allows deX to receive and accept/reject DER requests, achieving a simulated VPP e.g. via dynamic limits. deX can also automate the calling of forward option contracts from a DNSP's ADMS. More recent VPPs and the Evolve project have been exploring standard integration options e.g. via the DER API Integration Technical Working Group.

The Evolve project argues that future DER management will require new computational techniques that continuously calculate the optimal operating conditions. Existing ADMS may not be able to handle this new level of data and computation demands and may become increasingly "brittle". Functional modules may be better to long-term system integration and orchestration of DER.

Project Symphony is progressing towards TRL 8: Actual system completed and qualified through test and demonstration in an operational environment. The design of the various data integration elements and the method to which the integration will be undertaken will enable future aggregators to understand the potential requirements needed for integration with the key platforms. As noted with the previous work package, progress may be limited to achieving TRL 7 (System prototyping demonstration in an operational environment) given the Project may not provide sufficient scale (e.g. tens of thousands of devices) or overcome all technical barriers to demonstrate a full operational system and the DMO platform will be operating in a sandbox environment.

Commercial Readiness	1	2	3	4	5	6



The integration of platforms is currently at CRI 2: Commercial trials as described in the TRL section above.

The Evolve project is making some progress towards CRI 3: Commercial scale up, by developing an open-source software for dynamic operating envelopes that could provide long-term certainty if accepted by all DNSPs. This long-term certainty will support innovation in technologies (e.g. device manufacturers) and business models (e.g. DER aggregators). The components that will be open-sourced at the end of the project are:

- An IEEE2030.5 utility server core
- Tools for simulating and validating server and client behaviour
- An interface to administer out-of-brand processes e.g. device registration

Leveraging the work undertaken by the Evolve project, Project Symphony is seeking to achieve CRI 3. To move beyond this level, the project partners understand it is critical to approach interoperability standards in a consistent way across Australia to promote mainstream deployment of DER orchestration. The key is to engender an environment that fosters, not stifles, innovation and grows the DER ecosystem without compromising the stability and security of the electricity grid.

3.7. Work Package 7: End-to-End Transactions (AEMO)

Description: Test and monitor the performance of all three platforms working together to provide network and market services. This will involve executing the transaction of service, end-to-end, to quantify the benefits of DER services and to measure the effectiveness of the response from a network, market and customer perspective.

Relevant precedents: Alkimos Community Battery (Synergy), Onslow DER (Horizon Power), PowerBank Community Battery (Synergy, Western Power), Synergy VPP Technology Trials, AGL VPP Trial, AEMO VPP Demonstrations, Tesla VPP, Active Hot Water Control (Rheem), Project EDGE (AEMO & AusNet Services), Trialling a New Residential Solar PV and Battery Model (Ergon Energy), CONSORT Trial (TasNetworks), Networks Renewed (UTS – Essential Energy, United Energy, AusNet Services)

Impact pathway:

Activities:

- Execute the three platforms to provide the complete end-to-end network and market services requirements.
- Measure the accuracy of the DCOA outcomes and implement changes to the algorithm as required.
- Test the DSO-DMO-Aggregator platform communications capability and the efficacy of the APIs.
- Run the DMO Platform to test the ability to: receive available DER capability for network and market services; check network conditions; and provide relevant dispatch instructions to the aggregator(s).
- Run Aggregator Platform to test the ability to: receive constraint information from the DSO and develop an appropriate generation plan; provide the generation plan within the required timeframe; receive dispatch instructions from the DMO to deploy DER; and manage, deploy and measure DER capability.
- Test the performance of all three platforms.

Key outputs:

7.1 Regulation and Rules Report (public) – A report for the WA government and AEMO regarding: the key regulations or rules that will need to be amended (if any) to enable a high volume of DER integration; and the impact to market participants from a cost recovery perspective.

7.2 Future Market Participation Requirements Report (public) – A report aligned to the WA DER Roadmap, taking into account market reform activities, outlining high-level design and requirements for a future Market Platform that could achieve whole-of-system optimisation with high volumes of DER integration

7.3 DER Market Participation Principles Report (public) – A report providing market participants with a clear and transparent view and guidelines for how aggregators can: register for market and network services; participate in providing both market and network services; better understand technical standards and procedures for registration and service delivery; and develop IT systems (such as APIs) to enable their aggregator platforms to engage with both the DSO and DMO platforms.

7.4 AEMO Planning and Forecasting Report (public) – A report summarising the enhancements to AEMO's planning and forecasting process in light of the lessons learnt from Project Symphony and including insights into future changes for greater DER integration in the WEM.

Relevant project outcomes:

(a) Identify different methodologies for integrating and managing high levels of DER across the SWIS based on testing within the pilot area.

(b) Demonstrate how aggregated DER can support system safety and reliability.

(c) Identify the technical aspects and requirements to enable DER orchestration via DER Aggregators.

(d) Identify the functions and services DER can provide, and how they can most efficiently be utilised to participate in WEM energy, network support services and capacity markets (and potentially new markets).

(e) Determine methods to maximise DER hosting capacity in the pilot area.

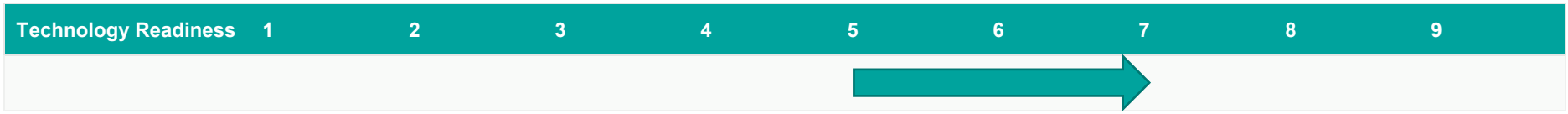
(f) Identify alternatives to both imposing zero export limits on new DER or continuously augmenting network capacity to accommodate new DER.

(g) Support the delivery of the DER orchestration elements of the WA DER Roadmap.

(j) Improve understanding of the cost and benefits of DER integration with key stakeholders and develop evidence base for future investments in DER integration.

(k) Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

Expected impact:



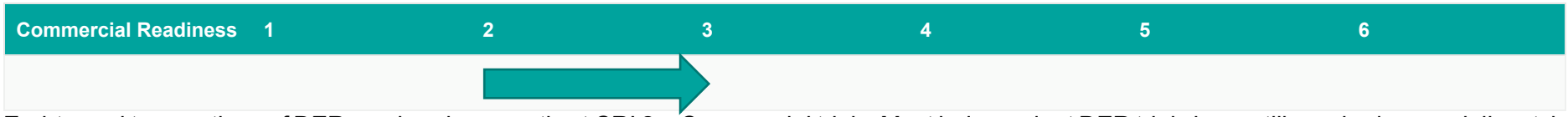
End-to-end transactions of DER service is currently between TRL 5 (System validation in relevant environment) and potentially TRL 6 (System prototyping demonstration in a relevant end-to-end environment). Although most current DER trials are focused on achieving TRL 6, it appears that many issues under TRL 5 still have not been resolved.

From AEMO's perspective, its VPP Demonstrations have developed a collective understanding of market participation for some services (FCAS and price response) however this is yet to be proven via an on-market platform. Further, these demonstrations uncovered challenges related to the competition between market and network services e.g. FCAS response is lower if DER have already responded to high prices. AEMO uncovered other barriers to technical readiness, including the ability of DER to respond to an Automated Generation Control signal sent through the SCADA network.

From the network perspective, although many DER trials have been conducted, many have been missing the adequate network monitoring and/or Advanced Metering Infrastructure (AMI) to settle the inflows and outflows. United Energy also encountered challenges when estimating the state of charge of the batteries participating in its trial related to both: accounting for losses; and low SOC due to self-consumption. Most individual DER trials have also required manual dispatch, which must be automated for DER orchestration to become mainstream.

From the retailer and/or aggregator's perspective, recent VPP trials have been shown to deliver value by reducing peak demand and/or increasing self-consumption of solar PV. However, Synergy and AGL's trials both showed that, even with the necessary metering infrastructure, connectivity can still limit the availability of DERs to respond to a signal for service. This shows that reliability of service is still a critical factor that must be resolved before VPPs are invited to participate in markets.

Looking abroad, deX Markets has moved closer to TRL 7 (System prototyping in an operational market) in the UK, developing capabilities to upload telemetry data, nullify and archive contracts, handle unavailability submissions, record dispatch information and settle transactions. However, this is yet to be implemented in Australia. This is the level that Project Symphony is hoping to achieve by executing and testing the performance of the three integrated platforms, noting limitations as the DMO platform will be operating in a sandbox environment with minimal visibility and no integration with network system management.



End-to-end transactions of DER services is currently at CRI 2 – Commercial trials. Most independent DER trials have still required manual dispatch that cannot be resourced by DNSPs, or dispatched by AEMO, in the long term. Automatic dispatch and aggregation of DER at a sufficient scale to ensure reliability of response are two factors that will influence the viability of DER orchestration. In order for DER orchestration to achieve CRI 3 (Commercial scale up) and beyond, market reforms are still required for improved transparency and access to additional DER service markets that Project Symphony are exploring.

To move beyond this level, regulatory change is needed to assist the full participation of DER in the energy market. For instance, AEMO has identified that bi-directional arrangements will need to be embedded in the rules, rather than VPPs having to register as two participants for load and generation resource. The Energy Security Board's Post 2025 NEM Market reforms will also heavily influence the viability of DER orchestration as a mainstream market option.

4. Project Symphony: Next Steps

Ultimately, the outcomes of Project Symphony's consolidated work packages over two years, together with evaluation of any interim measures such as DPVM, will determine the viability of the safe and reliable integration of DER in the SWIS at scale. More specifically, Project Symphony will be evaluated on the basis of substantially informing a mainstream, market-based option for WA, and will substantially inform the policy and regulation requirements in support of wider application to achieve technology and commercial readiness and customer acceptance. Progress towards achieving the technology and commercial readiness scores outlined in this report will be assessed mid-project (WP 8.2) and at the final assessment (WP 8.3).

The framework presented in this report is also provided to inform energy policy makers of the technical and commercial factors that should be taken into account when considering policy and regulatory changes required to support application at scale. It also provides a contextual bridge to the interim and final reports which will outline policy considerations for policy makers and regulators, as Project Symphony progressively achieves its objectives.

APPENDIX 1: References

Australian Energy Market Operator (AEMO) (2019) *Integrating Renewables and Distributed Energy Resources in the SWIS*.

Australian Energy Market Operator (AEMO) (2021a) *AEMO NEM Virtual Power Plant Demonstrations: Knowledge Sharing Report #4*. doi: 10.5694/j.1326-5377.1919.tb30652.x.

Australian Energy Market Operator (AEMO) (2021b) *Project EDGE: Lessons Learned Report #1*. doi: 10.1080/0371750X.1957.10877729.

Australian Energy Market Operator (AEMO) (2021c) *Renewable Energy Integration – SWIS Update*.

Australian Renewable Energy Agency (2014) *Commercial Readiness Index for Renewable Energy Sectors*, *http://creativecommons.org/licenses/by/3.0/au/ For*.

Clean Energy Regulator (2015) *Australian Energy Flows diagrams*.

Energy Networks Australia (2019) *Open Energy Networks Interim Report: Required Capabilities and Recommended Actions*. Available at: https://openenergy-platform.org/dataedit/view/supply/wind_turbine_library.

Energy Transformation Taskforce (2019a) *DER Roadmap: DER Project Stocktake*.

Energy Transformation Taskforce (2019b) *Distributed Energy Resources Roadmap*. Available at: https://brighterenergyfuture.wa.gov.au/.

Energy Transformation Taskforce (2020) *Issues Paper - DER Roadmap : Distributed Energy Resources Orchestration Roles and Responsibilities*.

Ergon Energy Retail (2018) *Residential solar PV + battery (Hybrid Energy Service) pilot*.

Farrier Swier Consulting and Gridwise Energy Solution (2021) 'State of distributed energy resources technology integration report', (February), pp. 1–197. Available at: https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/.

Ford, R. *et al.* (2017) 'Emerging energy transitions: PV uptake beyond subsidies', *Technological Forecasting and Social Change*. doi: 10.1016/j.techfore.2016.12.007.

Geels, F. W. and Schot, J. (2007) 'Typology of sociotechnical transition pathways', *Research Policy*. doi: 10.1016/j.respol.2007.01.003.

GreenSync (2021) *deX Project Progress Report*.

Kapoor, S., Sturmberg, B. and Shaw, M. (2020) *A Review of Publicly Available Energy Data Sets*. Available at: https://arena.gov.au/projects/wattwatchers-.

Naber, R. *et al.* (2017) 'Scaling up sustainable energy innovations', *Energy Policy*. doi: 10.1016/j.enpol.2017.07.056.

Ngar-yin Mah, D., Wu, Y. Y. and Ronald Hills, P. (2017) 'Explaining the role of incumbent utilities in sustainable energy transitions: A case study of the smart grid development in China', *Energy Policy*. doi: 10.1016/j.enpol.2017.06.059.

Shaw, M. (2020) *Consumer engagement in energy data services: recommendations moving forward*. Available at: https://arena.gov.au/assets/2020/12/consumer-engagement-in-energy-data-services-recommendations-moving-forward.pdf.

Taft, J. and Becker-Dippmann, A. (2015) *Grid Architecture*.

United Energy (2019) *Residential Solar and Storage Program Final Report*.

Wattwatchers Digital Energy (2021) *My Energy Marketplace: Interim Public Project Knowledge Sharing Report*.

Weise, B. (2021) *On the implementation and publishing of operating envelopes*.

Wyndham, J. *et al.* (2019) *Networks Renewed : Project Results and Lessons Learnt*.

Zeppelin Bend Pty Ltd (2021) *DER Impacts on Operational Technology*.

APPENDIX 2: Australian DER Integration Projects

Project	Description	Key focus area[5]	Project Symphony progression
Western Australia			
Alkimos Community Battery (Synergy)*	**Community battery.** A four-year trial of Australia's first community battery (1.1MWh) to manage peak demand at Alkimos Beach in partnership with Lendlease and LandCorp. The trial has involved 133 customers who have saved an average of $311.92 per annum.	Resource valuation (WP2), customer acquisition (WP3), end-to-end transactions (WP7)	• Valuing the services of community batteries, if selected as an option (WP2) • Developing innovative retail products via customer feedback (WP2, WP3) • Maintaining customer protection (e.g. privacy) in new business models (WP3) • Metering and settlement requirements incl. 3rd parties (WP7)
Alkimos Direct Load Control (Synergy)*	**DER management.** Fourteen customers were incentivised ($200 p.a.) to install a SwitchDin control device to ramp down their air conditioners (via compressors) during peak demand events.	Resource valuation (WP2), customer acquisition (WP3), network integration (WP6)	• Aggregating DER, incl. developing aggregator registration and accreditation requirements (WP3) • Developing a bilateral agreement for network services with the DNSP (WP7)
Broome Smart Sun (Horizon Power)*	**DER management, VPP.** Piloting the SwitchDin StormCloud platform to actively manage rooftop solar (95.5kW), air conditioning units and battery energy	Customer acquisition (WP3), market and network planning (WP4), network/platform integration (WP5,	• Explicitly developing DER Management Use Cases (WP2)

[5] Constraint and resource identification, market and network architecture planning, resource valuation, customer acquisition, network/platform integration (including both platform development and integration of the platform), service measurement, end-to-end transactions, feedback (Wyndham *et al.*, 2019)

Project	Description	Key focus area[5]	Project Symphony progression
	storage (150kWh) from 15 customers in Broome (of 30 on the transformer), which runs on a smaller microgrid.	WP6), feedback and mainstreaming (WP8)	• Building customer understanding of DER hosting capacity limits to garner support (WP3) • Considering customer contract arrangements in the context of the DSO model (WP3, WP5)
Carnarvon DER Trials (Horizon Power)*	**DER management.** A three-year trial with sixteen customers in Carnarvon to test DER orchestration using Wattwatchers monitoring devices, Reposit Power control technology and VPP cloud integration.	Market and network planning (WP4), network/platform integration (WP5, WP6)	• Building customer understanding of DER hosting capacity limits to garner support (WP3) • Considering customer data collection requirements and permissions (WP3) • Considering customer contract arrangements in light of establishing longer-term DSO engagement (WP3, WP5)
Grid Transformation Engine (GTEng, Western Power)*	**Network management.** Western Power is developing the GTEng software modelling system to forecast economic, demographic and technology changes over a 30-year period.	Constraint and resource identification (WP1), network planning (WP4)	• Using GTEng to assess market benefits through the provision of network services (WP1) • Assessment of economic regulation processes to use tools like GTEng in network planning approaches (WP4)
Kalbarri Microgrid (Western Power)*	**Network battery.** A microgrid, supported by a network-owned battery, was installed in the small regional town of Kalbarri to improve electricity reliability to customers, which have historically suffered from some of the most common outages in WA.	Network planning (WP4), network integration (WP6)	• Considering how automated solutions impact customers involved in VPPs and/or DSO/DMO dispatches (WP3) • Assessing the regulatory constraints related to grid-connected batteries (WP6)
Onslow DER (Horizon Power)*	**DER management.** Subsidies were offered to Onslow residents and businesses to	Constraint and resource identification (WP1), customer	• Explicitly developing DER Management Use Cases (WP2)

Project	Description	Key focus area[5]	Project Symphony progression
	install up to 2MW of solar PV and 1MW of battery storage on the proviso that these could be orchestrated via a DERMS and SwitchDin Secure Gateway Device, which were validated through DER Management Use Cases.	acquisition (WP3), market and network planning (WP4), network/platform integration (WP5, WP6), end-to-end transactions (WP7)	• Building customer understanding of DER hosting capacity limits to garner support (WP3) • Considering customer contract arrangements in light of establishing longer-term DSO engagement (WP3, WP5) • Defining and testing DER response and latency requirements (WP7)
Perenjori BESS (Western Power)*	**Network battery.** Installation of a 1MWh network-owned battery with off-grid functionality and customer engagement in Perenjori (which is susceptible to extreme weather impacting the network) to eliminate 80% of the community's extended electricity outages.	Network planning (WP4), network integration (WP6)	• Improving network visibility to identify appropriate DER solutions for particular constraints (WP1) • Developing a DER valuation methodology for greater investment certainty (WP2) • Understanding network battery participation under DSO/DMO arrangements (WP4)
PowerBank (Synergy, Western Power)*	**Community battery.** A 105kW/420kWh Tesla network-owned battery is installed in Meadow Springs, which is Australia's third "solar hotspot", that is paired with a retail offering from Synergy that allows customers to virtually store up to 8kWh of their excess PV generation. The trial has involved 49 households who have saved an average of $112 per annum.	Resource valuation (WP2), customer acquisition (WP3), network integration (WP6), end-to-end transactions (WP7)	• Facilitating retailers and others to use network-owned storage for a positive business case (WP2) • Developing a DER valuation methodology for greater investment certainty (WP2) • Developing innovative retail products (WP2, WP3) • Assessing the regulatory framework for adoption of network storage (WP4)

Project	Description	Key focus area[5]	Project Symphony progression
			• Understanding network battery participation under DSO/DMO arrangements (WP4) • Developing metering and settlement arrangements (WP7)
Virtual Power Plant Technology Trials (Synergy)*	**Virtual Power Plant.** Six VPPs consisting of ten solar-battery installations with Synergy employee households are testing a mix of: controlled battery import and export; frequency response; and/or exportable customer data.	Resource valuation (WP2), network integration (WP6), end-to-end transactions (WP7)	• Test the value-stack for different market and network services (WP2) • Assessing the cost/benefits of retailer versus aggregator-led approaches to VPPs (WP3) • Developing requirements for telemetry data for market participation (WP4)
South Australia			
Virtual Power Plant Trial (AGL)*/**	**Virtual Power Plant.** A trial orchestrating 1,000 behind-the-meter batteries (5MW capacity / 9MWh stored energy) in Adelaide to: increase solar self-consumption; provide network support through peak demand management; and offer a physical hedge and/or arbitrage opportunity in the wholesale energy market. The VPP targeted 3kW dispatches from batteries over an hour.	Resource valuation (WP2), customer acquisition (WP3), network integration (WP6), end-to-end transactions (WP7)	• Explicitly developing DER Management Use Cases (WP2) • Testing and CBA of DMO/DSO model (WP2, WP4, WP8) • Actively engaging customers (WP3) • Developing VPP capability including automation and dispatch (WP5) • Developing contracting, data and settlement requirements incl. customer protections (WP7)
Virtual Power Plant (Tesla)*/**	**Virtual Power Plant.** The world's largest VPP of up to 50,000 households (250-650 MW) including a real-time (dynamic) and locational network constraints. The first	Constraint and resource identification (WP1), resource valuation (WP2), customer acquisition (WP3), network planning	• Sharing real-time and locational data on network constraints with retailers/aggregators (WP1)

Project	Description	Key focus area[5]	Project Symphony progression
	1,100 customers do not own their systems (Housing Trust tenants), while the remainder are system owners.	(WP4), network integration (WP6), end-to-end transactions (WP7)	• Testing and CBA of DMO/DSO model (WP2, WP4, WP8) • Considering network impacts of DER and the potential for dynamic operating envelopes (WP4) • Incorporating communication with AEMO in future DER trials (WP4) • Developing VPP capability including automation and dispatch (WP5) • Integrating VPP into Western Power operations (WP6) • Developing contracting, data and settlement requirements incl. customer protections (WP7)
Flexible PV Exports (SAPN)	**DER management.**		• Building on improved customer load/generation forecasting to trial advanced determination of flexible PV export limits (WP1)
Active Hot Water Control (Rheem) *Source:* *https://arena.gov.au/projects/rheem-active-hot-water-control/*	**Demand management.** A trial to actively control 2,400 residential hot water systems in SA, testing the feasibility and value (via incentives) of these systems providing wholesale energy and frequency control services. A range of customers will be engaged across a range of energy asset ownership and socioeconomic groups.	Resource valuation (WP2), customer acquisition (WP3), network planning (WP4), network integration (WP6), end-to-end transactions (WP7)	• Investigating multiple value streams for hot water systems beyond FCAS and tariff arrangements (WP2) • Orchestrating hot water systems in conjunction with other DER (WP3)
Victoria			

Project	Description	Key focus area[5]	Project Symphony progression
Project Energy Demand and Generation Exchange (EDGE, AEMO & AusNet Services) *Source:* (Australian Energy Market Operator (AEMO), 2021b)	**DER marketplace.** A proof-of-concept (off-market) DER marketplace in the Hume Region of Victoria including: data exchange; wholesale integration of DER; delivery of network services via DER; and understanding the customer value proposition. By Phase 5, the project aims to recruit 10MW of flexible capacity or a mix of 1,000 residential and C&I customers.	Customer acquisition (WP3), network/platform integration (WP5, WP6), end-to-end transactions (WP7)	• Exploration of alternate pricing affects DER behaviour (WP3) • Investigating operating envelopes via DCOA, which is of key interest to DNSPs incl. the inclusion of fairness (WP4) • Testing DER-network-market optimisation in the WA context (WP6) • Investigating multiple trading relationships (WP7)
Yackandandah microgrid SWER trial (Totally Renewable Yackandandah (TRY), Microgrid Demonstration Initiative) *Sources:* *https://www.premier.vic.gov.au/new-microgrid-project-yackandandah* *https://onestepoffthegrid.com.au/yackandandah-swer-line-microgrid-wins-state-government-backing/*	**Microgrid.** A microgrid demonstration in with the active community group – TRY, who has been involved in many DER trials to date – increasing the hosting capacity of a SWER line towards 100% renewables in regional Victoria.	Customer acquisition (WP3), network planning (WP4), network integration (WP6)	• Acquiring customers who have self-funded DER, not just those that have been funded by government grants (WP3) • Extending control technologies of customer-owned solar and batteries to extend network hosting capacity and defer network expenditure (WP4,6)
Virtual Power Plant (Origin Energy, Microgrid Demonstration Initiative) *Sources:* *https://www.originenergy.com.au/solar/panels-batteries/virtual-power-plant.html* *https://www.premier.vic.gov.au/building-victorias-largest-virtual-power-plant/*	**Virtual Power Plant.** A cloud-based VPP aggregating PV and load resource from 650 solar customers (receiving a 45% discounted 6.5kWh LG battery system) to reduce network peak. Customers are guaranteed $1,200 in credit from their battery system over 5 years, which is guaranteed to be lower than the value of discharged energy.	Resource valuation (WP2), customer acquisition (WP3), network planning (WP4), network and platform integration (WP5, WP6)	• Extending resource valuation beyond battery storage to solar PV and load control (WP2) • Acquiring customers who have self-funded DER, not just those that have been funded by grants, beyond the VPP model (WP3) • Extending platform technologies for customer-owned solar and batteries to extend network

Project	Description	Key focus area[5]	Project Symphony progression
			hosting capacity and defer network expenditure (WP4,5,6)
Euroa Microgrid (Euroa Environment Group, Microgrid Demonstration Initiative) *Sources:* *http://www.jaclynsymes.com.au/media-releases/new-microgrid-funding-for-the-euroa-community/* *https://mondo.com.au/news/euroa-micro-grid-kicks-off*	**Microgrid.** Installing <400kWh customer-owned battery storage, 589kW new solar PV (also offering solar PPAs for Euroa businesses), Mondo's "Ubi" Energy Management Platform that offers real-time energy monitoring. These will be integrated into the design and implementation of a microgrid with the goal to reduce grid demand and demand for seasonal diesel generators.	Constraint and resource identification (WP1), customer acquisition (WP3), network planning (WP4), network and platform integration (WP5, WP6)	• Extending real-time monitoring beyond one commercially available product (WP1) • Acquiring customers who have self-funded DER, not just those that have been funded by grants (WP3) • Extending control technologies of customer-owned solar and batteries to extend network hosting capacity and defer network expenditure (WP4,6)
Birchip Cropping Group Microgrid Demonstration (SwitchDin, Microgrid Demonstration Initiative) *Sources:* *https://www.energy.vic.gov.au/renewable-energy/microgrids* *https://www.energy.vic.gov.au/renewable-energy/microgrids*	**Microgrid.** Installed an islandable microgrid at Birchip Cropping Group's – a not-for-profit agricultural research body – facility (as a proxy for other Victorian farmers) with 51kW of solar PV and 137kW battery storage with SwitchDin's control technology.	Network planning (WP4), network and platform integration (WP5, WP6)	• Further demonstrating control technology platforms to integrate solar and medium-scale battery storage (WP5) • Integrating control technologies of customer-owned solar and batteries to extend hosting capacity beyond solely operating within network constraints (WP4,6)
Peak Demand Reduction using Solar and Storage (United Energy) *Source: (United Energy, 2019)*	**Virtual Power Plant.** A trial investigating the capability of 42 solar/storage systems to address specific constraints across 13 United Energy substations, seeking to defer infrastructure investment by: developing automated control algorithms with Reposit Power; investigating business models for DER-based network support services; and identifying future opportunities for non-	Constraint and resource identification (WP1), customer acquisition (WP3), network planning (WP4), network integration (WP6)	• Facilitating retailers and others to use network-owned storage for a positive business case (WP2) • Assessing the regulatory framework for adoption of network storage (WP4)

Project	Description	Key focus area[5]	Project Symphony progression
	network alternatives to address network constraints.		• Understanding network battery participation under DSO/DMO arrangements (WP4) • Extending control technologies of customer-owned solar and batteries to extend network hosting capacity and defer network expenditure (WP4,6)
New South Wales			
Pooled Energy Demonstration Project (Pooled Energy) *Source:* *https://pooledenergy.com.au/pooled-energy-moves-into-the-big-time-with-a-2-5m-grant-from-the-australian-renewable-energy-authority-arena/* *https://arena.gov.au/projects/pooled-energy-demonstration-project/*	**Demand management.** A retailer aggregation of 5,000 residential swimming pools in Sydney via an integrated control system to make 5MW of demand management resource available to the AEMO/ARENA RERT Trial. Pools contribute approximately 10% to total residential energy use, which is ~30-40% of total energy from the households that own them.	Resource valuation (WP2), customer acquisition (WP3), network planning (WP4), platform integration (WP5)	• Extending load resource valuation and integration beyond solely demand response (shed) applications e.g. through AEMO's RERT scheme (WP2,5) • Acquiring key customer loads for DER orchestration in conjunction with solar PV and battery storage (WP3,4)
My Energy Marketplace (MEM, Wattwatchers) *Sources:* *(Kapoor, Sturmberg and Shaw, 2020) (Shaw, 2020) (Wattwatchers Digital Energy, 2021)*	**DER marketplace.** An $8 million, 3-year trial funded by ARENA ($2.7m) developing a customer-facing marketplace platform to securely collect, process and productise energy data. It is installing Wattwatchers devices at 5,000 homes and small businesses, 250 schools, and enrolling an additional 1,500 non-Wattwatchers devices.	Constraint and resource identification (WP1), network planning (WP4), platform integration (WP5)	• Providing customers with access to 30-min interval data on a daily basis (WP1) • Involving customers in the development of value propositions that are then communicated with extensive community engagement (WP2,3) • Developing "greater awareness and appreciation of the context in which households make decisions about their energy" (WP3)

Project	Description	Key focus area[5]	Project Symphony progression
Queensland			
Townsville Virtual Power Plant (Yurika) *Sources:* *https://www.pv-magazine-australia.com/2020/01/10/timely-tesla-delivery-charges-queenslands-community-scale-battery-toward-fruition/* *https://www.yurika.com.au/news/2019/yurika-to-deliver-community-scale-battery-in-townsville*	**Virtual Power Plant, network battery.** Yurika, as part of Energy Queensland, installed a 135MW VPP of excess solar at Bohle Plains in Townsville (a solar hotspot), which are provided by 10 suppliers. Yurika also installed a 4MW/8MWh Tesla Powerpack to contribute to the existing VPP by dampening the volatility of the wholesale electricity markets through responding to high price events.	Resource valuation (WP2), network planning (WP4), network integration (WP6)	• Extending network-connected batteries' value beyond participating in a VPP by integrating it into a wider DER orchestration on the network (WP2,6)
Trialling a New Residential Solar PV and Battery Model (Ergon Energy) *Source: (Ergon Energy Retail, 2018)*	**Virtual Power Plant.** A one year trial aggregating 33 centrally monitored and control solar/battery systems (4.9kW SunPower PV, 12kWh/5kW Sunverge battery) in Cannonvale, Toowoomba and Townsville to reduce network peaks.	Resource valuation (WP2), customer acquisition (WP3), network planning (WP4), network integration (WP6), end-to-end transactions (WP7)	• Improving understanding (data) of customer consumption patterns and DER performance to better estimate resource (WP1) • Extending resource valuation beyond battery storage to solar PV and load control (WP2) • Developing innovative retail products via cx feedback (WP2, WP3) • Considering how energy storage should be configured and controlled to optimise the value to customers? (WP2) • Implementing software platform solution(s) that optimise DER outcomes and reduce the need for onsite maintenance (WP4)

Project	Description	Key focus area[5]	Project Symphony progression
			• Developing VPP capability including automation and dispatch (WP5) • Developing a self-adjusting, responsive algorithm to deploy DER orchestration at scale (WP7)
Tasmania			
CONSORT Bruny Island Battery Trial (TasNetworks)**	**Virtual Power Plant.** A trial implementing an automated control platform for solar-storage systems to provide network support services, which relies on the Network Aware Coordination (NAC) platform for fair remuneration of services.	Resource valuation (WP2), customer acquisition (WP3), network/platform integration (WP5, WP6), end-to-end transactions (WP7)	• UTas will extend their social research from CONSORT to improve customer engagement and acquisition (WP3) • A commercial approach to platform development and/or procurement will bring DER orchestration closer to mainstream (WP5,6) • The scale of customer acquisition and DER orchestration will be expanded to deliver a close-to-mainstream model for deployment (WP7)
Australian Capital Territory			
Intelligent Storage for Australia's Grid (Reposit Power, ACT)	**Virtual Power Plant.**		
DER Integration and Automation Project (Evoenergy) *Source:* *https://arena.gov.au/projects/der-integration-and-automation-project/*	**DER marketplace.** Integrating Schneider Electric's DERMS platform and Greensync's deX platform into Evoenergy's operating system to expand the network's hosting capacity.	Network/platform integration (WP5, WP6)	• Extending the network integration of market and DERMS platforms beyond one commercial provider (WP5,6)

Project	Description	Key focus area[5]	Project Symphony progression
Multiple states			
VPP Demonstrations (AEMO) *Source: (Australian Energy Market Operator (AEMO), 2021a)*	**Virtual Power Plant.** Part of AEMO's broader DER Program, the demonstrations began in July 2019 and were designed to inform changes to regulatory frameworks and operational processes to ensure DER can be effectively integrated into the NEM whilst also maximising value to consumers and supporting power system security. The demonstrations included: • 8 VPP portfolios across all mainland NEM states • 31 MW, 27 MW of which is in SA • ~6800 consumers	Constraint and resource identification (WP1), resource valuation (WP2), customer acquisition (WP3), network integration (WP6), end-to-end transactions (WP7)	• Improving valuation methods and propositions for different customers (WP2) • Using APIs to integrate platforms rather than the public internet (WP6) • Addressing cybersecurity concerns in platform design, implementation and integration (WP4, WP5, WP6)
Decentralised Energy Exchange (deX, Greensync) *Source: (GreenSync, 2021)*	**DER marketplace.** deX is an open-access digital software platform to register customer-owned devices for network and market visibility with four layers: • deX Vision, showing capability, telemetry and impact – linked to Evoenergy project in the ACT; • deX Markets, DSO contracting capability; • dex Command, first implemented in the SA Simply Energy VPP; and deX Connect.	Constraint and resource identification (WP1), resource valuation (WP2), network planning (WP4), network/platform integration (WP5, WP6)	• Allowing DER to resolve more than one network or market issue i.e. non-exclusivity for value stacking (WP2) • Investigating platforms beyond deX that can also provide DER visibility to the market (WP1) and can be integrated into network planning (WP4) • Investigating operating envelopes via DCOA, which is of key interest to DNSPs incl. the inclusion of fairness (WP4)
Evolve Project (Zeppelin Bend – Energy Queensland, Essential Energy, Endeavour Energy, Ausgrid)	**DER management.** A project focused on developing and demonstrating a system for coordinating DER via operating envelopes	Constraint and resource identification (WP1), network	• Developing tools to easily identify network constraints and

Project	Description	Key focus area[5]	Project Symphony progression
Sources: (Weise, 2021) (Zeppelin Bend Pty Ltd, 2021)	across four distribution network service providers (DNSP) in Queensland and NSW. This is to support the development of real-time management of networks and longer-term planning horizons for DER.	planning (WP4), network/platform integration (WP5, WP6)	DER capacity to resolve them (WP1) – Where are these assets? – What capabilities do they have? – Where/when are operational issues on the network? – What behaviours can be dis/enabled by orchestration? • Investigating operating envelopes via DCOA, which is of key interest to DNSPs incl. the inclusion of fairness (WP4)
Networks Renewed (UTS – Essential Energy, United Energy, AusNet Services) *Source:* (Wyndham *et al.*, 2019)	**DER management.** A trial recruiting 90 residential customers to test the technical voltage control (active and reactive power) capability of solar and battery systems using innovative commercial models with three DNSPs in NSW and Victoria. The control and integration technologies were provided by Reposit Power and Mondo.	Constraint and resource identification (WP1), resource valuation (WP2), customer acquisition (WP3), network/platform integration (WP5, WP6), end-to-end transactions (WP7)	• Developing tools to easily identify network constraints and DER capacity to resolve them (WP1) • Improving valuation methods and propositions for different customers (WP2) • Better engaging a wider customer base to design and communicate products better (WP3) • Pursuing a "mainstreaming" / life-cycle approach to future DER trials (WP8)

* *Source:* (Energy Transformation Taskforce, 2019a)
** *Source:* (Farrier Swier Consulting and Gridwise Energy Solution, 2021)

APPENDIX 3: Project Symphony Objectives

The objectives of the Project will be achieved through the following outcomes:

a. Identify different methodologies for integrating and managing high levels of DER across the SWIS based on testing within the Project area.

b. Demonstrate how aggregated DER can supporting system safety and reliability.

c. Identify the technical aspects and requirements to enable DER orchestration via DER Aggregators.

d. Identify the functions and services DER can provide, and how they can most efficiently be utilised to participate in WEM energy, network support services and capacity markets (and potentially new markets).

e. Determine methods to maximise DER hosting capacity within the Project locational area.

f. Identify alternatives to both imposing zero export limits on new DER or continuously augmenting network capacity to accommodate new DER

g. Support the delivery of the DER orchestration elements of the WA DER Roadmap.

h. Increase customer understanding of DER, it's potential value streams and define methods to encourage participation in the broader SWIS.

i. Understand residential and commercial preferences regarding DER, including willingness to engage, level of engagement and value drivers

j. Improve understanding of the cost and benefits of DER integration with key stakeholders and develop evidence base for future investments.

k. Help inform the development of policy, market design and regulatory reform required to integrate DER in a WEM market construct.

APPENDIX 4: Applying Socio-Technical Transitions Theory

Systems thinking is a useful concept for tackling highly complex problems such as those raised by the energy transition; the linkages and interactions between each element (stock and flow) of the system is pivotal to best develop solutions to the underlying problems. It is inherently transdisciplinary as it considers sociological, technical, economic, environmental and political factors. The fractal nature of this process is apparent when each interrelationship is mapped, as shown the complexity of solely supply and utilisation in the Clean Energy Regulator's energy flow diagram (Clean Energy Regulator, 2015). Thus, this approach must be carefully targeted to deliver meaningful outcomes.

Within systems thinking, socio-technical transitions (STT) theory has emerged as a useful approach to analysing the transformation of energy systems across industrialised countries, particularly when considering new smart-grid developments (Ford *et al.*, 2017; Naber *et al.*, 2017; Ngar-yin Mah, Wu and Ronald Hills, 2017). Under a multi-level perspective of this transitions theory (Geels and Schot, 2007), new technologies are seeking to break through the socio-technical regime by capitalising on niche windows of opportunity e.g. the ability for new energy technologies to provide demand-side resource and network support services. The multi-level perspective can be practically applied to key organisations in the energy sector: landscape actors will be the energy market organisations and policy makers; regime actors will be the large incumbent businesses; and niche actors will be the emerging energy and technology businesses that seek to disrupt the system.

STT approaches are well-suited to designing large-scale demonstration projects and evaluating their impact in the most effective way. These approaches bring together the front-runners to mainstream new technical solutions in a collaborative way. Rather than promoting a traditional win-lose disruption, this approach facilitates socio-technical 'experiments' or 'niche innovations' that can evolve within a dominant industry regime. It brings the organisations themselves – and the change agents within them – to the fore of the project, recognising that technical innovations are developed within a landscape of culture, practices and institutions.

Project Symphony is leveraging the multi-level perspective within STT by positioning a researcher as a “knowledge broker” who will facilitate workshops, interviews and co-design outputs with key Knowledge Groups that exist within and alongside the project (Figure 4). The members of the Knowledge Groups align with the three levels of the multi-level perspective:

- Innovation (niche) partners: DER and demand-side aggregators with alternative business models; community group(s); and new technology providers
- Incumbent industry (regime): A transmission and distribution network (Western Power); large incumbent retailer (Synergy); the Australian Energy Market Operator (AEMO); and potentially commercial & industrial (C&I) businesses who may participate in the project
- Energy policy and regulators (regime): State and Australian government departments (including Energy Policy WA and the ARENA); customer and industry representatives (e.g. Energy Networks Australia, Energy Consumers Australia, Energy Users Association of Australia); other research institutes (University of Tasmania and University of Western Australia); and potentially social equity organisations e.g. the Australian Council of Social Service

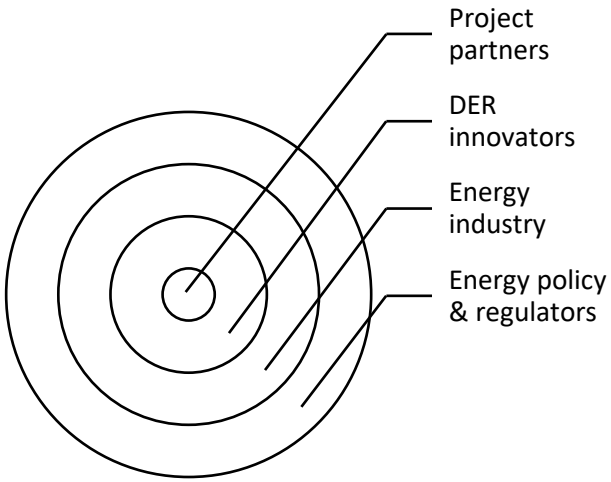


Figure 4. Knowledge groups aligning with socio-technical transitions theory