Project Symphony

Our energy future

Work Package 8.2
Final project assessment

UTS Institute for Sustainable Futures

In partnership with:

western power synergy AEMO Government of Western Australia Energy Policy WA

Citation and disclaimer

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

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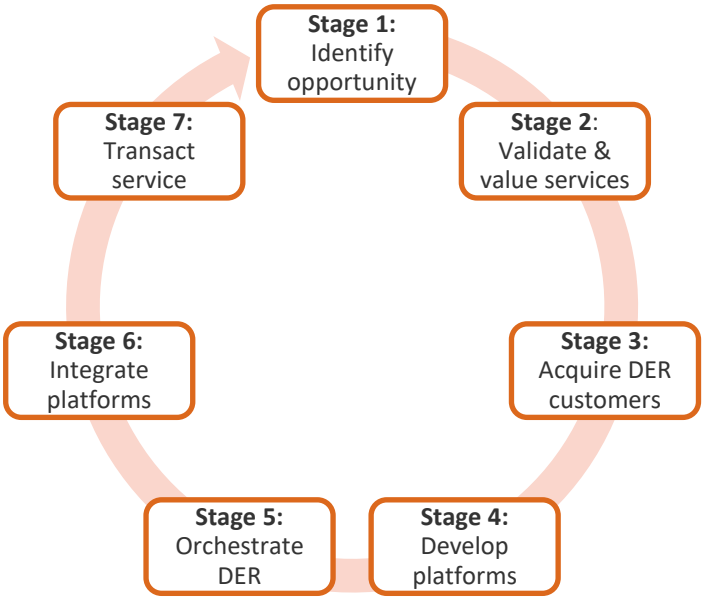
Executive Summary

Project Symphony, Western Australia's largest Virtual Power Plant (VPP) Pilot, is complete. The Pilot tested the ability of Distributed Energy Resources (DER) to participate in a simulation of the Wholesale Electricity Market (WEM) while simultaneously providing peak load support to improve the reliability of the local network.

Delivered in collaboration between Western Power, Synergy, the Australian Energy Market Operator (AEMO) and Energy Policy WA (EPWA), the Pilot is expected to unlock greater economic and environmental benefits for the Western Australian community.

The purpose of this document is to report on the final project evaluation of Project Symphony. Each of Project Symphony's work packages are measured against the stages of a rubric for both technology and commercial maturity that was outlined in Work Package 8.1: Vision and Impact Pathway. The rubric corresponds to both:

- the stages of a mutually exclusive and collectively exhaustive life-cycle framework of DER integration and orchestration (see figure below), and
- the Australian Renewable Energy Agency's (ARENA) maturity matrices i.e. technology readiness levels (TRL 1-9) and the commercial readiness index (CRI 1-6).



Life-cycle framework of DER integration and orchestration (adapted from Networks Renewed (UTS, 2019)), with stages corresponding to Project Symphony work packages.

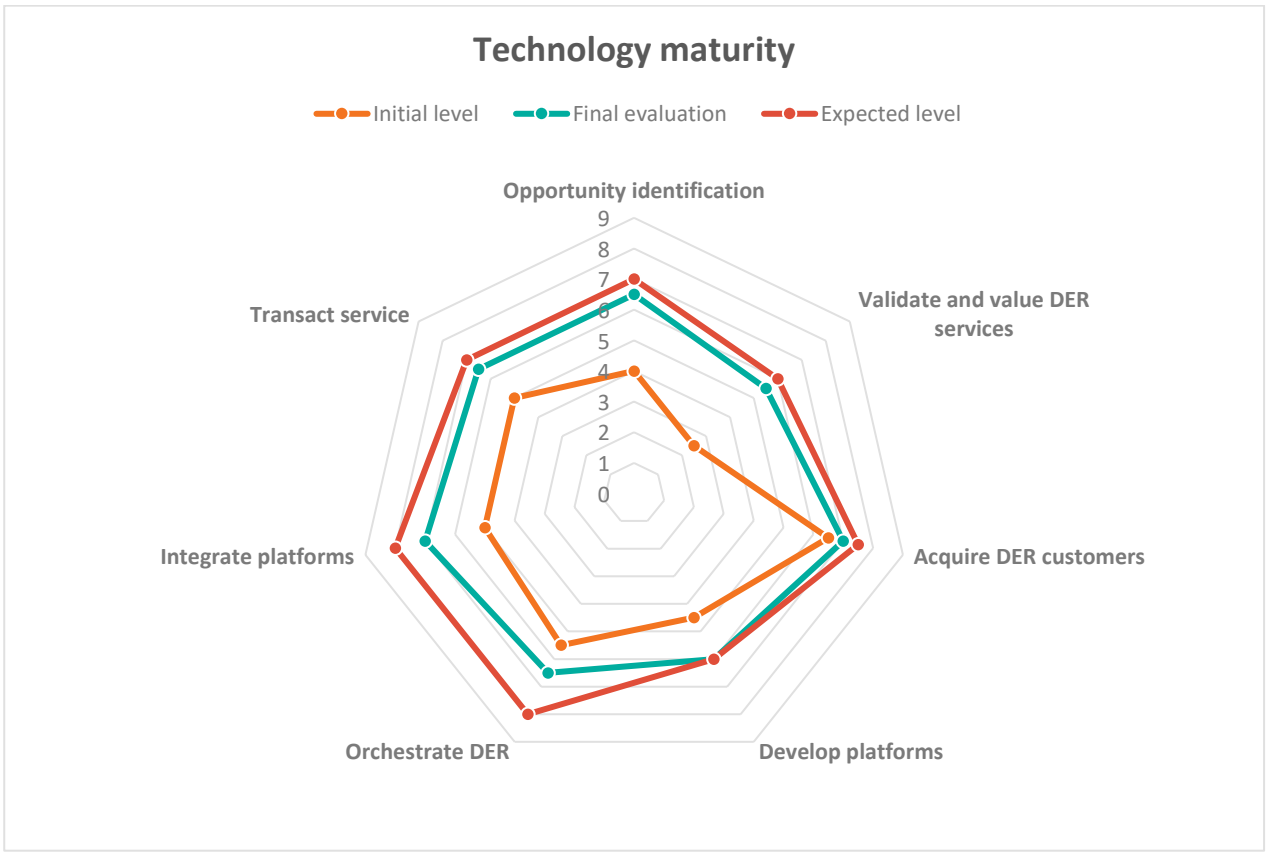
Project Symphony's progress towards technology and commercial maturity is summarised below and represented schematically on the following page.

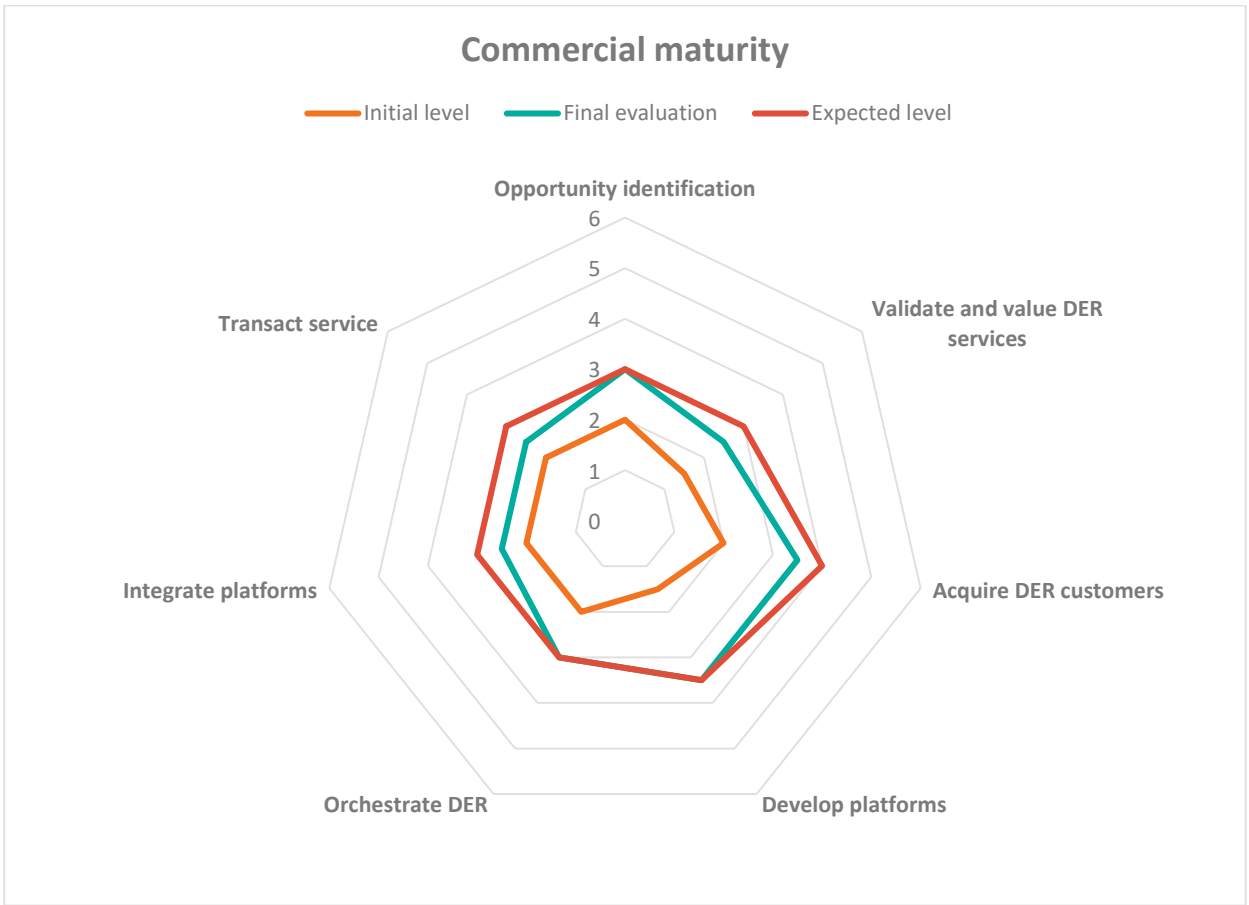
Stage	Technology maturity	Commercial maturity
1	**TRL 6 was achieved and significant progress was made towards TRL 7** Western Power (conforming to its role as DSO) further developed its Grid Transformation Engine (GTEng) to provide accurate and dynamic insights into emerging network issues at a whole-of-system level, which was applied to the Southern River zone substation (SNR 540). Synergy as Aggregator further enhanced DER visibility and control via telemetry data from DER assets within customer homes and on the distribution transformers. Outside of Project Symphony, Western Power has also published three iterations of its annual Network Opportunities Map (NOM), which is now an established regulatory requirement and a mature product with ongoing refinement.	**Significant progress was made towards CRI 3** To enable orchestration, customer consent was required to share NMI-level data with all members of the project team, however reforms are still required to access this type of data for future DER orchestration projects. There was consensus in the project team that there is sufficient network visibility of areas of constraint that could be alleviated through DER orchestration, particularly through the regular publication of the NOM. AEMO has made a recommendation to move from a static DER Register to a DER Participation Framework, noting that this will need to provide value to participants to account for the costs that they will incur. Significant progress was also made outside of Project Symphony towards interim regulations for sharing data, such as recent changes to chapter 6A of the Electricity Networks Access Code (2004) that requires Western Power to publish the NOM to help facilitate NCESS.
2	**TRL 5 was achieved and significant progress was made towards achieving TRL 6** Oakley Greenwood developed economic valuation methodologies for four mechanisms of frequency management (ESS), a reserve capacity mechanism and network support services (both peak demand and overvoltage conditions). Prototype valuations were tested through a comprehensive Cost Benefit Analysis (CBA) of DER orchestration. Real bilateral contracts for NSS (as NCESS) were tested in the pilot, which is the form they would take in a commercial environment. Thus, TRL 6 was achieved by the end of the project for NSS and NCESS from the perspective of the DMO, DSO and Aggregator. However, Project Symphony did not fully achieve TRL 6 given prototype valuations were not tested to the customer level.	**CRI 2 was achieved and significant progress was made towards CRI 3** The CBA found a positive Net Present Value (NPV) between $280 million to $920 million (the range across four modelling scenarios from pilot to hyper growth) for the fully orchestrated scenario. From a customer perspective, the pilot itself provided sufficient value through the provision of generous upfront capital subsidies where necessary (so they were "no worse off") and annual payments (paid monthly) of $150 for existing assets. The key to achieving CRI 3 is the 'productisation' of DER participation, which was not intended to be part of the Pilot. The CBA has informed what an economically viable product could be for customers, which will be tested after Project Symphony.
3	**TRL 7 was achieved** A total of 514 customers, with a total of 911 DER assets, were recruited for the Pilot. The project partners are confident that this delivered a statistically relevant number of customers and assets to enable high levels of confidence and inform the scaled application of DER orchestration in WA.	**CRI 3 was achieved and significant progress was made towards CRI 4** Although 43% of participants received a subsidised battery, Synergy also developed a product in Project Symphony where customers could participate with existing assets. Customers with existing assets received an upfront $150 annual payment for access to solar PV, hot water systems, HVAC and/or batteries. The CBA determined that these value offerings are broadly

Stage	Technology maturity	Commercial maturity
	The Pilot quantified the dispatch performance of multiple modes including: behind the meter optimisation; high and negative price targets; negative price injection cap; and network support services target. Project Symphony has informed the scope and requirements to achieve TRL 8, including policy interventions that could include mandatory participation of future solar, battery and electric vehicle customers in a VPP. Further work is also needed to improve the installation, maintenance and support of orchestration infrastructure.	equivalent with the commercially viable amount that could be offered beyond the Pilot. Other DER integration pilots in the NEM have also successfully recruited customers to deliver both network and market services although not concurrently or 'value-stacked'. Given there is not a standard product available applied in multiple jurisdictions that has tiered option and a clear risk profile, it was not possible to fully achieve CRI 4.
4	**TRL 6 was achieved** Project Symphony designed and built three platforms for the specific roles of each project partner as defined in the Open Energy Networks Hybrid Model. Together they provided an end-to-end solution, integrated with each organisation's system and processes, that was tested for the four test scenarios: energy services – bi-directional energy – balancing market; network support services; constrain to zero; essential system service. There was a lack of "fit-for-purpose" commercial solutions available so AEMO, Western Power and Synergy all contributed to internal development of the prototype platforms, leveraging commercial products where possible. Several outstanding issues remain with all three platforms that have been flagged as 'amber' in the Work Package 5 final report.	**CRI 3 was achieved and significant progress was made towards CRI 4** The DMO/DSO/Aggregator platforms were successfully integrated over a 90-day stability period as demonstrated in the "Test and Learn" results. However, as the DMO Platform was not implemented in an on-market capacity, CRI 4 was not fully achieved. Negotiations on data ownership, data communications, and confidentiality arrangements was delivered to an acceptable standard to ARENA through Work Package 6. However, the lack of industry standards was a significant obstacle to the Pilot. Partners of Project Symphony have now committed to aligning with a national approach and have been engaging in ARENA's DEIP Interoperability Working Group.
5	**TRL 6 was achieved and significant progress was made towards TRL 7** Between April – June 2023, Project Symphony successfully conducted a 90 Day Clean Run at the zone substation level. Although none of the four scenarios – bi-directional energy, NSS, CTZ, ESS-CRR – included reactive power dispatch, TRL 6 is still considered to be achieved given the Pilot was able to deliver multiple network and market services. Given the Pilot was operating in an off-market environment (non-business critical) and its network model was isolated from Western Power's BAU Network Model, TRL 7 was not fully achieved.	**CRI 3 was achieved** All project partners expressed satisfaction in the technical results of the orchestration and confidence that scale-up to the required standard to deliver a strategic market solution was technically possible. While telemetry was automated, collected and made available to the participants, there is some concern that the approach may not scale. Project EDGE also concurrently validated market services in the NEM, contributing to progress towards CRI 4. However, it is not possible to record significant progress given scaling limits were also acknowledged in that trial, operational telemetry is not able yet to be made publicly available and there is still no consensus on an industry standard for interoperability.

Stage	Technology maturity	Commercial maturity
	Some progress was also made towards TRL 8 by delivering real network benefit (NSS) from the orchestration.	
6	**TRL 7 was achieved** The DSO, DMO and Aggregator Platforms were successfully integrated at the substation level and below. To meet the operational requirements of a 5-minute market, most end-to-end integrations between the platforms were via API connection and either fully automated (API-API, pull or push) or via a manual API User Interface (UI – manual file transfer). DOE compliance was adequately measured using AMI data. Work Packages 6.1, 6.2 and 6.3 outlined the data (including data server) hosting and sharing agreements and specifications for APIs linking the platforms.	**Significant progress was made towards CRI 3** The partially customised solution that has been developed – for instance, to deliver DOEs – could be used again for scale-up in certain areas of WA, since the project partners remain the key actors in the DER orchestration. However, there was not consensus amongst the partners whether the platforms as developed could be made commercially available to actors in other jurisdictions both in the wider state or the NEM. National standards and practice, such as IEEE2030.5 communications within a DER network building on CSIP, is being considered outside Project Symphony but the Pilot is informing what will be selected in WA.
7	**TRL 6 was achieved and significant progress was made towards TRL 7** Transactions were demonstrated at zone substation level including the fundamentals of forecasting, measuring, scheduling and settlement. Telemetry data was provided to measure aggregated injections or withdrawals from all connection points. The pilot was able to validate automated operation, but not at all times. While there was agreement that the technical elements of the Pilot to deliver the scope of WEM functions had been delivered, there was also agreement that this did "not necessarily reflect ideal operational arrangements outside of the Pilot". The key issue that must be resolved is that aggregated DER acts in a fundamentally different way to the existing Facility Classes in the WEM. Until this is resolved, DER orchestration will not be able to participate in the market and fully achieve TRL 7.	**Significant progress was made towards CRI 3** There is consensus among the project partners that "DER aggregations demonstrate capability that can support system needs for the secure and reliable operation of the SWIS". During the Test and Learn period, the DSO was "publishing DOEs on a day-to-day basis without manual intervention apart from registration prior to the Pilot and manual override actions". However, since "NSS is not presently contemplated by the WEM", the Pilot required some bespoke arrangements to coordinate with other WEM services. Given the way the Pilot was structured, the network battery did not provide market services therefore there was no settlement required.

At the conclusion of Project Symphony and based on its findings, the project partners agreed on a series of recommendations to scale DER orchestration in WA. These recommendations are included in the Final Project report (final reference) and summarised in Appendix E.





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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).
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. DER can also be referred to as Consumer Energy Resources or CER.
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.
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.
Essential System Services (ESS)	As part of Security Constrained Economic Dispatch (SCED), Essential System Services (ESS) are used by AEMO to maintain security and reliability of supply, thereby supporting the energy market.
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.
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 (NSS)	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.
Non-Co-optimised Essential System Services (NCESS)	The Non-Co-optimised Essential System Services (NCESS) framework has replaced the current frameworks for Network Control Services (NCS) and Dispatch Support Services (DSS) in the WEM Rules and provides a more efficient framework for transparently identifying the need, specifying the requirements, procuring, dispatching and recovering costs for new types of ESS not already catered for under FCESS.
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
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.
Stability period	The stability period marks the end of the building and integration of the technology platforms, where the where the IT systems that support the VPP will not be updated with a new code.
System architecture	System architecture is a discipline for describing, analysing, 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.
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.

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Introduction

The following section outlines the framework for both technology and commercial maturity that Project Symphony's work packages will be evaluated against. Scores correspond to ARENA's technology readiness levels (TRLs) and commercial readiness index (CRI) matrices[1] and the categories correspond to Project Symphony's work packages, which then correspond to the mutually exclusive and collectively exhaustive life-cycle framework of DER integration and orchestration outlined below. *Note: Project Symphony also has an eighth work package that relates to knowledge brokering, which includes monitoring and evaluation, therefore it is not included in the assessment protocol.*

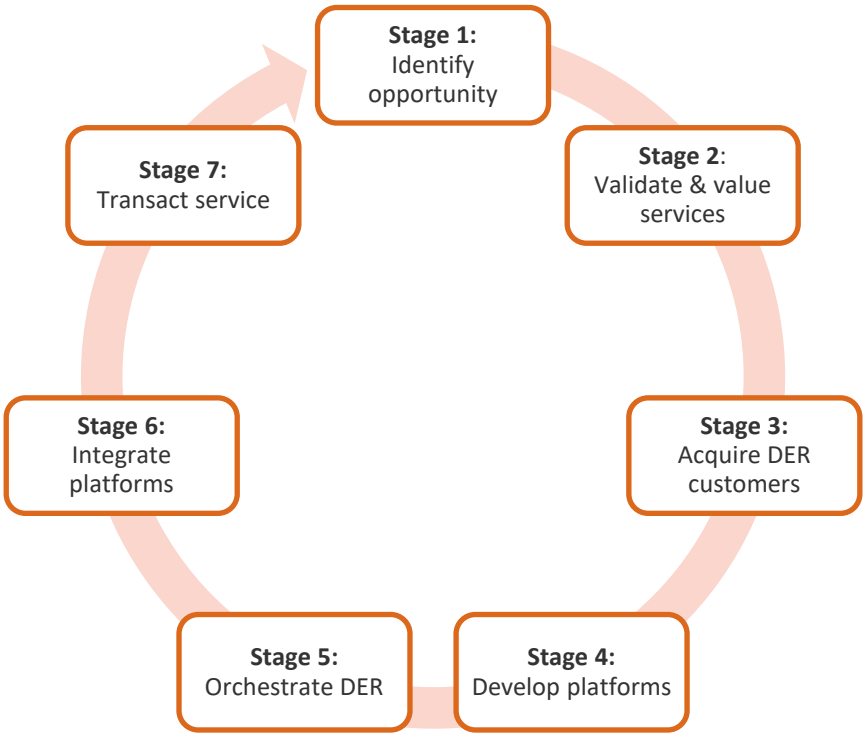


Figure 1. Life-cycle framework of DER integration and orchestration (*adapted from Networks Renewed (UTS, 2019)*), with stages corresponding to Project Symphony work packages

A description of each stage of the life-cycle and how it, and the corresponding Project Symphony work package, relates to mainstreaming DER integration and orchestration is further outlined in

[1] https://arena.gov.au/knowledge-bank/technology-and-commercial-readiness-tools/

Table 1.

Table 1. Description of DER integration and orchestration life-cycle.

Stage of life-cycle	Description
Identify opportunity (WP1: Identify pilot area)	Identify the target area, confirming the suitability of DER penetration, network constraints, and residential and commercial customers connected to the zone substation.
Validate and value DER services (WP2: Validate and value DER services)	Quantify both: • The value of DER for customers, networks, markets and retailers; and • The role of DER in the wholesale market(s).
Acquire DER customers (WP3: Acquire DER customers)	Recruit a minimum viable number of DER assets into an aggregation platform.
Develop platforms (WP4: Architecture planning)	Select and develop platform(s)/tool(s) to deliver the DMO-DSO-Aggregator roles and responsibilities.
Orchestrate DER (WP5: Build platforms)	Implement platform(s)/tool(s) to facilitate the delivery of energy, network and essential system services.
Integrate platforms (WP6: Integrate platforms)	Link the platform(s)/tool(s) needed to deliver the DMO-DSO-Aggregator roles and responsibilities.
Transact service (WP7: End-to-end transactions)	Execute the transaction of service, end-to-end, quantifying the benefits of DER services and measuring the effectiveness of the response from a network, market and customer perspective.

A schematic of the TRLs and CRI is in Figure 2 and a description is also provided at Appendix A.

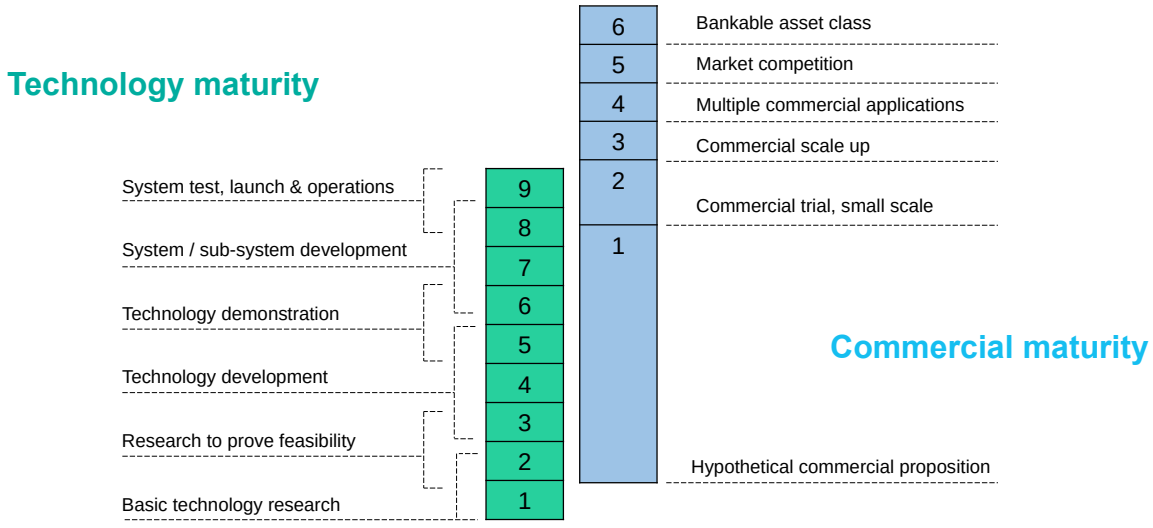


Figure 2. ARENA's technology readiness levels and commercial readiness index

Using the framework established in the Vision and Impact Pathway[2], the final project assessment was undertaken in five steps, engaging with the Project Symphony Core Project Team as well as technical experts and energy industry members, for example through the Symphony Information Forum (SIF):

1. Gathering and screening interim/final reports for work packages 1-8 to undertake a preliminary evaluation of the technical and commercial readiness of each stage along the impact pathway. Inputs included but may not be limited to the: Pilot Area Report; DER Service Valuation Report; DER Services Report; Commercial Agreements Summary; Customer Acquisition Plan; Aggregator Report; DCOA Report; DMO/DSO/Aggregator Platform Functional and Non-Functional Requirements Report; Combined Platform (As Built) Report for DSO, DMO and Aggregator; Data Hosting and Sharing Agreement Reports; API Specifications Report; Detailed Specification for Full DER Market Participation in the WEM; Generally Accepted Principles for DER Market Participation Guidelines; Report Outlining Key Changes to Regulations and Rules; Mid-Project Assessment; and Cost Benefit Analysis.

2. Interviews with Product Owners (POs) and Project Symphony Program Management Office (PMO) to clarify any content of the above reports and/or seek additional information that were not included in those reports to support the evaluation, including key achievements across customer participation, technology development and integration, and value streams.

3. Review by the Core Project Team (Western Power, Synergy, AEMO) and Energy Policy WA (EPWA) to provide an opportunity for feedback on the draft evaluation prior to engaging with external stakeholders.

4. Presentation to industry and experts to both: gather further supporting information from technical experts and energy industry members that may help provide further context for the evaluation e.g. further progress of technology and commercial maturity from other projects; and seek high-level feedback on the draft evaluation and the contribution Project Symphony has already made to achieving higher technology and commercial maturity.

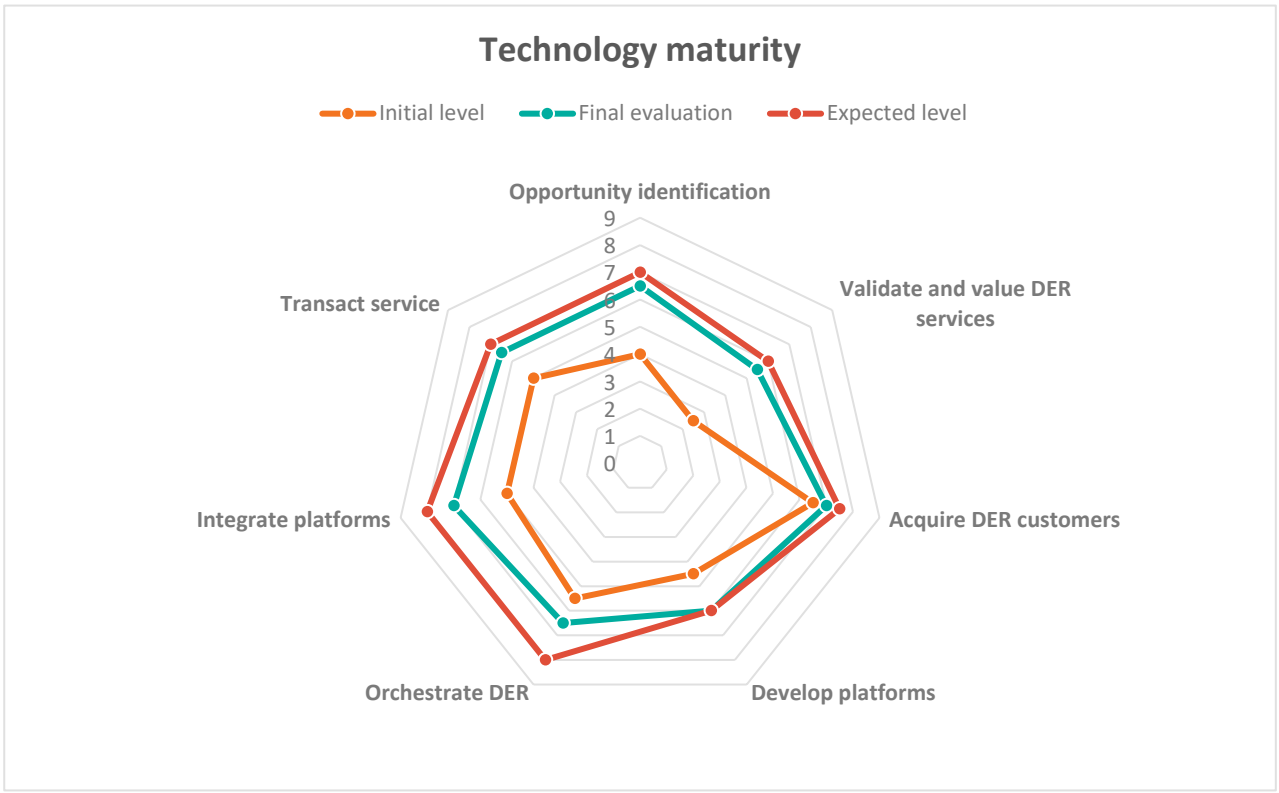
5. Final review by the Project Steering Committee, which represents a relevant cross-section of energy industry members with an interest in the success of Project Symphony: Core Project Team, EPWA and ARENA.

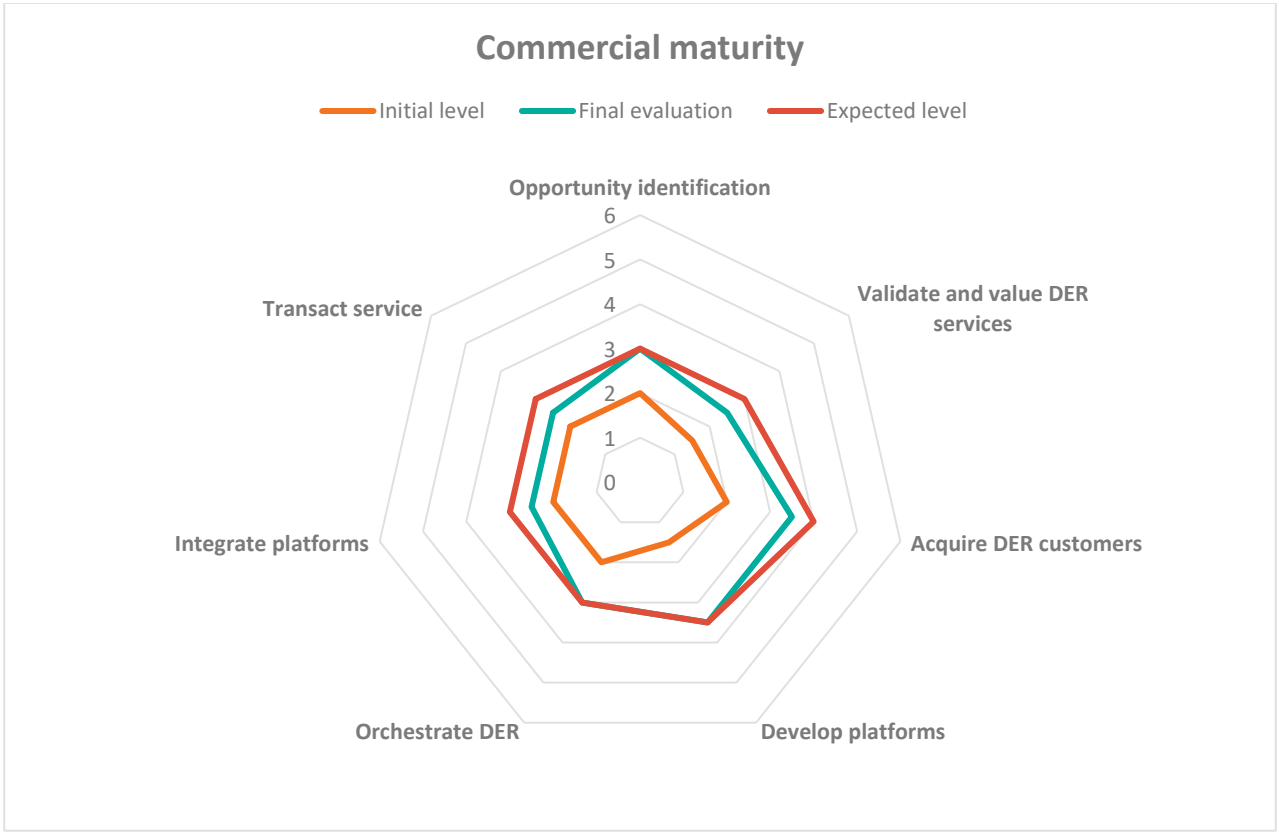
The output of the final project evaluation is this report which evaluates the status of the technology and the overall commercial maturity since the commencement of Project Symphony, in preparation for broader, scaled application. The remainder of the report is structured as follows:

- A summary of the final project assessment
- A detailed analysis of the assessment, outlined for each work package, and
- A summary of the assessment against the categories of project objectives.

[2] https://arena.gov.au/knowledge-bank/project-symphony-vision-and-impact-pathway/

Summary of the final project assessment





Detailed final project assessment

This section outlines the detailed final project assessment for each work package and the suite of project objectives outlined in the Project Management Plan (PMP). Each assessment is structured in the following way:

- A summary of the data that was analysed for the assessment, including reports reviewed and interviews/workshops conducted. All data has been coded via the qualitative analysis software "NVivo".
- For the work packages, a visual summary is provided outlining the progress that Project Symphony has made towards technology and commercial maturity. The white arrows outlined in orange indicate the anticipated progress that the Project was expected to achieve by its conclusion. The orange bars indicate the progress that has been achieved, which may or may not align with the anticipated progress level. The final project assessment of each level of technology and commercial maturity is then provided alongside its relevant reference from the assessment rubric. Red text in the rubric indicates where progress needs to be made by DER orchestration / integration projects (including, but not limited to, Project Symphony) to achieve that level of maturity. The complete assessment rubric is available provided at Appendices B and C.
- For the project objectives, data was cross referenced from the documents and interviews based on the descriptions outlined in the PMP. The nine project objectives are categorised as technical (3), new market (2), customer (2), roles and responsibilities (1), and policy and regulation (1).

The following data was analysed for the final project assessment:

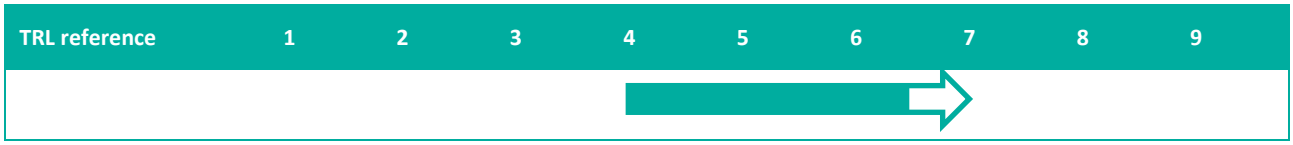
Source	References
Work package deliverables	Work Package 1.1 – Pilot Area Report (Western Power, 2021b) Work Package 2.1 – The economic value of a virtual power plant in the South West Interconnected System of Western Australia (Oakley Greenwood, 2022) Work Package 2.2 – Commercial Agreements Summary (Synergy, 2021a) Work Package 2.3 – DER Service Valuation Report (Synergy, 2022a) Work Package 3.1 – Customer Acquisition Plan (Synergy, 2021b) Work Package 3.2 – Aggregator Report (Synergy, 2021c) Work Package 3.3 – Social Research Report (Boyle et al., 2023) Work Package 4.1 – Distribution Constraints Optimisation Algorithm Report (Fernando et al., 2022) Work Package 4.2 – Provision of Distribution Market Operator Platform Functional and Non-functional Requirements (Australian Energy Market Operator, 2021)

	Work Package 4.3 – Distribution System Operator (DSO) Platform Functional and Non-Functional Requirements (Western Power, 2022) Work Package 4.4: Provision of Aggregator Platform Functional and Non-functional Requirements (Synergy, 2022b) Work Packages 5.1, 5.2 and 5.3 – Combined Platform (as built) Report for DSO, DMO and Aggregator (Synergy, Australian Energy Market Operator and Western Power, 2023) Work Package 6.1 – Server Hosting Agreement Report (Australian Energy Market Operator, 2022a) Work Package 6.2 – Data Sharing Agreement Report (Australian Energy Market Operator, 2022b) Work Package 6.3 – API Specifications Report (Australian Energy Market Operator, 2022c) Work Package 7 – DER Participation Framework (Australian Energy Market Operator, 2023) Work Package 8.3 – Cost Benefit Analysis (Ernst & Young, 2023)
Other project reports	Lessons Learnt Report: Milestone 1 (Western Power, 2021c) Cross Organisational Test Summary Reports (X-SIT) – Drop 2A, 2B, 3A, and 3B (Western Power, Australian Energy Market Operator and Synergy, 2022d, 2022c, 2022b, 2022a) Test and Learn Outcomes (Western Power, Australian Energy Market Operator and Synergy, 2023)
Project presentations to external audiences	Synergy Showcases: 31 August and 2 November 2022 Project Symphony Information Forum #2 – DER Value (11 August 2022) Project Symphony Information Forum #6 – Policy & Regulation (November 2023) Project Symphony Industry Briefing – Test & Learn Results (10 October 2023)
Interviews and workshops with project partners	Interview with the product owner (PO) from Western Power, on the topic of Work Package 1, in July 2022 Two interviews with the product owner (PO) from Synergy, on the topic of Work Packages 2 and 3, in July 2022 A workshop with the POs from AEMO (lead), Western Power and Synergy on the topic of Work Package 4 in July 2022

	An interview with the PMO on the topic of project progress and policy implications of Project Symphony in August 2022 An interview with the EPWA on the topic of project progress and policy implications of Project Symphony in August 2022 Independent interviews (five in total) with: PMO; the POs from Synergy, Western Power, AEMO; and EPWA on the topic of final project progress of all stages in Project Symphony during October 2023
Other relevant references	DER Roadmap: DER Orchestration Roles & Responsibilities Information Paper (Energy Policy WA, 2022) The DEIP DOE Working Group Outcomes Report (DEIP Dynamic Operating Envelopes Working Group, 2022) Network Opportunity Map 2021 (Western Power, 2021a) Network Opportunity Map 2023 (Western Power, 2023) Alternate Electricity Services regulatory framework (Energy Policy WA, 2023)

Stage 1 – Identify Opportunity

Technology maturity



The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Opportunity Identification** moving from level 4 (component/subsystem validation in laboratory environment) to level 7 (system prototyping demonstration in an operational environment). The final project assessment of the progress towards level 7 is summarised below.

TRL	Rubric reference	Assessment
4	Target area identification tool(s) implemented at scale with real data to experiment with different problems/scenarios e.g. calculating hosting capacity, and potential dynamic operating envelopes, for real locations using historical data.	**Achieved via Project Symphony and other DER integration projects** Project Symphony achieved this level through WP1.1 which identified its target feeder. Western Power identified the Southern River zone substation (SNR 540) as an optimal target since this feeder has "more instances and higher levels of reverse power flow, and similar or greater levels of evening peak loading"(Western Power, 2021b). Other DER integration projects that achieved this level of technology maturity prior to, or in parallel with, Project Symphony include: Project Evolve; Project EDGE (with AusNet Services); the Advanced VPP Integration Project undertaken by South Australia Power Networks (SAPN); and the Flexible Exports for Solar PV trial (Ausnet Services & SAPN) (DEIP Dynamic Operating Envelopes Working Group, 2022). While these projects have succeeded in identifying optimal target areas from a technical perspective, lessons learnt from Project Symphony suggest that the method could be improved by also accounting for social (e.g. demographic, customer segmentation) data (Western Power, 2021c). By doing so, customer acquisition challenges may not be as prominent. This is discussed further under Stage 3: Acquire DER Customers.
5	Tool(s) to provide automatic visibility of target area(s) and DER assets on the distribution network tested in a representative environment including near real-time (~5 min), accurate and dynamic data on capability, telemetry and potential impact (RB). Outputs of tool(s) conform to DSO/DMO/Aggregator requirements.	**Achieved** Project Symphony achieved this level for target identification through WP1.1 by further developing its Grid Transformation Engine (GTEng) to provide **accurate and dynamic** insights into emerging network issues at a whole-of-system level. Western Power notes that the following has already provided: a better understanding of the customer base; better visibility to the retailer (Synergy) by identifying priority feeders; and an opportunity to further develop its technical capability for Non-Cooptimised Essential System Services (NCESS). Specifically, GTEng is now **automatically** able to consider "different macro-economic, macro-demographic and technology factors, including the impact on the network" (Western Power, 2021b). GTEng was applied to the four scenarios outlined in the WA Whole of System Plan: Double Bubble, Techtopia, Groundhog Day and Castaway. Based on the GTEng analysis, Western Power expects only several low voltage (LV) networks to experience issues with excess solar PV (renewables peak) under the Techtopia and Double Bubble scenarios, while the issue becomes more pronounced across most LV networks under the other two scenarios. Most LV networks will experience issues with the evening peak and

TRL	Rubric reference	Assessment
		there are already a number of LV networks where the evening peak load is reaching a level of constraint. **The outputs of GTEng conform to Western Power's evolved role as DSO.** Visual outputs of this analysis are provided at Figure **3** and Figure 4. For visibility of DER assets, Project Symphony achieved this level through WP4.2-4.4 by defining DER facility structures and registering the facilities for the Pilot. DER facilities are "logical groupings of NMI connection points". Under the agreed platform functional and non-functional requirements, Synergy as the Aggregator is required to "enable end-to-end data flows from customer devices to AEMO". This includes **accurate NMI data and dynamic (once per day) DER facility capacity and telemetry data for settlement, monitoring and compliance**.
6	Target identification and/or DER visibility tool(s) – identifying the issue (e.g. constraint) and opportunity for DER orchestration – are implemented at the zone substation level of a hypothetical constraint. Minimum functionality includes: internet connection, 5-minute interval telemetry and control, a default safety mechanism when disconnected, and the ability to be scheduled. Basic troubleshooting mechanisms are established e.g. managing interim offline DER devices. The tool(s) and/or its outputs are aligned with DSO/DMO/Aggregator "BAU" operations.	**Achieved** The achievement of this level of technology maturity depended on the ability for: Western Power as DSO to identify local network constraints; AEMO as DMO to identify market requirements; and Synergy as the Aggregator to identify the opportunity for aggregated DER to address these constraints and/or requirements. In practice, this required (at a minimum) for Western Power to need to have greater visibility of the low voltage (LV) network (including both network topology and two-way power flows in near real time) and Synergy to provide greater visibility of DER including their location, type and concentration. *Target identification* Project Symphony achieved this level for target identification through its **load calculations to identify network constraints** in GTEng, which was **applied to the Southern River zone substation (SNR 540)**. SNR 540 was an optimal target since this feeder has "more instances and higher levels of reverse power flow, and similar or greater levels of evening peak loading" (Western Power, 2021d). In the Pilot, loading on the LV network was calculated using "a combination of customer energy usage data from tariff metering, telemetry from upstream devices, and the total inverter capacity" (Western Power, 2021b). The DSO Platform also supported the achievement of this level by forecasting network behaviour and network constraints using weather, solar irradiation, metering and network monitoring data (Fernando *et al.*, 2022). The DSO Platform also demonstrated how registered information for all DER, particularly NMI capacity, can assist this forecast with the end aim of calculating and allocating Dynamic Operating Envelopes (DOE). Synergy, Australian Energy Market Operator and Western Power (2023) noted that "The ability for the overall solution to transfer high frequency telemetry data in a timely fashion (i.e., less than five minutes) has been identified as a potential issue". An interview with AEMO confirmed that the Pilot **successfully demonstrated Facility Telemetry data (the portfolio level telemetry data gathered on local distribution transformers and provided by the Aggregator) at 5-minute intervals.** Along with tariff data from Advanced Metering Infrastructure (AMI), this provided the level of visibility required to augment load duration curves output by GTEng. There is also organisational confidence that 1-minute telemetry could be possible in certain circumstances to provide additional services in the future.

TRL	Rubric reference	Assessment
		These tools and platform were developed to **achieve functionality as an ongoing requirement beyond Project Symphony, including Western Power's role as DSO**. Western Power expects them to mature over time. Examples provided by Synergy, Australian Energy Market Operator and Western Power (2023) included: • VPP forecasting accuracy could be improved if aggregated telemetry can be factored into calculations and reset and short intervals e.g. hourly or every 5 minutes, and • Future VPPs could be more effective if they are geographically diverse to accommodate issues of local variability such as intermittent cloud cover. *DER visibility* Although currently limited in accuracy and completeness, DER visibility, in part, has been achieved by the Pilot using a new and more complete DER database. This acted as an enhanced DER Register. The existing DER Register in SWIS was developed outside Project Symphony to deliver on DER Roadmap Action #15. The DER Register identifies the type, capacity and location of DER connected to the LV network. In Project Symphony, the DSO platform intended to provide information on NMI capacity of all registered DER to help forecast hosting capacity and allocate DOEs. Synergy as Aggregator further **enhanced DER visibility and control via telemetry data from DER assets within customer homes and on the distribution transformers**. All sites have power meters but not all assets. In addition, High Speed Data Recorders were installed at 96 sites noting that this is not intended to be rolled out on a commercial basis, rather to provide additional visibility to the Pilot. Project Symphony defined DER facility structures and registered the facilities for the Pilot, including: accurate NMI data; a dynamic (once per day) DER facility capacity; and telemetry data for settlement, monitoring and compliance (Synergy, Australian Energy Market Operator and Western Power, 2023a). **A physical Ethernet cable was used to connect customer's home network with the controllable DER and the Gateway Controller. However, the DER Monitor & Control Platform and the Gateway Controller was connected by an internal 3G/4G modem, which did not connect to the customer's home network.** Western Power also installed monitors on a select sample of distribution transformers and had close to 100% penetration of advanced meters which are aggregated at a transformer level. The sensors on transformers collect loading and power quality data for better forecasting and DER service validation. A sample of transformer monitoring data is provided at Appendix D. It is important that DER responds to instructions in a timely manner to optimise the operations of the DSO platform. If assets do not respond effectively, the DSO platform must more frequently update its strategy leading to sub-optimal outcomes (Synergy, Australian Energy Market Operator and Western Power, 2023b). Of course, if they do not comply at all, then the service cannot be effectively provided. Troubleshooting mechanisms for DER devices is the responsibility of Synergy as the Aggregator. An interview with Synergy evidenced the troubleshooting mechanisms established within Project Symphony. **An internal ticket system was developed to manage devices that provided incorrect outputs, went offline or required additional customer support.** A software upgrade was implemented after the stability period to deliver the "Power BI" report that shows availability and

TRL	Rubric reference	Assessment
		capacity, along with the internal tickets for the troubleshooting mechanism, at regular cadence. Compliance with Dynamic Operating Envelopes (DOEs) specifically was considered critical. The outcomes of the 90-Day Clean Run demonstrated instances of both strong and poor compliance (Figure 5). At the end of the test period suggests that there was approximately a 50% overall compliance rate (Ernst & Young, 2023). **DOE breaches improved over time as issues were troubleshooted.** For example, rescheduling DOE publication to avoid overloading the Aggregator Platform (Ernst & Young, 2023). Further testing is required to validate that DOE compliance is sufficiently high to maximise utilisation of the network and DER. Establishing minimum functionality requirements for BAU application will remain the responsibility for Synergy as the Aggregator. In the interim, Western Power noted in an interview that it has established a failsafe mechanism whereby a default DOE (identical to the offline devices) is used if the DOE is not provided, noting that this is not a failsafe mode from the Gateway device to the asset.
7	Target identification and/or DER visibility tool(s) are implemented at the zone substation level of an emerging constraint to develop scenarios for the area. The tool(s) and/or its outputs are managed, and potentially hosted by, the DSO/DMO/Aggregator to integrate it into "BAU" operations (including a functional user interface).	**Partially achieved** *Target identification* Outside of Project Symphony, Western Power has published three iterations of its annual Network Opportunities Map (NOM) (Western Power, 2021a;Western Power, 2023).The NOM is published as a report and an online interactive map on the NOM Webpage. The NOM is designed to facilitate tenders for NCESS required to address emerging constraints (Synergy, 2021a). The information is a "snapshot view" of the challenges, risks and constraints emerging for the network at a point in time and thus is not a real-time visualisation tool. The intent is to provide customers, industry and market participants advance notice of future opportunities for alternative solutions to network constraints that Western Power will engage in the near future. For example, in mid-2022, Western Power sought solutions from Aggregators and service providers to alleviate local network constraints at/or below the substation level across the SWIS. The request was for demand control services to provide a minimum of 8MW in at least seven metro areas from 1 November 2022 to address potential thermal overload issues that could occur on the medium voltage network driven by the evening peak. This demonstrates that the **NOM is practically used to facilitate tenders of NCESS for an emerging constraint.** Two community batteries have already been procured based on this information. Again, Western Power expects the NOM and other tools to mature over time, particularly in relation to distribution network forecasting that was identified in the outcomes of the *Independent Review of Christmas 2021 power outages* (March, 2022). **As this is now an established regulatory requirement and a mature product, noting there will be ongoing refinement, it can be considered aligned with Western Power's (which will extend to its role as DSO) BAU operations.** While the GTEng informs the development of the NOM and was used to identify the network constraint at SNR 540, it is not certain whether this could be used at other locations on Western Power's network. Before this is included in BAU operations for Western Power in its DSO role, GTEng should be evaluated further in contexts different network topologies and characteristics (Synergy, Australian Energy Market Operator and Western Power, 2023a).

TRL	Rubric reference	Assessment
		DER visibility Although the Pilot has demonstrated sufficient visibility over the DER for orchestration purposes, AEMO noted in an interview that this level of visibility does not exist across the SWIS. EPWA (2024) also reiterated that "device level visibility and exchange of that data was only possible under the Pilot conditions and an appropriate way to facilitate this at scale is not yet confirmed". While the DER Register provides static information it does not include operational data (e.g. forecasts, telemetry, settlement data) that is critical for understanding orchestration opportunities. Aggregated DER is not contemplated by the WEM Rules' definitions of registered Facilities, which has the potential to create issues with a lack of clarity for investors in VPP capability, and create challenges with retrofitting requirements once VPPs grow in scale. Therefore, AEMO has recommended the establishment of a DER Participation Framework that "should recognise that visibility and predictability should be provided along a continuum of aggregator capability, whilst clarifying how value streams will be made accessible over the longer-term" (Australian Energy Market Operator, 2023a). A shared understanding of visibility requirements could be embedded in the WEM Rules to account for unregistered DER aggregations. In addition, the project partners noted that data gathered for the Pilot would need to be further extended to account for other types of DER including electric vehicles, air-conditioning units, hot water systems and swimming pool pumps (Synergy, Australian Energy Market Operator and Western Power, 2023a). This is expected to be undertaken via the AEMO initiated proposal to amend the WEM Procedure relating to the DER Register.

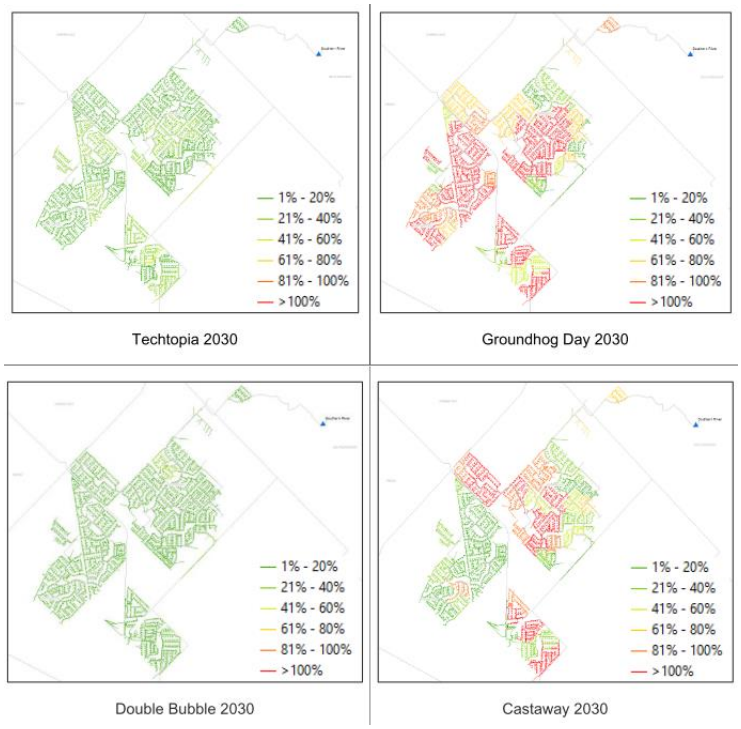


Figure 3. Renewables peak loading in 2030 under different scenarios for SNR 540 (Western Power, 2021b)

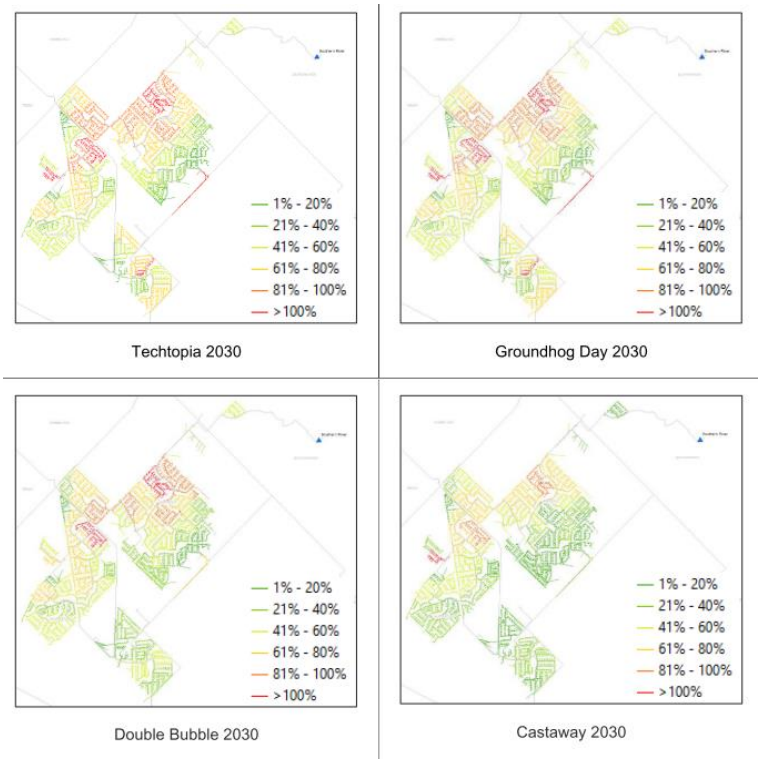


Figure 4. Evening peak loading in 2030 under different scenarios for SNR 540 (Western Power, 2021b)

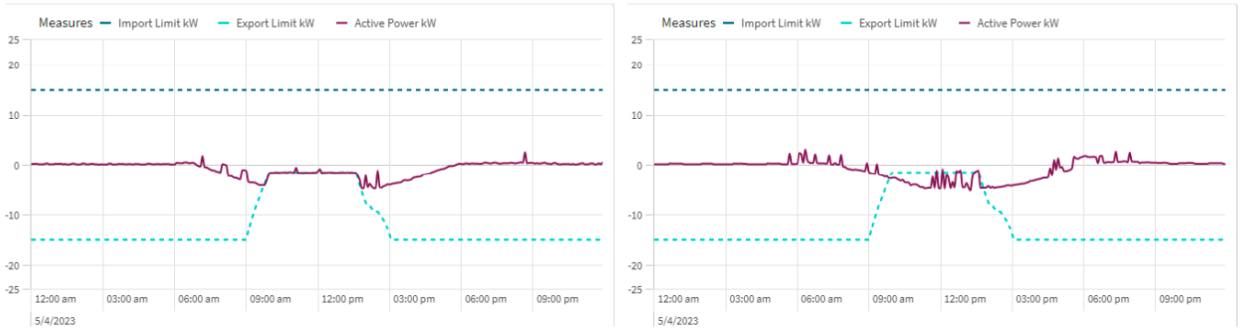


Figure 5. Examples of strong and poor DOE compliance in the 90-Day Clean Run (insert final reference from close out report)

Commercial maturity

CRI reference	1	2	3	4	5	6

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Opportunity Identification** moving from level 2 (commercial trials) to level 3 (commercial scale-up). The end of project assessment of the progress towards level 3 is summarised below.

CRI	Rubric reference	Assessment
3	DER (batteries, solar, loads, generators etc.) data required for orchestration made available for a demonstration project, following agreed interim regulations for sharing customer/network/market participation data. Development of preliminary standards related to network modelling, data measurement, DER asset communications and device registration.	**Achieved** DER data was developed and shared in such a way that successful orchestration of DER is delivered within the Pilot. A Data Sharing and Communications Protocol was developed for data that was not covered by existing agreements, procedures or legislation. Given the established agreements in place with Synergy, it is expected that Western Power will continue to be the metering provider in WA. However, the project team identified that several other data gaps are creating barriers to progressing commercial maturity of this aspect of DER orchestration beyond CRI3. For example, a lack of customer demographic data, DER data (asset communications and device registration) and LV topology data may hinder DER valuation and customer recruitment (Western Power, 2021c). This work is not within scope of Project Symphony but is critical to achieve higher levels of commercial maturity and thus is further explored below. There has already been **significant progress outside of Project Symphony towards interim regulations for sharing data**, such as recent changes to chapter 6A of the Electricity Networks Access Code (2004) that requires Western Power to publish the NOM to help facilitate NCESS. CUSTOMER DATA: To enable orchestration, **customer consent was required to share NMI-level data with all members of the project team, including performance of customer DER, since only the retailer (Synergy) holds that information** (Australian Energy Market Operator, 2022a)**.** This included "verifiable consent under the Metering

CRI	Rubric reference	Assessment
		Code and consents under project terms and conditions to share such data". At an early stage of the Pilot, the project team agreed to a data sharing principles document outlining partner obligations for sharing and protecting data (Australian Energy Market Operator, 2022a). This was adopted alongside the existing DER Register that accounts for the type, size, location and technical specification of DER assets (Western Power, 2021c). It is important to note that the connection-point data that was shared as part of Project Symphony, cannot be shared outside of the Pilot environment. Further, there are existing WEM Rule obligations for data sharing between Western Power and AEMO for the DER Register, which includes some of the data that was collected in the Pilot. **Synergy noted during an interview that reforms are still required to access this type of data for future DER orchestration projects.** **AEMO has made a recommendation to move from a static DER Register to a DER Participation Framework**, noting that this will need to provide value to participants to account for the costs that they will incur (Australian Energy Market Operator, 2023b). AEMO developed a Visibility Framework and Guideline – a voluntary and transitional approach, developed in consultation with existing VPPs – to clarify requirements of VPPs and providing AEMO with visibility of their performance. This will allow for AEMO to estimate the size and location of VPPs, to understand whether a DER aggregation must provide further information to avoid it compromising PSSR. However, in an interview Western Power acknowledged there may still be challenges with forecasting customer behaviour. This is likely to be alleviated only once the technology is mainstream and there is greater diversity of orchestrated DER across different locations. As outlined by AEMO (2023), DER orchestration acts differently to a conventional Facility and "should be defined by their control mechanism rather than their location and should be expected to scale to span the entire SWIS". NETWORK DATA: Western Power acknowledges that **network data to inform forecasting is improving with the installation of more than 500,000 meters, but is still somewhat limited and additional AMI are required to provide more LV network visibility.** The *DER Orchestration Roles and Responsibilities Information Paper* (Energy Policy WA, 2022) questioned whether AMI-level data is necessary for successful DER orchestration, or whether it could be aggregated at the transformer level. Following the Test and Learn phase of the Pilot, there appears to be consensus in the project team that there is **sufficient network visibility of network constraints that could be supported through DER orchestration**, particularly through the regular publication of the NOM. Western Power has clarified, however, that the level of visibility that was sufficient for the pilot is "not systemised across the rest of the network". The NOM provides planning-level visibility and does not provide operational-level visibility for constraints, at both the HV or LV network scales, at sufficient granularity required for effective orchestration. MARKET PARTICIPATION DATA: A proposed pathway to market participation of DER aggregations, with formal registration and obligations, is outlined in Figure 6. AEMO anticipates that registration of DER aggregators will enable more value streams, facilitate the scaling of orchestration via the Aggregator and support system operation by

CRI	Rubric reference	Assessment
		providing better forecasts and control. Beyond Project Symphony, the project partners are exploring the development of the Participation Frameworks (voluntary versus mandatory application, threshold levels, aggregation sizes) in conjunction with the DER Orchestration Roles and Responsibilities.

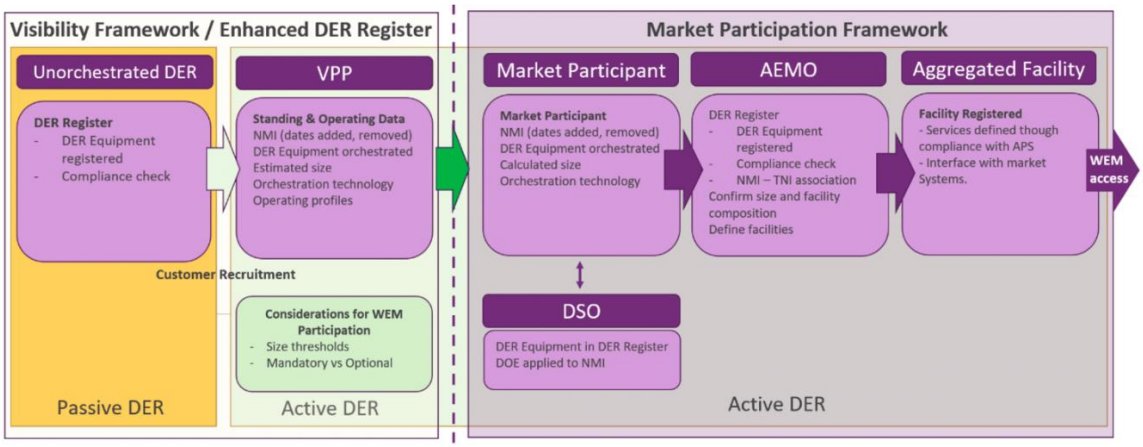


Figure 6. Indicative process map from visibility to registration

Stage 2 – Validate and Value DER Services

Technology maturity

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Validating and Valuing DER Services** moving from level 2 (technology concept and/or application formulated) to level 6 (system/subsystem model or prototyping demonstration in a relevant end-to-end environment). However, the assessment acknowledged that there was a strong chance that the project would achieve a level of 4 or 5 where the prototype would only be able to be validated in a laboratory (e.g. digital replica) or relevant (solely at the identified site) environment. The end of project assessment of the progress towards level 6 is summarised below.

TRL	Rubric reference	Assessment
2	Development of effective DER valuation methodologies that are applied to specific scenarios e.g. testing the payback periods for DER under simulated and hypothetical valuations of active and reactive power.	**Achieved** Project Symphony has achieved this level by commissioning an analysis on both: the economic value of a VPP in the SWIS (Oakley Greenwood, 2022); as well as the financial value of Project Symphony to key actors in the energy system (Synergy, 2022b). Oakley Greenwood **developed economic valuation methodologies for four mechanisms of frequency management (ESS), a reserve capacity mechanism and network support services (both peak demand and overvoltage conditions).** A schematic of the conceptual framework is provided at Figure 7. A non-orchestration base case is included to determine whether the economic benefits outweigh the costs of establishing a VPP. For example, depending on the scenario, this is compared to network augmentation costs (based on Energex's published long run marginal costs as the most comparable network publishing this data) or the value of curtailed energy on minimum demand. Although economic benefits are estimated for key actors, it is not a financial model. This is important because all actors must see some financial benefit for DER orchestration to reach commercial maturity. For future financial modelling, Oakley Greenwood notes that some valuable services are yet to be priced or incentivised in the current market. Pricing these services will be critical to achieve the maximum economic benefit. Synergy also developed an internal financial valuation methodology for Project Symphony in parallel with the economic valuation. A high-level architectural design of the financial services valuation approach is provided at Figure 8. The design compares the operating cash flows for each of the four value distribution lenses: the gentailer, aggregator, customer and network operator (Table 2). The model combines observed DER load and generation control data with a market simulation and customer behaviour estimates. The non-orchestration base case is built into the Concerto aggregation platform procured by Synergy, that estimates customer energy usage and battery operation without a VPP in place. AEMO's hypothetical market clearing outcomes (noting that Project Symphony is an off-market pilot) are applied through the PLEXOS software. A proxy is used for a price for ESS contingency raise, equivalent to the compensation amount Synergy receives to provide spinning reserve.

TRL	Rubric reference	Assessment
3	Experiments to apply DER valuation methodologies to real-life scenarios using representative data e.g. quantifying the value of using DER to address hypothetical voltage excursions on the distribution network to defer replacement/upgrading expenditure (RB).	**Achieved prior to Project Symphony.**
4	Experiments to apply DER valuation methodologies to real-life scenarios using real data e.g. quantifying the value of using DER to address real voltage excursions on the distribution network to defer replacement / upgrading expenditure.	**Achieved** Project Symphony has achieved this level by **applying the economic valuation method to the Project Symphony pilot scenarios using real data from the project.** The maximum value of $1.4 billion of gross economic benefits over 15 years is possible if all benefits are monetised and flow through to the customer (Oakley Greenwood, 2022). Controlled water heating is identified as the most likely load-based DER for shifting, noting that quality of life factors may need to be included when shifting loads such as air conditioning and EV charging. **The Pilot demonstrated 1-minute data telemetry shared every 5 minutes.** This provided confidence that the Aggregator Platform could provide near real-time telemetry data. Further, **Synergy used the data from 96 high speed data recorders installed at behind-the-meter customer battery sites. This data was used to quantify the ESS-CRR response from each site.** This will be used as a basis for future analysis to determine the suitability for DER to participate in essential system services.
5	Prototype valuations tested in a pilot environment using commercially available technologies with testing visibility needs to key actors (customers, network, market, retailers) e.g. real-time visibility of the financial performance of batteries providing network support services to a VPP	**Achieved** *Valuations* **Prototype valuations were tested through a comprehensive Cost Benefit Analysis (CBA) of DER orchestration.** The CBA was based on the scenarios tested in the Pilot was completed following the stability period. This informed whether, and under what conditions, the economic value will flow through to all key actors across the four scenarios. A key input was the DER uptake projections, which were largely derived from the 2023 WEM Electricity Statement of Opportunities. **Supporting technologies to realise most of the value from a VPP are considered commercially available.** For example, the Gateway device that was used to establish the VPP is technologically mature. However, it comes at a relatively significant expense and is likely to be superseded by the use of API for communications and management (Oakley Greenwood, 2022). While technology development for this API may be required for commercial maturity, it does not affect the technology maturity of DER orchestration. To reduce the per-site commissioning and on-going licensing costs, **Work Package 5** (Synergy, Australian Energy Market Operator and Western Power, 2023a) **recommended the project partners engage DER asset manufacturers and Software as a Service (SaaS) vendors to promote "interoperability between DER assets and gateway controllers through uniform adoption of technical and API standards"**. If API is selected as an alternate option in the future, technology

TRL	Rubric reference	Assessment
		developments may need to address risks related to using market power in a non-commercial way and the inability to provide certain services e.g. fail safe modes (Default DOE) or CTZ. *Visibility* The Pilot was able to more deeply understand how visibility needs will be met. AEMO as DMO explored how aggregated DER can facilitate market participation and returns as compensation for increased visibility and controllability with the aim of maintain power system security and reliability with high and increasing DER penetration. Synergy as the Aggregator explored how to respond to dispatch instructions, DOEs and aggregator asset performance. Western Power explored how to validate that the DOE has been followed. **Visibility options were tested for the project partners but could not be delivered to customers.** Prior to Project Symphony, Synergy had limited visibility and no physical control under the current contestability and licensing framework, which was tested in the Pilot (Synergy, 2021a). Synergy explored the option of a third-party dashboard to provide visibility to customers, however this was deemed too challenging as it was considered risky to provide customers with access to the administrative settings. If these were made available to customers "it would have provided access to areas where essential settings could be changed, along with other sensitive information" (Boyle *et al.*, 2023).
6	Prototype valuations tested in an end-to-end environment using commercially available technologies with testing visibility needs to key actors (customers, network, market, retailers)	**Partially achieved** *Valuation* Since wholesale market participation would impact upon trading and the financial arrangements in the WEM (and the central aim of the Pilot is to define the requirements for VPP participation), AEMO established an 'off-market' simulation. The off-market operation of a VPP at a minimum, needs to "ensure accurate demand forecasts that can facilitate the lowest cost dispatch to meet demand" (Australian Energy Market Operator, 2023a). For this reason, a market clearing simulation was used to dispatch market services from the VPP. **Thus, market data did not align with the financial performance of the DER assets in the VPP.** Estimating cash flows as inferred values rather than actual values creates challenges when comparing the value of the VPP compared with the non-orchestration base case. However, these were measured in line with a future market design scenario (Synergy, 2022b). Nonetheless, real bilateral contracts for NSS (as NCESS) were tested in the pilot, which is the form they would take in a commercial environment. **Thus, this level was achieved by the end of the project for NSS and NCESS from the perspective of the DMO, DSO and Aggregator.** While some of the commercial terms (pilot-specific terms clauses in the contract) would be different under BAU and would be renegotiated, the bilateral contract between the DSO and Aggregator was fit for purpose. It is also important to note that the Aggregator as a Market Participant is able to operate VPPs in the WEM under the existing Rules, however progress is still required to ensure that the VPP meets the performance standards required. Further work will be required to establish acceptable levels of Aggregator performance to participate in the market (based on lessons from the Pilot to date), and potentially specific market arrangements to allow this participation. Other longer-term issues may also emerge, such as: greater levels of degradation in batteries used in a VPP; and/or the use of proprietary control systems that may

TRL	Rubric reference	Assessment
		not be compatible with some VPPs or aggregators as is currently the case with Tesla batteries (Oakley Greenwood, 2022). However, **Project Symphony did not fully achieve this level of technology maturity given prototype valuations were not tested to the customer level.** Financial incentives tested in the Pilot were not those that would be likely provided in a real-world environment i.e. battery subsidies, yearly incentive payments and no access to pricing signals. Testing of these incentives in the absence of a substantial capital subsidy payment in future VPPs will support the achievement of TRL 6. *Visibility* As noted in the previous level, visibility needs were also not met from the customer's perspective. The social science study (Boyle *et al.*, 2023) identified this as a critical factor indicating that customers are seeking "clear, graphical information about how their assets were being used in orchestration, and a broader contextual understanding of what this meant for them and the broader community". They require a clear value proposition at the point of recruitment to establish baseline expectations of the use of their assets and the benefits (financial and non-financial) they will receive. This aligns with the findings in the *DER Orchestration Roles and Responsibilities Information Paper*, which refers to customer protections and states that "prosumers will require visibility of how their equipment is managed to ensure trust and social licence is maintained" ((Energy Policy WA, 2022), p. 7). Thus, further work towards visibility of orchestration for customers is considered critical to the future viability and social license of VPPs.

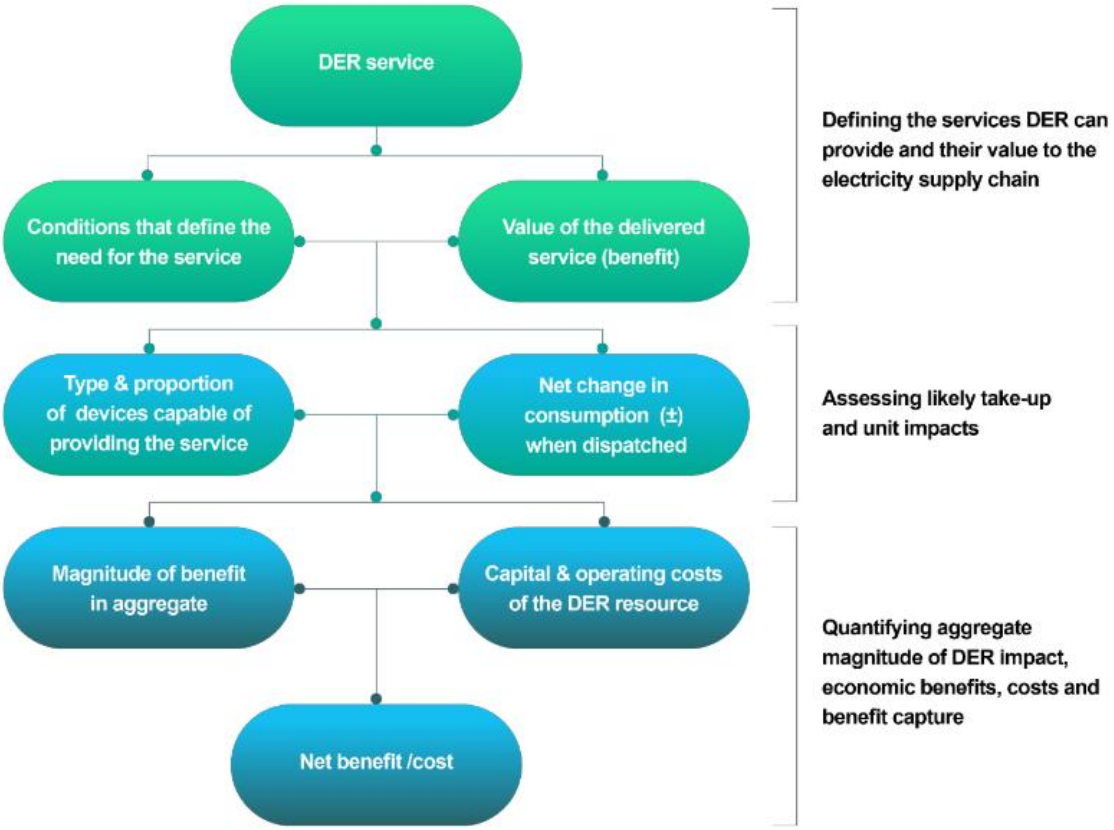


Figure 7. Economic valuation methodology developed for Project Symphony (Oakley Greenwood, 2022)

Figure 8. Financial valuation methodology developed for Project Symphony (Synergy, 2022b)

Table 2. The internal financial valuation method specification by value distribution lenses (Synergy, 2022b)

Lens	Operating value in each half hour interval =
Gentailer*	Δ market operating profit + NSS payment + Δ customer bill + Δ retail MBC – finder's fee
Aggregator*	finder's fee – VPP incentive
Customer	VPP incentive – Δ customer bill
Network operator	Δ network bill – NSS pathway

*In most cases, the gentailer will also be the customer's aggregator so the finder's fee is an internal transfer payment

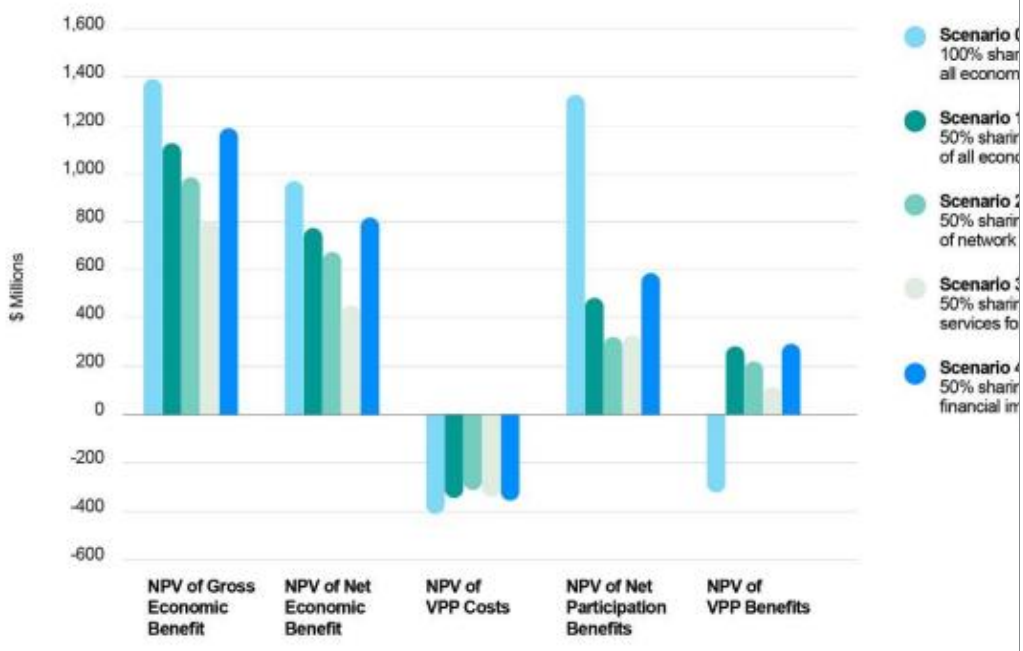
Table 3. Orchestration payments (solar participants without a battery subsidy)

Solar system size	Daily payment ($)	Monthly amount ($)	Annual amount ($)
2 kW	$0.85	$26	$310
3 kW	$1.27	$39	$464
4 kW	$1.68	$51	$613
5 kW	$2.12	$64	$774

Commercial maturity

CRI reference	1	2	3	4	5	6

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Validating and Valuing DER Services** moving from level 1 (hypothetical commercial proposition) to level 3 (commercial scale-up). The end of project assessment of the progress towards level 3, along with additional progress towards level 4, is summarised below.

CRI	Rubric component	Assessment
1	Hypothetical value proposed derived from theoretical data e.g. DER performance, levels of customer engagement, quality of service delivery.	**Achieved previously as part of the business case for Project Symphony and award of ARENA funding.**
2	Pilot project to test incentives (funded by government grant(s)) for network and/or market services from DER e.g. one-off payments for DER monitoring and control. Trials demonstrate a positive value proposition / business case for customer and key actors (network, retail, market).	**Achieved** The economic analysis (Oakley Greenwood, 2022) suggested that there will be value for all actors, however this will moderate the maximum benefit of ~$1.4bn (based on a weighted average cost of capital of 4%) that flows solely to customers. While other scenarios deliver less benefits, the lowest estimate was $453m when batteries are unable to provide regulation raise and lower services. A summary of the economic analysis is provided at  Figure **9**. How the value can be accessed and distributed to all actors was assessed through the detailed CBA. Early in the Pilot, the project partners noted that there is a reasonable chance that financial benefits for some services may not flow to ***all*** actors (gentailers, aggregators, customers and the network operator) (Synergy, 2022b). Nonetheless, it is understood that there is overall system benefit for some services that are provided by DER orchestration. The system benefits

CRI	Rubric component	Assessment
		(and hence the value proposition) may not be solely financial and may also include stability benefits, increased access to DER and more equitable distribution of DER benefits. To access these overall system benefits, it was understood that there may be some capital transfer between actors to accommodate the imbalances of financial benefits. For example, benefit is likely to be demonstrated from simple solar curtailment through Emergency Solar Management. (Ernst & Young, 2023) found a **positive Net Present Value (NPV) between $280 million to $920 million (the range across four modelling scenarios from pilot to hyper growth) for the fully orchestrated scenario (Figure 11)**, **which is a factor of "value stacking" or "co-optimising" network and market services. However, when considering each scenario independently, only the Bi-Directional Balancing Market delivered a positive NPV**. It is important to note that, even when a positive NPV was achieved, sufficient value was not always demonstrated for each of the key actors (DSO, DMO, Aggregator and customers). This will be a critical factor in the overall success of DER orchestration, given there should be a strong value proposition and a mechanism for value transfer for all actors to secure their participation. Alternatively, if a value proposition is not positive for all actors, government policy will likely need to play a role in promoting DER orchestration to achieve the overall system benefit. Another factor that must be considered is that the NPV could be significantly understated since many of the costs included in the CBA were related to Pilot expenses, such as battery subsidies and high installation expenses, that would not be expected in a business-as-usual context. Specific sources of value include: • Customers responding to price signals to both maximise their self-consumption of solar and obtain revenue for providing additional services. **Additional self-consumption of solar results in "a commensurate reduction in the purchase of WEM balancing energy".** This has the potential to lower costs for all customers by driving down the price of power by reducing peak and reducing the need for additional generation facilities. • **The opportunity for Western Power, as the DSO, to reduce capital expenditure by deferring network augmentation**. A benefit that was not considered in the CBA was the overall value to customers relating to that deferral of network expenditure, given state budget (accumulated from taxation) could be redistributed for other positive purposes. Thus, the total benefits of orchestration may be underestimated. • Adding 1.6GW of dispatchable generation over 15 years, "**deferring the need for additional generation required to offset the phased retirement of 620MW of thermal generation in Muja by 2030**." This overall validation of value also validates the effectiveness of the hybrid model that Project Symphony piloted – the responsibilities of the DSO, DMO and Aggregator – supporting those roles being formally implemented in the WEM. From a customer perspective, the pilot itself provided sufficient value through the provision of generous upfront capital subsidies where necessary and annual payments (paid monthly) of $150 for existing assets. The capital subsidies ranged between $7,475-$10,150 for battery systems, $2,475 for hot water systems and $8,000 for air-conditioners (Boyle *et al.*, 2023). This accounted for 39-64% of the total capital expenditure for those assets. These subsidies were provided to **ensure that customers were not worse off for their participation which allowed the Pilot to test the hypothesis that the VPP could meet the requirements of a scheduled generator where the DER assets were "not optimising benefits for participants"**. This was also called "heavy orchestration" and included examples such as discharging the battery at night or

CRI	Rubric component	Assessment
		gross curtailment of solar leading to zero self-consumption at times of high electricity usage. Orchestration payments between $310-$773 per annum were provided to participants without batteries in line with Table 3, based on an estimated 4.4 hours of orchestration (Ernst & Young, 2023). This provided an indication of what a reasonable incentive would be for future VPPs. For example, reducing annual incentive payments from $150 to $120 to maintain a positive NPV for customers, or providing variable payments for service. However, the authors noted that this could lead to push back from customers and should be approached with caution. The CBA was based on the results of the Pilot, which only tested four scenarios with a limited number of DER assets. It identified several factors that could expand the value of DER orchestration in the SWIS including: developing better incentives for customers; moving towards orchestration-friendly contracts e.g. dynamic connections and DOEs; reducing the costs (capex and opex) of VPPs; orchestrating additional assets e.g. air conditioning and pool pumps; and delivering additional services from the orchestrated assets e.g. regulation raise and lower services.
3	Commercial product(s) available and economically viable (including balance of system costs) for DER owners to provide network and/or market services through registered platform(s). Policies/regulations developing to remove barriers to multiple value streams e.g. direct load control, VPP establishment and delivery, dynamic export limits, dynamic operating envelopes, universal access to cost-reflective pricing.	**Partially achieved** *Valuation* The key to the achievement of this level of commercial maturity is the 'productisation' of DER participation. While Project Symphony delivered a prototype product to customers, the achievement of CRI3 will depend on whether these (or other) products are made available to customers beyond the Pilot. The social science study (Boyle *et al.*, 2023) argued that a key motivator of 76% of participants was the upfront asset subsidy. However, this scale of subsidy outlined in CRI2 is unlikely to be a commercially sustainable option. Although the CBA (Ernst & Young, 2023) found that an ongoing annual incentive payment of $120-$150 would deliver sufficient benefit to customers to justify the cost of orchestration, this was ranked as the second lowest motivator by customers. Customers were reported to have found this type of incentive to be "intangible and difficult to determine". The social science study (Boyle *et al.*, 2023) also found that "few participants could understand what the value proposition of the project was". There was consistent reports of confusion and dissatisfaction related to the orchestration activities, particularly in the first phase of orchestration (Figure 10). In particular, many participants expressed dissatisfaction with the application of CTZ (gross) when zero self-consumption of solar PV was possible. This created confusion since participants had been told that the project purpose was "green energy" or "saving energy", which was another source of value for many people. Further, the costs associated with the recruitment of customers, per-site commissioning and the product development were found to be high in the Pilot and are recommended to be a focus of increased efficiency in the scale-up phase (Synergy, Australian Energy Market Operator and Western Power, 2023a). Thus, **an economically *viable* product for all actors across all scenarios is yet to be demonstrated and CRI3 has not been achieved.** To achieve this level beyond the Pilot, the above factors will need to be considered when developing a strong value proposition and maximising the degree to which DER can be orchestrated for system benefit, including achieving decarbonisation goals. The social science study (Boyle *et al.*, 2023) highlighted several considerations that are critical to delivering sufficient value to customers: • adjacent costs, such as their time and effort to participate

CRI	Rubric component	Assessment
		• adjacent benefits that customers value such as the ability for batteries to be used for back-up power during an electricity outage, environmental benefits from better utilisation of solar PV, and community benefit of better use and management of DER • how the costs and benefits compare to alternative uses of DER e.g. batteries being used for price arbitrage and/or self-consumption of solar PV generation • how to clearly communicate the level of control needed over a customer-owned asset and how it will benefit customers more broadly • the perception of value from the customer's perspective, noting that this is not always simple and can change in context, and • the equitable pass-through of financial benefits from DER orchestration considering customers in the SWIS that either do not own DER or do not participate in a VPP. *Policy and regulation* Noting that "the current WEM registration framework does not readily enable the participation of Aggregated DER in the market", **Project Symphony partners are working directly with EPWA to progress policy and regulatory activities in the DER Roadmap that will underpin DER orchestration in the WEM** (Synergy, 2021a). Significant regulatory barriers have already been addressed in the DER Roadmap that facilitate, and in some cases have been influenced by, the Project Symphony activities (Synergy, 2021a). For example, changes to the Electricity Networks Access Code (ENAC) have clarified that Western Power can use network-connected batteries as an alternative to network augmentation but not for market participation. For this reason, Synergy operated the network-connected battery, owned by Western Power, for the life of Project Symphony to simulate a scenario where they lease battery capacity as they may in the future. The Pilot has also informed new DER connection processes to the distribution network given the unique, physics-based characteristics and constraints of WA's isolated, non-interconnected network. A key recommendation from AEMO, through its participation in Project Symphony, is the development of a DER Participation Framework that "addresses the principles of enabling 'visibility', 'predictability' and 'controllability', which are power system operational pre-requisites, and 'scalability', which is key to enabling DER to access value streams" (Australian Energy Market Operator, 2023a). This would encourage DER orchestration outside existing WEM Facility Classes, which are not fit for purpose. Introducing an Aggregated DER Facility Class that encompasses all the potential value streams (energy, capacity, energy variability, system restart, FCESS and NCESS/NSS) would help realise the net benefit of orchestration to the WEM. It is important to note that DER registration of this nature would bring additional costs and effort, such as administration, telemetry standards and data provision requirements, that must be balanced against the additional benefits offered to orchestrated assets. The goal to integrate Aggregators into the WEM will require specific enabling changes to accommodate limitations of, and the benefits provided by DER aggregations. Without this in place, it is possible that the value of DER orchestration to customers will not be accessible, which would instead promote behind-the-meter optimisation of those assets and forego the shared system benefit. For example, it is not yet clear whether DOEs and/or flexible exports could be implemented without market participation (Synergy, Australian Energy Market Operator and Western Power, 2023a). The overarching goal of the DER Participation Framework is to enable cost-reflectivity through direct interactions with the wholesale market, thus promoting more participation from customers and their assets. Other examples of policy and regulatory progress informed by Project Symphony include:

CRI	Rubric component	Assessment
		• The commercial agreements that Project Symphony established that involve multiple parties have or may become formally established depending on the WA Government's objectives. Commercial agreements include those between: Western Power and Synergy for NSS; Synergy, third-party aggregators and customers (including agreements between Synergy and third-party aggregators) for providing services; and Synergy and AEMO for dispatch and settlement. • The recent draft determination for Western Power's new access arrangement No. 5, which influences whether certain services in Project Symphony are applied as 'reference' or 'non-reference' services (Synergy, Australian Energy Market Operator and Western Power, 2023). • Further investigation of whether non-contestable customers should transition to a 5-minute settlement to assist with the transactions for orchestration payments as well as DOE and NSS compliance. • Further work is considering how to coordinate the Aggregator, DSO and DMO roles to align the benefit of network and system planning and operation for the benefit of customers. This is specifically relevant to when value streams available to VPPs converge, such as bi-directional energy and providing NSS (Australian Energy Market Operator, 2023a). • The Alternative Electricity Services (AES) regulatory framework was developed to "facilitate customer protections in new and emerging electricity business models" (Energy Policy WA, 2023) including behind-the-meter generation and storage. This could accommodate initiatives such as the consumer risk assessment tool that is being considered by the Australian Energy Regulator to deliver stronger and more targeted customer protection when their assets are being controlled (Boyle *et al.*, 2023). Oakley Greenwood, 2022) also notes that the development of DER interoperability standards (including DER, DER asset, Internet of Things (IoT) and IoT communications standards) will also help reduce the risk of "Balkanisation" noted at TRL 6. The Project Symphony position was that the project "supports the development and application of DER interoperability standards" and is "adopting a "Swiss army knife" approach that adapts to standards, rather than relies on standards". Project Symphony and the Pilot partners agree that WA will follow a national standard once it is agreed, such as IEEE2030.5 and CSIP-AU.

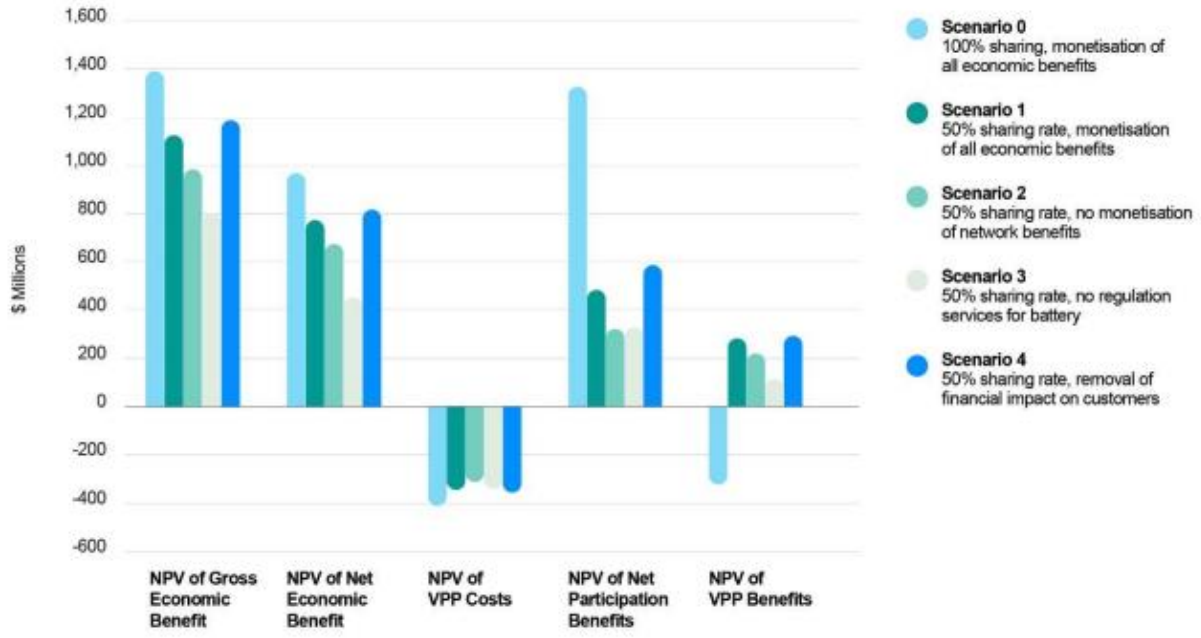


Figure 9. Summary of the economic benefits of a VPP in the SWIS (Oakley Greenwood, 2022)

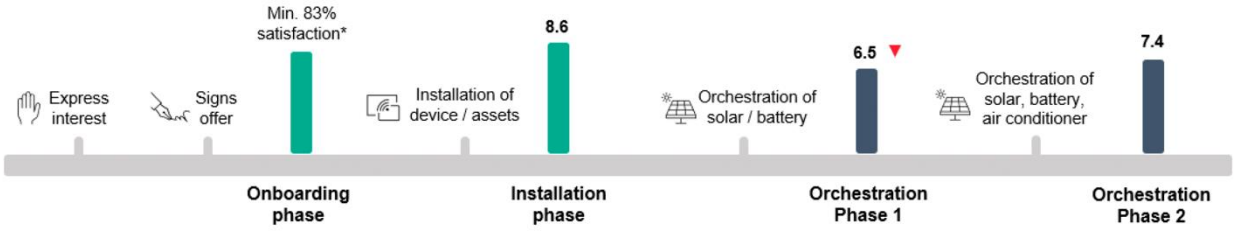


Figure 10. Participant sentiment at key phases of the Pilot (Boyle *et al.*, 2023)

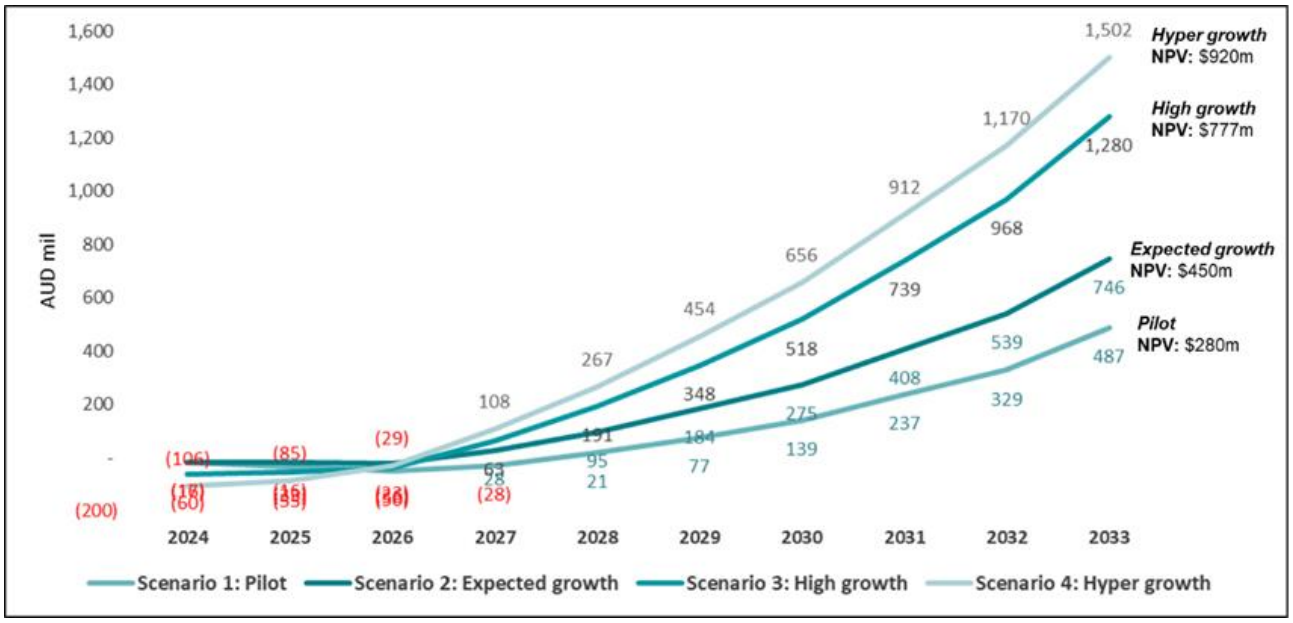
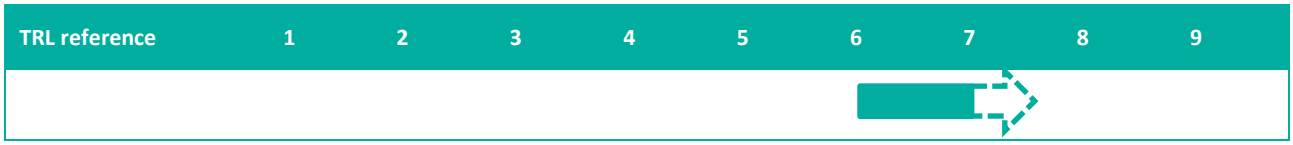


Figure 11. Combined cashflow for the "fully orchestrated" scenario (Ernst & Young, 2023)

Stage 3 – Acquire DER Customers

Technology maturity



The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Acquiring DER Customers** moving from level 6 (system/subsystem model or prototyping demonstration in a relevant end-to-end environment) to level 7 (system prototyping demonstration in an operational environment). The preliminary assessment noted an opportunity to make progress towards level 8 (end of system development), which was not achieved given that significant subsidies were still required and customers were not exposed to the real-time orchestration incentives. The end of project assessment of the progress towards levels 6, 7 and 8 is summarised below.

TRL	Rubric reference	Assessment
6	Implement a model to automatically output fair and attractive awards for customers that provide network or market services from DER. Implement the model at full-scale (e.g. feeder level) under a standard API with a suite of services (e.g. thermal, voltage, frequency). Recruit a minimum viable number of DER assets at pilot scale. Validate offer by measuring uptake, user experience and service delivery.	**Achieved** **A total of 514 customers, with a total of 911 DER assets, were recruited for the Pilot (Figure 12). Thus, the project partners are confident that a minimum viable number of DER assets were recruited, which was determined at the outset of the Pilot to be at 90% confidence levels to inform the scaled application of DER orchestration in WA.** Further work is needed to test and assess the performance of DER orchestration during scale-up. It is important to note that the participants did not fully represent a cross-section of broader community demographics with a greater representation of higher income, home ownership, solar PV ownership and those identifying as male (Figure 13 and Figure 14). given the eligibility criteria required home ownership and most home-owners already had installed solar PV systems. Pool pumps were removed from the list of possible assets early in the onboarding process due to unforeseen technical difficulties. Three different battery brands (QCell, Fronius (GEN24) and Sonnen) were tested to "understand how each respond to orchestration as well as general performance" (Boyle *et al.*, 2023). Examples of external and internal installations are provided in Figure **15**. A key goal was to explore what customers considered to be fair and attractive value for DER orchestration, validating the offer. User experience was documented through an extensive and longitudinal social science research project (Boyle *et al.*, 2023). **Given the customers were offered higher-than-commercial incentives, including a large upfront subsidy for assets including batteries, the financial offer was not validated. However, the CBA provided information on what a valid offer could be in future DER orchestration projects.** The user experience improved over time as technical issues were resolved and customers understood more about DER orchestration. The social science study found that improving visibility would enhance user experience by allowing customers to more easily monitor their assets and how they are being orchestrated. Resolving technical issues – e.g. there were significant customer frustrations when infrared control turned air conditioning units on and off when not required – also allowed the project partners to validate the service delivery. There were three key lessons learned from the early stages of customer recruitment (Western Power, 2021c). The first was that future recruitment should consider the type, location and concentration of DER assets that are needed to be orchestrated from the outset, so that the value of customers participating can be maximised. Secondly, an uplifted DER Register is considered to be able to target the appropriate type, location and concentration of assets. The DER Register has been progressed by Western Power and AEMO under the DER Roadmap. Thirdly, it is apparent that customers view different DER assets in different ways, which may affect their availability to provide some services. It will be important to consider the utility of customer assets in the scale-up of DER orchestration, for example considering customer comfort when orchestrating air conditioners (project partner interviews, 2023).

7	Test DER recruitment in an operational environment, achieving a target customer base to deliver an acceptable level of service. Determine a minimum viable number of DER assets and their reliability (Ergon Energy argues 95% reliability) to account for inconsistent customer "drop outs" e.g. opting out or technical outages. Test automated system to deliver offers, receive bids, evaluate contracts and dispatch service from registered DERs.	**Achieved** An important lesson learned from the project was that it can be problematic to use a percentage reliability figure to determine a minimum viable number of DER assets. Synergy noted during an interview that this is due to the dynamic nature of the orchestrated fleet, which evolves over time as aggregated connection points changed (network switching), customers choose to opt in or out, or other factors affect service delivery. For example, PV inverters were not available at some times when they were on "night mode". Another example, over the course of the 3-month stability period, was that the composition of the aggregated DER "Facility" changed over 15 times (Australian Energy Market Operator, 2023a). Instead, Project Symphony tested whether the dispatch instructions were met in different scenarios to develop a picture of the fleet's reliability to achieve TRL 7. **However, it is clear to the project partners that to provide reliable market and off-market services the aggregated DER asset base will need to comply with a percentage reliability figure – Project Symphony determined that this would need to be 95% or greater.** For the avoidance of doubt, this means that the aggregated capacity of DER to be orchestrated will need to be more than the energy required to deliver the service. The quantum of additional capacity is still to be determined. **Project Symphony quantified the dispatch performance of multiple modes including: behind the meter optimisation; high and negative price targets; negative price injection cap; and network support services target.** The result showed that 46% were within the tolerance level (5% capacity) that would apply at scale (Table 4). Therefore, this "demonstrated that it was extremely challenging for a DER aggregation to meet the requirements of any existing Facility Class at all times (Figure 16). For example, while the DER aggregation could, at times, meet dispatch targets, doing so 24/7 (as a Scheduled Facility is required to do) was at the expense of customer satisfaction". Notably, when the large network-connected battery was considered in isolation, it was found to achieve >90% in dispatch performance (Australian Energy Market Operator, 2023a). While this was an improvement in reliability, it sacrificed flexibility and the ability to scale. Thus, the development of a new Facility Class that can accommodate both network and customer owned assets, and can be coordinated across many connection points possibly across the SWIS, needs to be resolved before progressing beyond TRL 7. It is important to note the customer experience related to the two rounds of orchestration: an initial stage (averaging ~9.7 hours per day) as capabilities were being tested to prepare for and inform the 90-day stability period when orchestration was perceived as less intense (averaging ~1.4 hours per day) (Boyle *et al.*, 2023). Lessons that were learned early in the Pilot related to the available capacity of certain loads and types of customers (Synergy, 2021b). The estimated available capacity for both residential HVAC and hot water systems was downgraded following analysis of the target area, which has newer, more efficient systems. Controllable load capacity for HVAC systems were downgraded from an average of 10kW to 3 kW per household, and hot water systems were downgraded from an average of 4 kW to 0.5 kW. A lesson was also learned that, although renters were not able to participate in the Pilot, where there are locations with particularly high rates of tenancy, additional communication with landlords will be required. Synergy does not have a direct relationship with landlords, which will make this communication more difficult, and there are additional legal and

TRL	Rubric reference	Assessment
		economic considerations related to equipment installation e.g. negotiating the ownership of assets, resulting in the common issue of split incentives.
8	Recruit customers in the market to demonstrate operational service delivery from DER assets. A target customer base is achieved without additional technical or marketing support. An automated system delivers offers, receives bids, evaluates contracts and dispatches service from registered DERs. Most training and maintenance information is developed to support service delivery, including system design, site inspections and maintenance requirements.	**Not yet achieved** **Project Symphony has informed the scope and requirements to achieve TRL 8, including policy interventions that could include mandatory participation of future solar, battery and electric vehicle customers in a VPP.** There is an expectation that DER orchestration beyond Project Symphony will require lower marketing support. For example, the customer portal is already automated for contracting customers. AEMO has also procured residential-scale services under NCESS from Synergy via its "Solar Rewards[3]" product, facilitating the CTZ service. However, Synergy has noted that many other products and their delivery models are not yet scalable from its position as Aggregator. Technology requirements for third-party aggregators to participate in the WA energy markets will need to develop further beyond the Pilot. For example, their ability to provide on-market services, as VPP providers do in the NEM, is limited by the fact that Project Symphony is an off-market pilot (outside of NSS). Some progress has been made, since third-party aggregators can now contract with Synergy as the Financially Responsible Market Participant (Synergy, 2021c). An independent aggregator model (as has been tested in the NEM) is unlikely to be tested given the retail contestability policy in WA. However, outside of the Pilot, independent aggregators can establish based on contestable customers once market arrangements are put in place for them to participate. **The installation, maintenance and support of equipment ranged from simple to complicated**. Simple installations were a couple of hours duration and tended to only involve connecting an existing solar system in a house to the pilot via a gateway device, with one or two contractors/installers on site (PI46, October, 2022). Participants did not have issues with these simpler installs. Interviews indicated that more complex installations needed a significant number of installers in the house, with 6-10 tradespeople reported as turning up for some installs. A staff member explained that higher numbers were needed on site for the complicated technical installs to "get the job done" (Project partner interview, October, 2022). Complex installations also required significantly more time (seven to 10 hours) to complete, during which power had to be shut off. The numbers of installers on site appeared in part to ensure the long installs were undertaken in as timely a manner as possible, and because multiple types of skills were needed during the installations. This was described in the social science research as an expression of care from both the project partners and participants, which is unlikely to be sustained outside the pilot environment (Boyle *et al.*, 2023). **Given the installation, maintenance and support was "iteratively improved" and often required return visits (noted by participants as being "time consuming" and "somewhat disruptive", it is assessed that further work is required for this to achieve TRL 8.** Further work is likely needed to better understand "technology in place", including the installation, requirements for certain types of houses (most installations in Project Symphony were in newer houses) and assets e.g. batteries require significant space to account for safety requirements.

[3] https://www.synergy.net.au/solarrewards

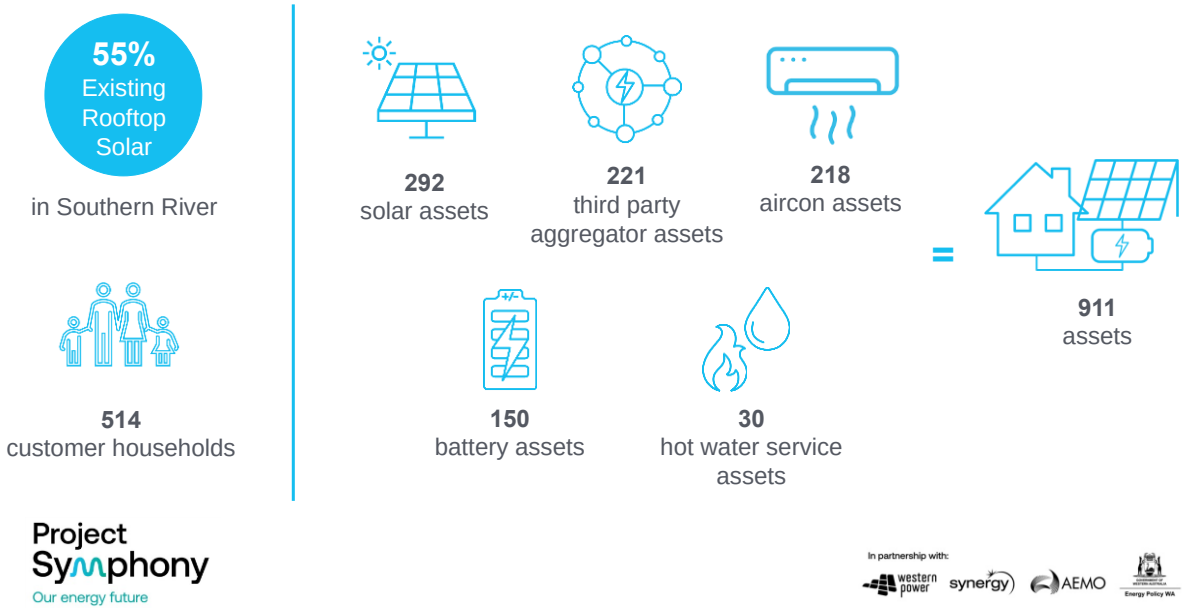


Figure 12. Final customer recruitment (Project Symphony Project Management Office, 2023)

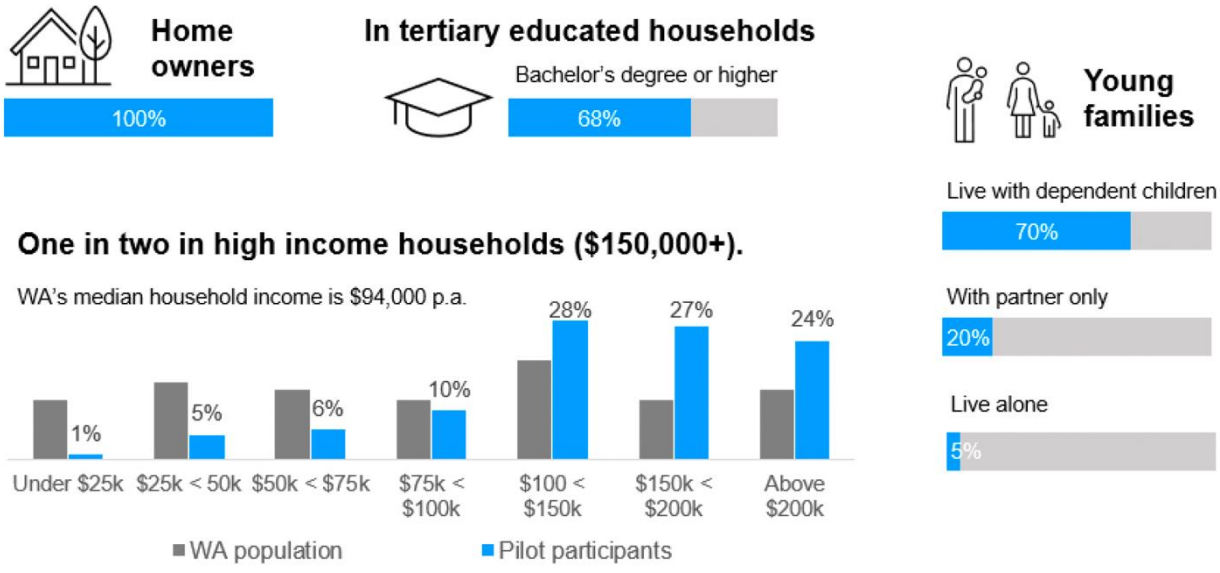


Figure 13. Overview of the average participating household (Boyle *et al.*, 2023)

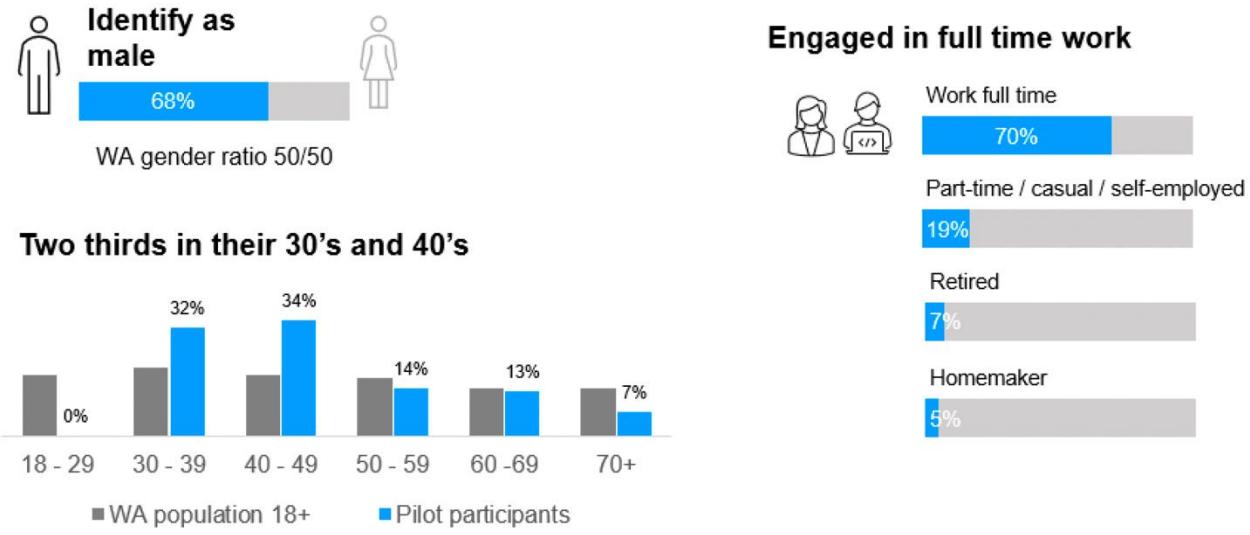


Figure 14. Overview of the average pilot participant (Boyle *et al.*, 2023)

Figure 15. Examples of external and internal installations (Boyle *et al.*, 2023)

Table 4. Dispatch performance categorised by dispatch mode (Australian Energy Market Operator, 2023a)

Dispatch mode	Main facility (90-day stability period	
	% of time	% within tolerance (5% capacity)
Behind the meter optimisation	85%	49%
High price target	5%	20%
Negative price injection cap	4%	27%
NSS target	3%	40%
Negative price target	1%	0%
All modes	**98%**	**46%**

Facility	Registration	Constraints	Submissions	Dispatch and real time operation	Monitoring & compliance	Settlement
Non-Contestable Customers	Market Customer (Synergy)		PASA information	Emergency Solar Management		Market data Interval meter data (optional)
Contestable Customers	Market Customer		PASA information			Interval meter data
DSP	NMI Association	Facility constraints Transmission constraints	Profile	Dispatch reduction with notice period		Interval meter Market data
Interruptible Load	NMI Association	Facility constraints Transmission constraints	ESS	Enablement	Telemetry WEM HRTSDR	Market data
Non-Scheduled Facility	Facility registration		Forecast (bidirectional)	Direction		Interval meter data
Semi-Scheduled Facility	Facility registration	Facility constraints Transmission constraints	Forecast (bidirectional)	Dispatch cap	Telemetry	Interval meter data
Semi-Scheduled Facility providing ESS	Facility registration, ESS accreditation	Facility constraints Transmission constraints	Energy (bidirectional) and ESS	Dispatch cap, target and enablement	Telemetry WEM HRTSDR	Interval meter Market data
Scheduled Facility	Facility registration	Facility constraints Transmission constraints	Energy (bidirectional)	Dispatch target	Telemetry	Interval meter data
Scheduled Facility providing ESS	Facility registration, ESS accreditation	Facility constraints Transmission constraints	Energy (bidirectional) and ESS	Dispatch target and enablement	Telemetry WEM HRTSDR	Interval meter Market data

Figure 16. WEM Facility Class Assessment (Green = underlying capability demonstrated. Red = identified gaps between Aggregator capability and class requirements) (Australian Energy Market Operator, 2023a).

Commercial maturity

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Acquiring DER Customers** moving from level 2 (commercial trials) to level 4 (multiple commercial applications) in tandem with Project EDGE. The end of project assessment of the progress towards level 3 is summarised below. CRI 4 is not yet achieved.

CRI	Rubric component	Assessment
3	Sufficient customers recruited to deliver network and market services for trials with multiple types of DER. Value offerings are commercially available (i.e. are not government-funded) and incorporate understanding of customer values and motivations. Business model is accessible to all key actors (customer, network, retail, market). Policies/regulations developed to address customer protection and technical risks.	**Achieved** Project Symphony is by design a Pilot, supported by the Australian and State Governments with the WA state policy agency directly involved as chair of the Steering Committee. **A total of 514 customers, with a total of 911 DER assets, were recruited for the Pilot (Figure 12), exceeding the target number of assets and achieving the four on- and off-market scenarios over a 90-day stability period.** Although 43% of participants received a subsidised battery, Synergy also developed a product in Project Symphony where customers could participate with existing assets. Customers with existing assets received an upfront $150 annual payment for access to solar PV, hot water systems, HVAC and/or batteries. These values were based on what is required to recruit customers based on the current perception and understanding of value. The CBA determined that these value offerings are broadly equivalent with the commercially viable amount that could be offered beyond the Pilot (Ernst & Young, 2023). As outlined in the *validation and valuation of DER* services, the CBA suggested that a commercially viable incentive could be lower than this amount but warned that this could lead to far lower customer recruitment. This is supported by the social science research (Boyle *et al.*, 2023), which noted that "subsidies were clearly a notable motivator, which may not be available when scaling pilot activities, which could mean the appeal to be involved could reduce" (Figure 17). Thus, it will be critical that participants achieve *and* perceive cost savings, in addition to other sources of value such as broader community benefit, emissions reduction or back-up power (network reliability was ranked as one of the lowest motivators), as DER orchestration scales in WA. The nature of Project Symphony is such that all actors – the distribution network, electricity network and market operator – are project partners. Thus, the business model was made accessible to all actors, however further work is required to ensure that they, and the customer, can access sufficient value as outlined in the CBA (Ernst & Young, 2023). Although mostly residential customers participated in the Pilot, one commercial & industrial (C&I) customer was also recruited from Synergy's customer base. A process was also developed through Project Symphony to recruit third-party aggregators through Synergy via an open expression of interest process (Synergy, 2021c). This contributed to the achievement of the Pilot's target customer and asset base and the broader development of aggregation capability in WA. It is important to note that "definitions and obligations of data and confidentiality in the Privacy and Electricity Acts, and rules stipulated in the Metering code and WEM rules do not allow for all of the data in the Pilot to be shared by all stakeholders without verifiable customer consent". This will need to be addressed in the scale-up phase. Rules for sharing customer data amongst participants were developed via a Data Sharing Protocol. Regulations to address customer protection are also currently being developed by EPWA.

CRI	Rubric component	Assessment
4	Sufficient customers recruited to deliver commercial network and market services in multiple jurisdictions with multiple types of DER. Multiple value offerings without lock-in clauses are commercially available, in multiple jurisdictions. Information available for customers e.g. comparable products, tiered options, clear risk profiles. Standards for equipment installation and "set and forget" functionality established.	**Partially achieved** **Other DER integration pilots in the NEM have also successfully recruited customers to deliver both network and market services (although not concurrently or 'value-stacked').** For example, SAPN's Advanced VPP Grid Integration Project recruited 1,000 customers for an 18-month field trial of dynamic export limits. Beyond Project Symphony, Project EDGE has also successfully completed its DER orchestration pilot in the Victoria. However, all of these trials have been operated mostly in an "off-market" context or are focused on informing policy and regulation (e.g. standards design) and are not yet considered commercial. To address the issues of both peak and minimum, AEMO has procured reliability services under Non-Co-optimised Essential System Services (NCESS) at the residential scale as well as Supplementary Reserve Capacity (SRC) ((Australian Energy Market Operator, 2023a), project partner interview). **However, this is not a standard product available applied in multiple jurisdictions that has tiered option and a clear risk profile, which is required to fully achieve CRI 4.** Once this and comparable products, such as the flexible exports product in South Australia, are more widely understood and implemented, this level will be achieved. While functional standards – such as AS4777 and AS4755 – are in place, Western Power noted in an interview that compliance with those standards still needs to be addressed.

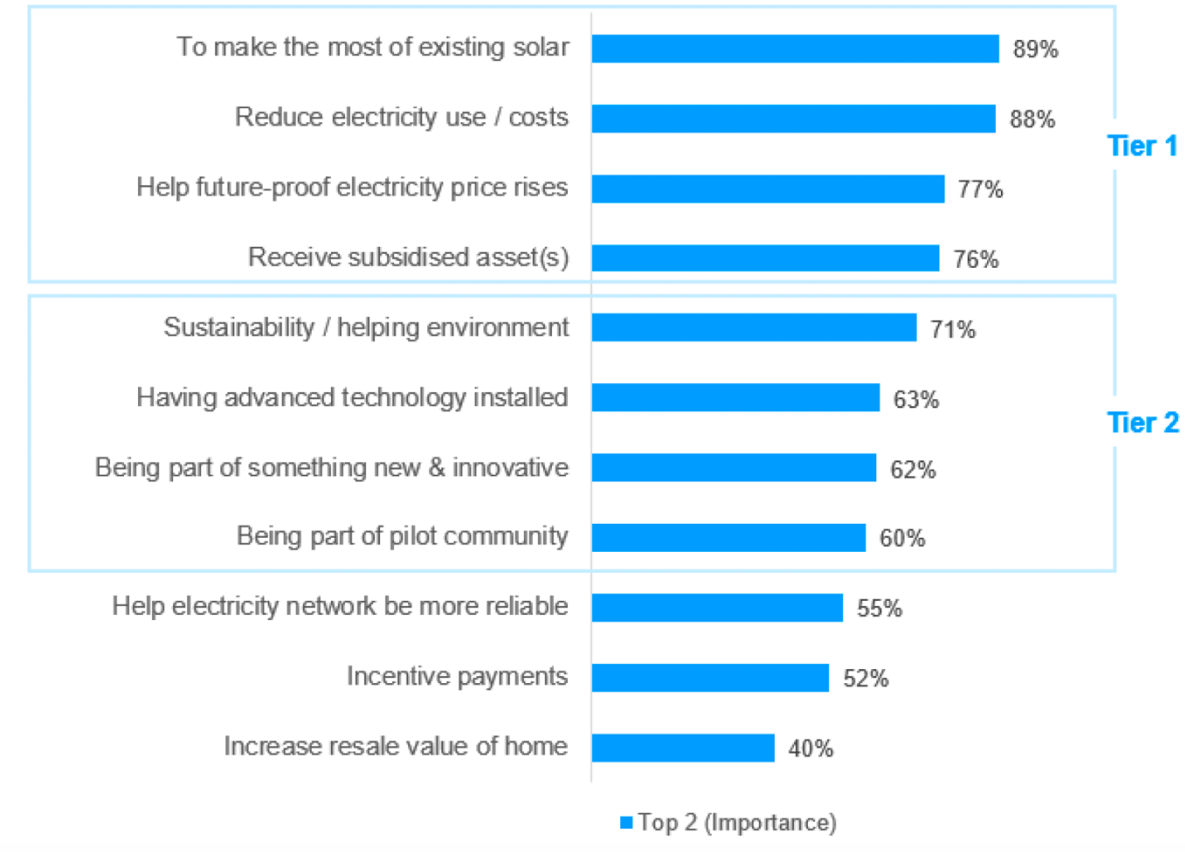


Figure 17. Reasons for participating in Project Symphony – level of importance (Boyle *et al.*, 2023)

Stage 4 – Develop Platforms

Technology maturity

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Developing Platforms** moving from level 5 (system validation in the relevant environment) to level 6 (a system model demonstrated in a relevant end-to-end environment). The end of project assessment of the progress towards level 6 is summarised below.

TRL	Rubric reference	Assessment
5	Prototype platform(s)/tool(s) designed and developed for piloting specific services (e.g. frequency or voltage support) for DMO-DSO-Aggregator functions in representative areas (e.g. an edge-of-grid community or urban meshed area). Additional support provided to key actors (network, market, retail, service providers) to clarify technical requirements and performance expectations.	**Achieved** **Western Power's prototype DSO platform, capable of issuing DOEs albeit by basic allocation methods, was a key development beyond what already existed before the Pilot.** While AEMO and Synergy also developed a DMO and Aggregator platform respectively, versions of these have been developed previously through other DER integration trials, in particular the shared solution developed in Project EDGE. Nonetheless, significant development was required to deliver a simulated version of AEMO's existing wholesale market platform including DER registration, aggregation of the DER Facility, managing "boffers" (bids and offers) and dispatch (not including settlement) (Synergy, Australian Energy Market Operator and Western Power, 2023a). Western Power also supported the University of WA (UWA) to further develop its Distribution Constraints Optimisation Allocation (DCOA) tool to investigate alternative approaches to equitably allocating DOEs (Fernando *et al.*, 2022). However, this was not implemented as part of Project Symphony but may be used in future DER orchestration projects. Following a preliminary desktop simulation, UWA found that a hybrid approach, applying static operating envelopes in certain contexts, may be the most efficient option for WA. UWA investigated these issues using real data from Project Symphony in its simulations and the results reinforced the hypothesis.

6	Prototype platform(s)/tool(s) designed and developed for specific DER use cases and/or network scenarios. In the case of DER orchestration via DMO-DSO-Aggregator roles (i.e. not vertically-integrated utilities), this entails function beyond "command and control" to more complex solutions such as dynamic operating envelopes.	**Achieved** Project Symphony designed and built three platforms for the specific roles of each project partner as defined in the Open Energy Networks Hybrid Model (Synergy, Australian Energy Market Operator and Western Power, 2023a). • The DSO Platform (Western Power): forecasting loads and network limits, calculating local hosting capacity, **allocating DOEs**, facilitating the orchestration of DER to provide NSS, and monitoring the impact of orchestration on the distribution network. The communication of DOEs leveraged the work undertaken in the Evolve project. • The market or DMO Platform (AEMO): providing energy, network support and ancillary services, and monitoring and evaluating the compliance of orchestrated DER when providing these services in a simulated market. The platform consists of an intelligence layer, including the market bids and offers solver, and a data exchange layer to interface with the other platforms. • The Aggregator Platform (Synergy): valuing DER, acquiring customers, real-time monitoring and control of DER (through the Gateway Controller), collecting aggregation data at the DER and the connection point, and procuring third-party aggregators that were treated in the platform as standalone virtual batteries. Each third-party aggregator needed to develop and publish APIs for Project Symphony given it is the first time this model was tested in the WA context. **Together they provide an end-to-end solution, integrated with each organisation's system and processes, that was tested for the four test scenarios**: energy services – bi-directional energy – balancing market; network support services; constrain to zero; essential system service (Figure 18). The capability of the platforms extended beyond "command and control" and even solely DOE, having the capability to support the integrated and coordinated provision of services alongside each other (i.e. network and market services) and advanced communication capability to manage scalable data exchanges. However, there was a lack of "fit-for-purpose" commercial solutions available so AEMO, Western Power and Synergy all contributed to internal development of the prototype platforms, leveraging commercial products where possible (described further below). Two key lessons learned in the early development stages were that: 1) no "off-the-shelf" offering for the platforms existed; and 2) the procurement process could be better coordinated to send a clear message to the market (Western Power, 2021c). Despite an extensive open procurement process from each partner, the suite of functional and non-functional requirements were not available from one product. Thus, AEMO, Western Power and Synergy needed to undertake additional development of capabilities internally and, in some cases, combine multiple commercial products. In addition, there was an understanding that some platform components would be solely used for, and retired after, the Pilot leading to some off-the-shelf solutions being procured as a subscription rather than embedded in BAU systems. Project Symphony has recommended that each project partner develop a phased transition plan for adopting these new technologies and processes towards a

		market-integrated solution (Synergy, Australian Energy Market Operator and Western Power, 2023a). In addition, some confusion was created in the market by procuring all three platforms at similar times without coordinated messaging. This was exacerbated by different organisational approaches to platform development and delivery. Beyond Project Symphony, when appropriate, AEMO, Western Power and Synergy expect to provide joint or well-coordinated procurements and market briefings. **Several outstanding issues remain with all three platforms that have been flagged as 'amber' in the Work Package 5 final report.** DSO platform: • In general, the approach taken to the DSO Platform was focused on the Pilot implementation, therefore it is acknowledged that some modules may not be fit-for-purpose for BAU implementation. • An extension of the DOE calculator is required to deliver network analysis, configure DOE calculator notifications, calculating DOEs in response to incidents and outages, load flow analysis, optimal allocation and load forecasting. • It may be necessary to explore alternative integrations of some data exchange service modules to ensure that they follow the IEEE.2030.5 standard. DMO platform: • A long-term data exchange solution suitable for DER aggregations will need to be developed beyond the solution that was tested in Project Symphony and shared with Project EDGE. • It was noted that WEM reforms, including the requirements for the DMO and Aggregator, are dependent on policy and still to be developed. Therefore, it is expected that integration with AEMO systems (e.g. with the WEM dispatch engine) will be required, but at this point those requirements are unclear. Aggregator platform: • Greater visibility of DER assets controlled by third-party aggregators may be needed since the virtual battery telemetry was sometimes shown to lag for several minutes. • Charging and discharging control between PV and batteries is not currently possible where there is a hybrid inverter. Allowing this would provide greater flexibility in the orchestration resource, which is a "nice to have" in scaling up but is not a "must have". • The social science report strongly recommended that a customer-facing user portal be developed to communicate: energy consumption and generation, real-time energy flows from all DER assets, past and future orchestration events, and providing an option for customers to opt-out. • AEMO also noted in an interview that further analysis is required to test whether high frequency telemetry data can be transferred in less than five minutes on the Aggregator Platform, which is a requirement to deliver additional services in the future. This supports the general recommendation that "further capability needs to be demonstrated by

TRL	Rubric reference	Assessment
		Aggregators to participate in a range of market services" (AEMO, 2023) including potentially developing and aligning with new service requirements.

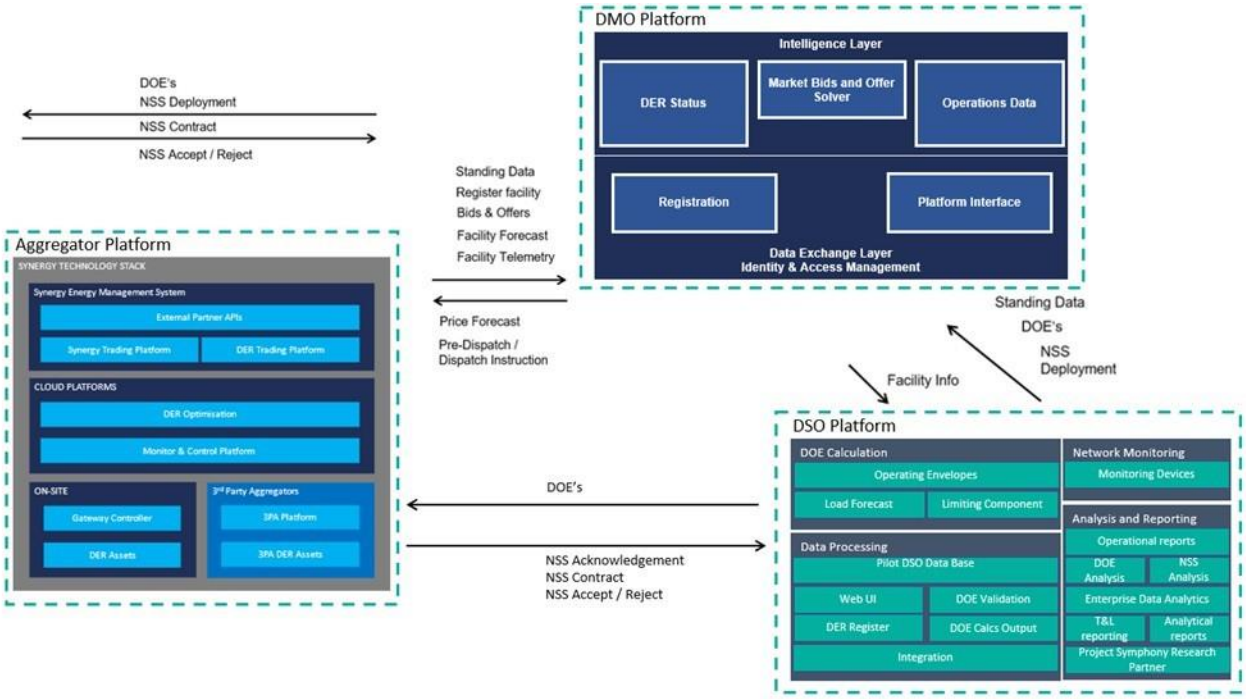


Figure 18. Conceptual platform design and function (Synergy, Australian Energy Market Operator and Western Power, 2023a)

Commercial maturity

CRI reference	1	2	3	4	5	6

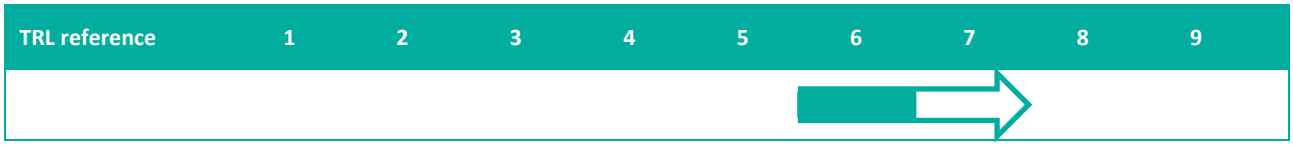
The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Developing Platforms** moving from level 2 (commercial trials) to level 3 (commercial scale-up). The preliminary assessment noted that Project Symphony and Project EDGE were working in tandem to make progress towards level 4 (multiple commercial applications), but this was unlikely to be achieved by the end of both projects. The end of project assessment of the progress towards level 4 is summarised below.

CRI	Rubric component	Assessment
2	Pilots of precursors of DMO-DSO-Aggregator platforms tested in the field for specific network and/or market services. Performance validation and design of platform(s)/tool(s) for end-to-end DER orchestration.	**Achieved** Project Symphony achieved this CRI level along with four other Australian pilots: Decentralised Dynamic Limits; Advanced VPP Grid Integration; Project Flex; and Project EDGE. Performance validation included: DOE can provide 120-400% greater utilisation of DER; a 60% increase in capacity through dynamic exports; 10kW can be exported for 98% of the time in areas of high PV penetration. Project Symphony validated its MVP via a trial with 30 customers. The *Platform Functional and Non-Functional Requirements Report* outlined the design and simulated performance of the three platforms for end-to-end DER orchestration in Project Symphony. Non-functional requirements included: legal and compliance; platform reliability, availability and performance; user experience and operation; and security.
3	Commercial trial of platform(s)/tool(s) delivering insightful data. Data ownership and confidentiality arrangements in negotiation.	**Achieved** Through the MVP and scenario testing, fifteen essential DSO Platform Conceptual Data Entities were identified. Final verification testing prior to BMO and NSS entering the stability period also delivered insightful data as to the functionality and performance required to achieve MVP capability of platforms and tools. **The DMO/DSO/Aggregator platforms were then successfully integrated over a 90-day stability period as demonstrated in the "Test and Learn" results** (Western Power, Australian Energy Market Operator and Synergy, 2023). **Negotiations on data ownership, data communications, and confidentiality arrangements was delivered to an acceptable standard to ARENA through Work Package 6.** This included the classification of data (internal, restricted, confidential, personal) at the point it is recorded, noting that some DER data was previously unclassified, and how it would be handled and/or disclosed to maintain its integrity (Australian Energy Market Operator, 2022a). The Pilot achieved verifiable consent from customers to use their data (excluding Personally Identifiable Information) for operational purposes across the platforms. The lessons learned from confidentiality and data sharing between partners was complex. While these issues were resolved for the Pilot, data sharing and hosting arrangements will need to be revisited in the scale-up to consider long-term arrangements that are feasible along with other network and market services that may be included.

CRI	Rubric component	Assessment
4	Commercial trial of platform(s)/tool(s) in multiple jurisdictions delivering regular verifiable data on performance. Technical and operational standards in development e.g. DSO (e.g. DERMS) product offerings, transporting envelopes to third party aggregators, new network planning approaches to incorporate DER orchestration.	**Partially achieved** Project Symphony along with Project EDGE have demonstrated end-to-end trials of platform integration in both the NEM and WEM contexts. The process of the DMO platform specifically was coordinated with Project EDGE, which simultaneously tested the DER Marketplace in the NEM. AEMO was specifically able to leverage broad capabilities across its organisation for both projects for "more comprehensive implementation", and to minimise costs through aligned procurement and implementation (Synergy, Australian Energy Market Operator and Western Power, 2023a). **However, as neither market platforms were implemented in an on-market capacity, CRI 4 is not fully achieved.** As WEM reforms progress, the project partners will develop a better understanding of how to fully integrate with systems, including the WEM dispatch engine. This is also true for certain aspects of the other two platforms. For example, some cloud services that were operational in the DSO platform cannot be used in their current form in BAU purposes without additional measures taken to address possible risks that were identified (Synergy, Australian Energy Market Operator and Western Power, 2023a). The Aggregator model in Project Symphony is reflective of a retailer in a non-contestable environment. Thus, DOEs were transported to a single "parent" Aggregator that two third-party aggregators utilised**.** Project EDGE instead demonstrated the viability of multiple aggregators (up to 10) in a contestable space, noting that it is still a simulated market. AEMO (2023) considered appropriate market arrangements for implementation in the WEM to apply to contestable retailers in the SWIS and WEM. **The lack of industry standards was a significant obstacle to the Pilot** (e.g. including IEEE2030.5, CSIP-AUS, IEEE 1574-2018, AS/NZS 4777.2:2015) (Synergy, Australian Energy Market Operator and Western Power, 2023a). The Aggregator Platform in particular faced challenges, for example, it was difficult to develop bespoke modules for the DSO platform and the Gateway Controller vendor needed to develop local connectivity protocols in place of an industry standard. It was also costly (time and funding) to custom integrate the Gateway Controller with many inverter manufacturers and models given there were no API standards for local integration in place. Partners of Project Symphony have now committed to aligning with a national approach and have been engaging in ARENA's DEIP Interoperability Working Group. **New network planning approaches were also not achieved** but the Pilot informed how network planning and operations must include the impact of DER orchestration. Due to scope and schedule limitations, the Pilot could only be able to identify, not correct, network management data collection processes that are not accurate enough for SWIS-wide implementation of DER orchestration.

Stage 5 – Orchestrate DER

Technology maturity



The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Orchestrating DER** moving from between level 5 and level 6 (a system model demonstrated in a relevant end-to-end environment) to level 7 (system prototyping demonstration in an operational environment). The preliminary assessment noted an opportunity to make progress towards level 8 (end of system development). The end of project assessment of progress is summarised below.

TRL	Rubric reference	Assessment
6	Demonstrate DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for specific services. Prototype can: respond to DSO contracts including real and reactive power dispatch; participate in the ESS-CRR / FCAS market; integrate with AEMO's data exchange API; and produce operational and telemetry data from VPPs. DER is optimised behind-the-meter.	**Achieved** The Pilot successfully prototyped the three platforms for NSS and BMO, in isolation and fully integrated, through Internal System Integration Testing (SIT) and four Cross-Organisational Tests (X-SIT) (Western Power, Australian Energy Market Operator and Synergy, 2022b, 2022a, 2022c, 2022d). The three figures below provide evidence of successful implementation of the protoyping: Figure 19 outlines the runsheet for a day where both scenarios NSS and BMO were tested in parallel on the same VPP facility, which is represented schematically in both Figure 20 and Figure 21 to demonstrate how overlapping submissions "Bids and Offers" (Boffers – Consolidated RTMS) are applied at 5-minute intervals. This successfully meets the criteria for TRL 5, which had also been achieved by previous DER trials. This was an outcome of a detailed design phase that also defined the business use cases, defined the platform and integration capability, and designed the messaging and APIs for data transfer. Prior to prototyping, the project team developed (and improved over time) the test environments, roles and responsibilities, the test schedule, testing tools, execution plans, management process for issues arising, governance arrangements and test supports (Synergy, Australian Energy Market Operator and Western Power, 2023a). The SIT and X-SIT strategies themselves were approached with "Test and Learn" principles with verification and execution phases. This allowed post-test analysis to improve the operation of the platforms in alignment with the Pilot's goals and hypotheses. The final element of the Test and Learn was the Stability Period. This period consisted of four phases to "drop" each scenario in isolation, in advance of the 90-day full orchestration "clean run" (Western Power, Australian Energy Market Operator and Synergy, 2023). A high-level overview of the initial Stability Period is shown in Figure 22. **Although none of the four scenarios – bi-directional energy, NSS, CTZ, ESS-CRR – included reactive power dispatch, TRL 6 is still considered to be achieved given the Pilot was able to deliver multiple network and market services.** It is expected that the Test and Learn protocol could be adjusted to

TRL	Rubric reference	Assessment
		include reactive power in the future scale-up of DER orchestration services such as voltage management. **The first MVP test and final "drop" of the stability period included behind the meter optimisation** (BTMO – where batteries could store and use stored energy for the maximum benefit of the household instead of in response to orchestration signals). When BTMO was not prioritised, such as in the first test in late October 2022 which "heavily orchestrated" solely solar PV and batteries on average for 9.7 hours per day, it was not a positive customer experience (WP 3 report). Examples of this include solar being completely constrained to gross zero and batteries charging at times of high prices. Thus, BTMO is expected to be how customer assets are used most of the time as orchestration projects are scaled up to preserve the customer's value and experience.
7	Demonstrate DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for a suite of network/market services. DER is made available for "business as usual" network management.	**Partially achieved** Achieving this level of technology maturity required Project Symphony to demonstrate DER orchestration at full-scale, in this case at the zone substation level. **Between April – June 2023, Project Symphony successfully conducted a 90 Day Clean Run at the zone substation level.** Over this period, the platform was able to assess Boffers and delivering Dispatch Instructions in under four seconds. In fact, during all test periods, orchestration was fully operational for over 99% of the time. This final round of orchestration involved all assets (solar, batteries, air conditioners, network battery) and was far less frequent and intense (an average of 1.4 hours per day) than the initial tests, which led to more improved customer outcomes - customers reporting a "low" overall experience reduced from 23% to 6% ((Boyle *et al.*, 2023); (Western Power, Australian Energy Market Operator and Synergy, 2023)). The modes used through this period were: BTMO to store and use stored energy onsite; incentivising selling extra solar or battery energy using high prices; using negative prices to either disincentivise the export of solar or battery energy or incentivise the use of energy; and controlling and deploying assets to deliver a NSS target (Australian Energy Market Operator, 2023a). **Given the Pilot was operating in an off-market environment (non-business critical) and its network model was isolated from Western Power's BAU Network Model, TRL 7 cannot be fully achieved.** This was an important factor for the Test and Learn phase of the Pilot, to allow additional flexibility that would not have been possible if the orchestration existed in BAU operations (Synergy, Australian Energy Market Operator and Western Power, 2023a). For example, data sharing was possible in the Pilot environment given customers had provided consent for the specific testing objectives. DER orchestration would likely need to operate (DER enrolment, facility registration and telemetry) at a higher level of performance when participating in the WEM and using BAU infrastructure. Western Power explained in an interview that, although the DSO platform was not integrated into Western Power's BAU Network Model, it was physically connected to the network and used an extract of the network model, the ADMS and GIS. **Thus, energy flows were changed due to certain actions taken by the Pilot. However, from a network management perspective, it would not have been possible to discern the orchestration's role in load shaping.** For this to be possible in the future, Western Power would need to make changes to its forecasting system to account for orchestration data inputs, allowing its network planners to discount that orchestrated load whether it be passive, active or non-DER. It is unclear whether network controllers will need additional

TRL	Rubric reference	Assessment
		information to be able to account for orchestrated DER to provide services such as NSS. In the early days of orchestration there are opportunities to test models of integration with network planning and control given the risks are lower while constraints and opportunities are scarce. For example, Work Package 5 recommended that the network model be altered to feature both an import and export rating to avoid DOE breaches (Synergy, Australian Energy Market Operator and Western Power, 2023a). Once the uptake of DER is higher, the need for visibility and control is likely to also grow, which will require more seamless integration. Alternatively, the Test and Learn Results suggested that the Planned OE (Operating Envelope) method developed by UWA "could be used instead of a computationally complex DOE which depends on real-time AMI data" (Fernando et al., 2022; Western Power 2024). Western Power will need to determine and implement the most appropriate approach before this level of technology maturity can be achieved, given this approach may only be effective in the growth phase of DER participation.
8	DER orchestration platform(s)/tool(s) delivered on the entire value chain for the suite of network/market services. Test and validation of standardised approaches e.g. IEEE 2030.5 communication protocol to transport DER commands to inverters	**Progress was made towards TRL 8, but this cannot be achieved until TRL 7 is fully met.** In addition to WEM participation and integration with Western Power's BAU Network Model, further testing and analysis is also required to better understand both the ESS service specifications (both contingency reserve raise and lower) and batteries could address rooftop solar PV (DPV) fluctuations (Australian Energy Market Operator, 2023a). In both cases, there is significant potential for DER orchestration to provide valuable services to the WEM. For example, once at scale, batteries (including EVs) could help with the black start process by providing constant load. This need for future testing analysis in these areas may be a result of commercial outcomes focusing the Pilot on NSS-related capabilities (Synergy, Australian Energy Market Operator and Western Power, 2023a). **While it was a positive outcome for the Pilot to deliver real network benefits from DER, achievement of this and the previous TRL relies on a suite of network and/or market services.** As mentioned in Stage 4, project partners are committed to aligning with a national approach to industry standards and **ARENA's DEIP Interoperability Working Group is actively considering IEEE2030.5 as an inverter communication protocol**.

Integration type	Test Steps	Responsible	Comment	Timing
	Check for Life Support customers	Synergy	Not needed in Practitest	9:00am
	Check that NSSVPP1 is running	Synergy	Not needed in Practitest	9:05am
Auto (simulated V	AEMO sends Day 10 Forecast Energy Price to Synergy	AEMO	From Live WEM Market	9:05am
EWF UI	Synergy submits **Variation RTMS (A)** - RTMS Type -INITIAL	Synergy	Intervals 13-200 *not a full day submission* (Gate closure for interval 13 is interval 17-9.15am	9.00am
	AEMO acknowledge Variation RTMS (A) Initial	AEMO		
Auto	AEMO sends Pre-dispatch instructions -TC1	AEMO		
EWF API	AEMO sends dispatch instructions - RTMS (A) - RTMS Type -INITIAL	AEMO	Testing gate closure	
	Synergy sets dispatch instructions for RTMS (A) - RTMS Type -INITIAL	Synergy		
EWF UI	Synergy Submits **Variation RTMS (B)** - RTMS Type Market	Synergy	Interval 27-49. MARKET and VPP Respond to Price change - (Gate closure for interval 27 is interval 31 to commence -10.25am)	10.10am
	AEMO acknowledge Variation RTMS (B)-- RTMS - Market	AEMO		
Auto	AEMO sends Pre-dispatch instructions -TC3	AEMO		
EWF API	AEMO sends dispatch instructions - RTMS (B) - RTMS Type Market	AEMO	DI for Intervals 26 to 65 PQ pairs is changed as per the change in FRC price (was negative to positive)	
	Synergy sets dispatch instructions-RTMS (B) - RTMS Type Market	Synergy		
EWF UI	Synergy Submits **Variation RTMS ("C")** - RTMS Type - OTHER	Synergy	Interval 34-46. OTHER Temp Reduce Quantity -, Reduction of maximum injection and withdrawal Capacity next DI and pre-dispatch DI for a 12 interval duration (Gate closure for interval 34 is 1030am) though the reduction should be accepted as its meets gate closures validation	10.45am
	AEMO acknowledge Variation RTMS ("C") - RTMS Type - OTHER	AEMO		
Auto	AEMO sends Pre-dispatch instructions -TC4	AEMO		
EWF API	AEMO sends dispatch instructions - Variation RTMS ("C") - RTMS Type - OTHER	AEMO	Intervals 34-46 have reduced max inject and withdrawals and reduced DI, from interval 47 onwards, reverts back to previous valid submiussion	
	Synergy sets dispatch instructions -RTMS ("C") - RTMS Type - OTHER	Synergy		

Figure 19. Runsheet: An extract of the daily runsheet for Day 11 of Cross Organisation Test 3A (24th Aug)

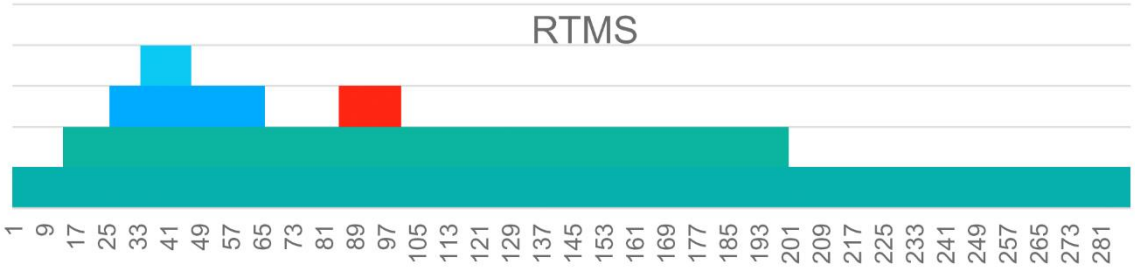


Figure 20. Real-time market signal: how the "Variation Boffers" related to Balancing Market Offers (BMO, blue & green) and Network Support Services (NSS, red) were applied on top of each other within a single day

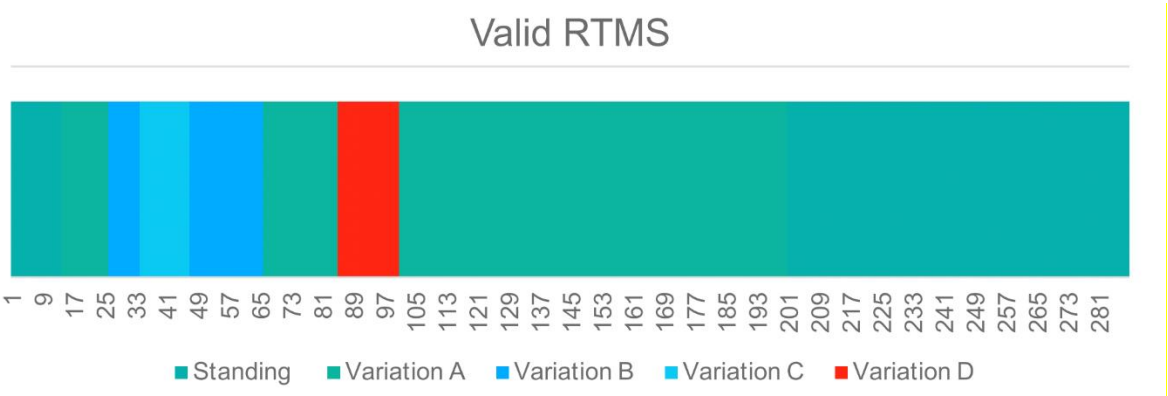


Figure 21. Valid RTMS: Identifying which "Boffer" is enacted at any particular 5 minute interval (the "Consolidated Boffer")

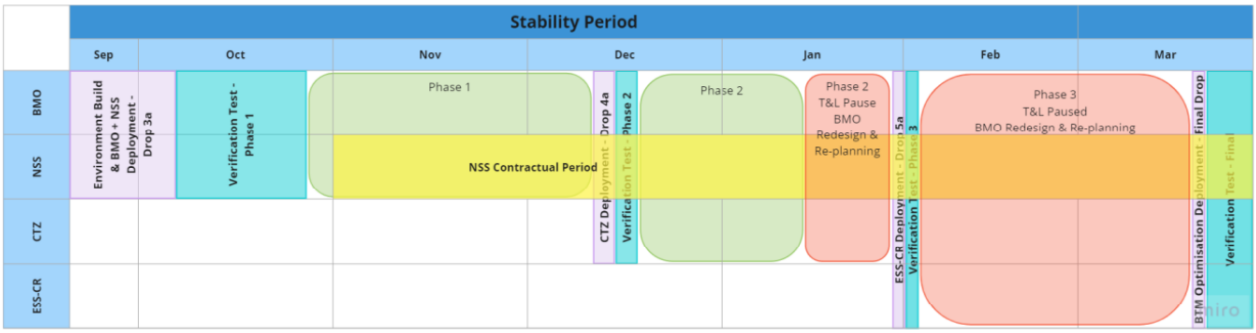


Figure 22. High-level overview of the initial Stability Period

Commercial maturity

CRI reference	1	2	3	4	5	6

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Orchestrating DER** moving from level 2 (commercial trials) to level 3 (commercial scale-up). The end of project assessment of the progress towards level 3 is summarised below.

CRI	Rubric component	Assessment
3	Commercial trial of DER orchestration, validating the network and market services can be delivered to a standard required for key actors (network, retail, market). Operational telemetry collected and made available to participants at a minimum.	**Achieved** The Pilot was successful at validating network and market services in the four scenarios. **During end-of-project interviews, all project partners expressed satisfaction in the technical results of the orchestration and confidence that scale-up to the required standard to deliver a strategic market solution was technically possible.** Three instances of successful orchestration are provided: • An example of how batteries were discharged and charged in response to market and network signals in July 2023 (Figure 23) • An example of the network and behind-the-meter (City of Armidale) batteries providing ESS-CRR to address a real contingency event when the Cockburn power station tripped on 6 July 2023 (Figure 24), and • Two trading days where the Pilot value-stacked three (out of four) of the core scenarios by responding to market prices, participated in three 15-minute ESS simulated tests and was scheduled for future NSS deployment (Figure 25). While **telemetry was automated, collected and made available to the participants from Drop 3B of the Cross Organisational Tests**, **there is some concern that the approach may not scale.** Work Package 5 argued that "further investigation is required around how to keep data and optimisation control closer to locally distributed control nodes (Synergy, Australian Energy Market Operator and Western Power, 2023a). While a centralised command and control model works in an environment that consists of a small number of industrial scale generation assets, it may prove problematic as a model for controlling localised DER assets at scale." Most issues are related to the large processing requirements of data when telemetry reporting scales, which may not be amenable to central command and control. Project EDGE also concurrently validated market services in the NEM, contributing to progress towards CRI 4. However, it is not possible to record significant progress given scaling limits were also acknowledged in that trial, operational telemetry is not able yet to be made publicly available and there is still no consensus on an industry standard for interoperability. In addition, if Work Package 7 recommendations are accepted, an additional Facility Class will need to be developed to enable participation of DER in the WEM in a way that provides value to all key actors (Australian Energy Market Operator, 2023a).

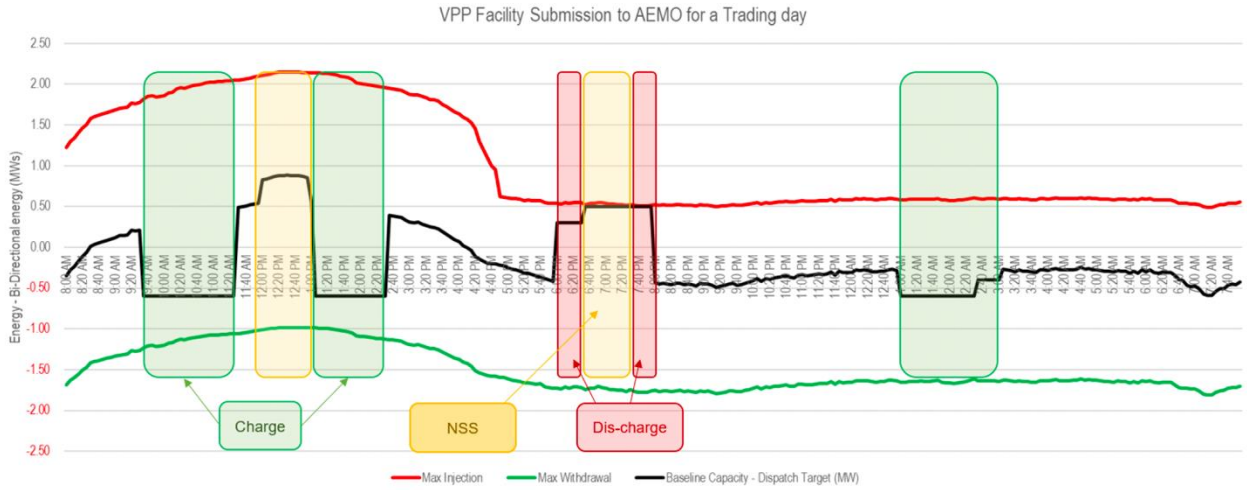
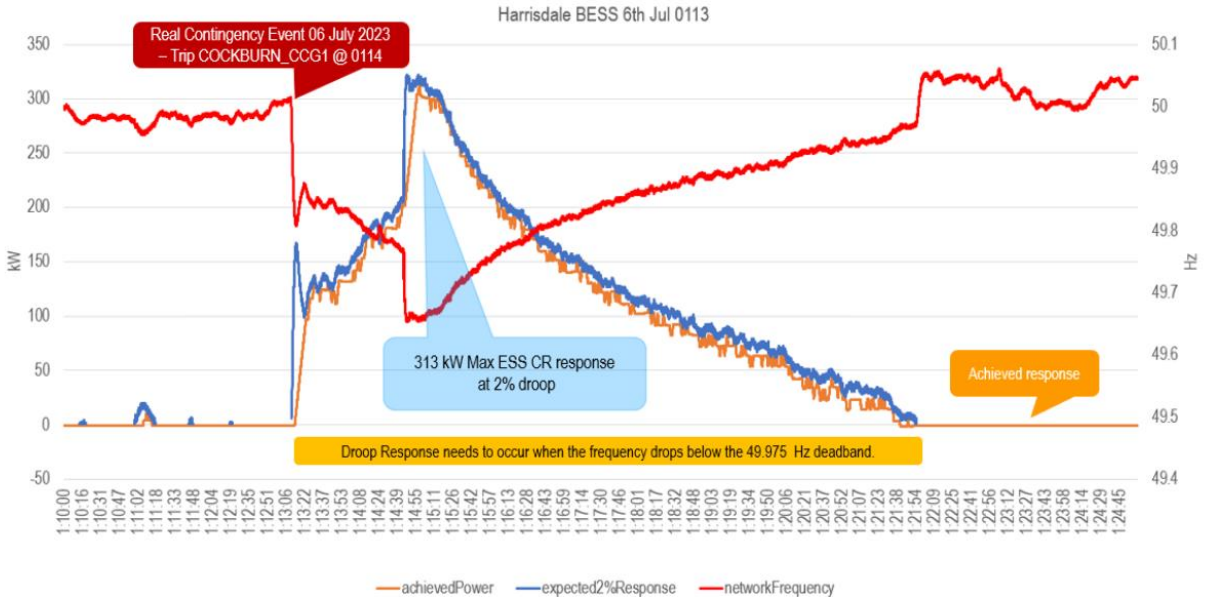


Figure 23. Charge and discharge of batteries in response to market and network signals in July 2023 (Boyle *et al.*, 2023)

a)



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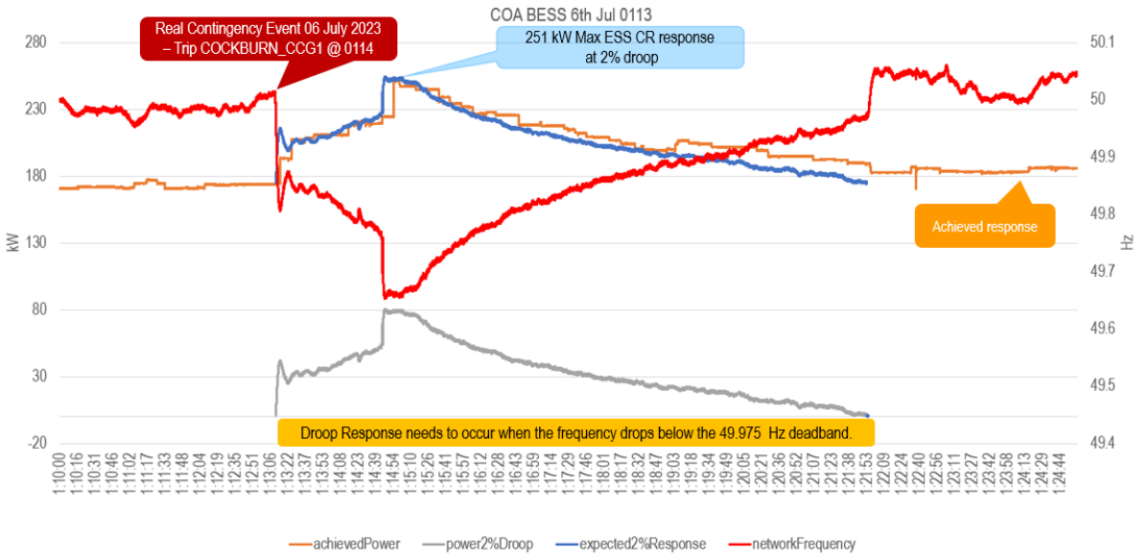


Figure 24. Harrisdale (a) and behind-the-meter (b) BESS response to contingency event on 6 July 2023 (Western Power, Australian Energy Market Operator and Synergy, 2023)

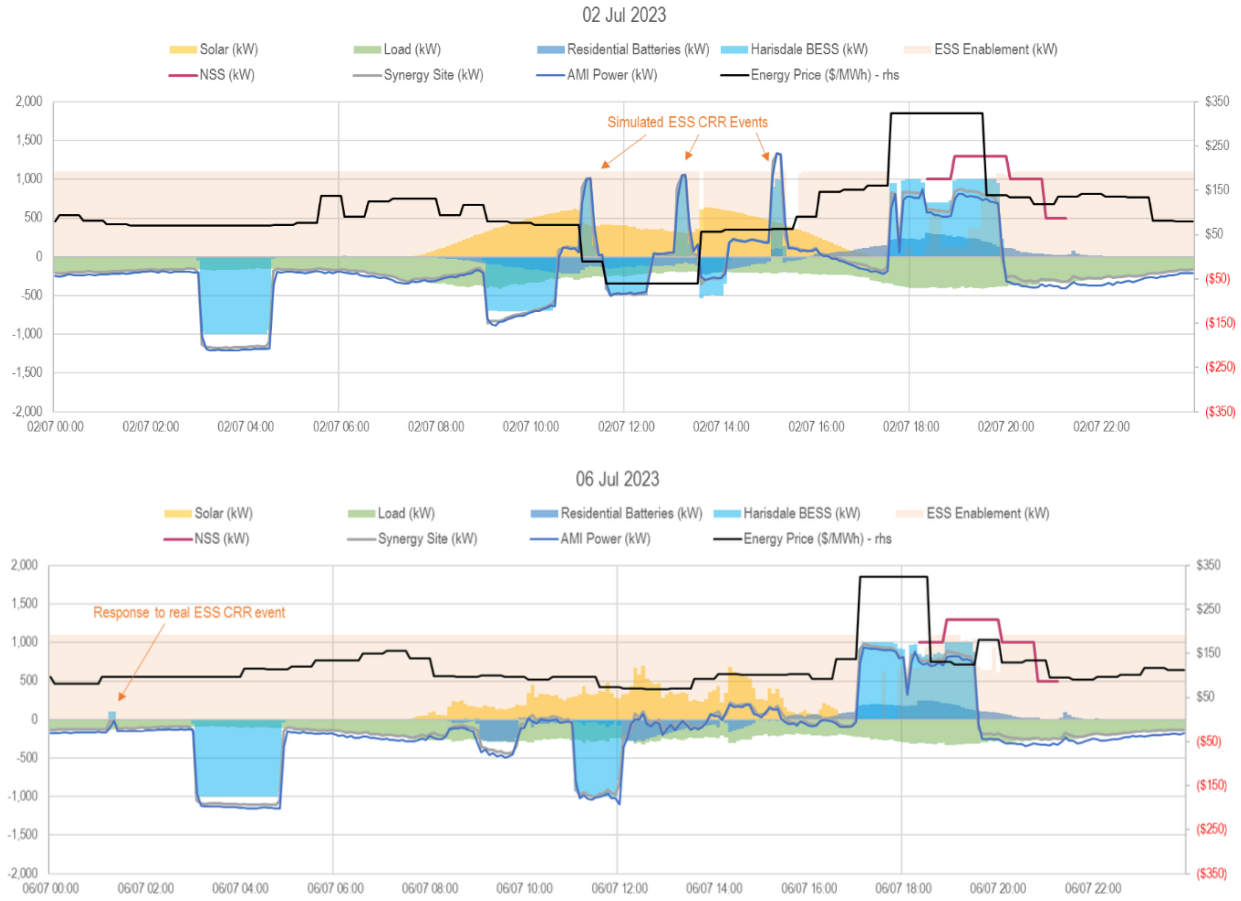
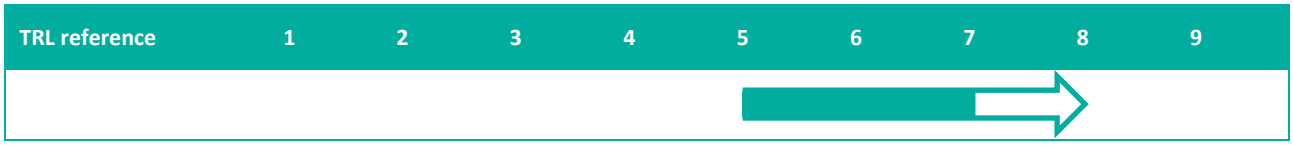


Figure 25. Two examples of the Pilot value-stacking three (out of four) core scenarios (Western Power, Australian Energy Market Operator and Synergy, 2023)

Stage 6 – Integrate Platforms

Technology maturity



The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Integrating Platforms** moving from level 5 (a system model demonstrated in a relevant end-to-end environment) to level 8 (end of system development). The end of project assessment of the progress towards level 8 is summarised below.

TRL	Rubric reference	Assessment
6	Demonstrate bespoke orchestration at full-scale (e.g. zone substation level) for specific services e.g. VPP for frequency or voltage support services using unique platforms (such as an "aggregator or aggregators"). Validate orchestration by achieving target levels of services (e.g. battery generation/export or achieved voltage envelopes) with a satisfactory level of reliability.	**Achieved** Although other trials in Australia have also achieved a target level of network or market services through orchestration, **this level of technology maturity was achieved at the prototyping (X-SIT) stage of the Pilot.** In particular, Drop 3B (Western Power, Australian Energy Market Operator and Synergy, 2022d) achieved successful execution of both the BMO and NSS capability on several fronts: 1. Automation via the data exchange integration solution 2. Against the data schema in preparation for Drop 4A (CTZ scenario), and 3. Via a consolidated Real Time Market Submission. More than forty issues were raised during Drop 3B that were resolved in the last two X-SITs prior to the stability period commencing. **DOE compliance was "adequately measured using AMI data"** (Synergy, Australian Energy Market Operator and Western Power, 2023a)**.** However, concerns were raised about the future ability to achieve Service Validation when scaling up the DSO Platform given the amount and complexity of data that will likely need more advanced data (including statistical) analysis. In its current form, the DSO Platform relies on additional work and resources from Western Power that is unlikely to be available in BAU. For example, there was a major issue with permanent power quality data loss preventing the verification of DOE and NSS compliance that needed to be resolved internally by Western Power. Additional resources for data warehouse design, data engineering and data analysis will likely be required to achieve the benefits of the scaled-up DSO Platform.
7	Demonstrate the integration of DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for suite of network/market services). Orchestration automated including receiving, accepting and rejecting a DER	**Achieved** **The DSO, DMO and Aggregator Platforms were successfully integrated at the substation level as outlined in Figure 26**. The functional and non-functional requirements outlined in Stage 4 included the end-to-end integration capabilities across the three platforms (Synergy, Australian Energy Market Operator and Western Power, 2023a). Related to integration, Work Package 6.1 (Australian Energy Market Operator, 2022a) identified the following requirements: • The DSO Platform needed to communicate constraints (in the form of DOEs) to both the DMO and Aggregator • The DMO Platform needed to receive distribution network conditions from the DSO (Western Power currently focuses on providing visibility of the SWIS

TRL	Rubric reference	Assessment
	request (potentially including forward option contracts). Detail for standards determined in consultation with key actors e.g. data hosting and sharing agreements and specifications for API's linking the DMO-DSO-Aggregator platforms determined.	*transmission* network), receive aggregator facility bids for market services, send dispatch instructions and settle the market • The Aggregator Platform needed to receive DOEs, provide bids to the DMO Platform, receive dispatch instructions and confirm the dispatch of both network and market services, and • A common set of stable, resilient and secure Application Programming Interfaces (APIs) needed to be built to interface the three platforms in the Pilot and other Aggregators in the future. Integration mostly relates to end-to-end data exchange, from customers connected to the Aggregator Platform to settlement on the DMO Platform (Figure 28). This includes communicating instructions, constraints and sharing telemetry (Australian Energy Market Operator, 2023a). The data exchange requirements for DER orchestration include conventional requirements such as WEM dispatch, and novel exchange models such as DOEs (Australian Energy Market Operator, 2022a). **Work Packages 6.1, 6.2 and 6.3 outlined the data (including data server) hosting and sharing agreements and specifications for APIs linking the platforms.** The data hosting and sharing agreements were underpinned by: data sharing requirements for AEMO and Market Participants outlined in the WEM Rules and related WEM Procedures; and a Joint Development Agreement and Communications Protocol that were signed before Project Symphony testing commenced. As mentioned in TRL 6, additional support – for example, a Python environment and associated data libraries in the DSO Platform – was required for the "intricate and varied datasets" to be supported in the Pilot's Test and Learn phase (Synergy, Australian Energy Market Operator and Western Power, 2023a). Among the principles of data hosting and sharing, the project partners agreed that personal information would not be shared, confidential data would not be hosted offshore and that all data entities would be decommissioned following the Pilot. However, the lessons learned by Project Symphony, such as operation data sets and the final data model (standard design to integrate the three platforms) established through the Pilot, will play a critical role in establishing the future sharing and secure hosting of data in the mainstream model for DER orchestration in the WEM and SWIS. The specification of APIs leveraged existing API schema used by AEMO and data specific to the orchestrated DER (Australian Energy Market Operator, 2022c). This approach was chosen since APIs are a common method of integrating software applications due to its low cost, simplicity and authentication capability. For example, Boffers can only be sent by participants that are registered to that Facility. AEMO uses API integrations aligned with the OpenAPI Specification (OAS) for market operations and services in both the WEM and the NEM, and has used API schema in prior DER demonstrations of Virtual Power Plants. In Project Symphony, the Aggregator also uses APIs to communicate with the DSO to allow for the transfer of large files at a high frequency in a way that can be easily automated and audited. **To meet the operational requirements of a 5-minute market, most end-to-end integrations between the platforms were via API connection and either fully automated (API-API, pull or push) or via a manual API User Interface (UI – manual file transfer).** The supported messaging formats were JSON for messages under 1MB and CSV for large data files. The design principles included requirements for the API scheme to be easily upgradeable, able to scale horizontally and not be tied to a particular vendor, which provide more optionality in the scale-up of DER orchestration within the partner organisations and in the SWIS and WEM.

TRL	Rubric reference	Assessment
		Work Package 5 (Synergy, Australian Energy Market Operator and Western Power, 2023a) and 7 (Australian Energy Market Operator, 2023a) identified the following major achievements in the end-to-end platform integration: • Developing a coordinated model with flexibility and visibility to all project partners, that prevented the Aggregator from receiving conflicting instructions and duplicated communication, noting that value-stacking was challenging • Implementing advanced DOE concepts in the DSO Platform, for greater control of hosting capacity, addressing multiple failure modes and scenarios, monitoring compliance, and improving battery control and high-speed data recording technology • Adopting an innovative data exchange layer in the DMO Platform, facilitating value-stacking by the Aggregator and its customers, including Distributed Ledger Technology, Self-Sovereign Identity and Decentralised Identifiers, and • Additional features of the DMO Platform that were developed were being able to manually trigger events for ESS or CTZ simulations, delivering pre-dispatch and forecasted insights into the capability of aggregated DER to deliver services, and developing a dashboard of day-to-day activity to provide visibility to both AEMO and the project partners.
8	DER orchestration platform(s)/tool(s) integrated across DMO-DSO-Aggregator systems (including ADMS and GIS). Standard communication mechanism (a consistent API for communication) is available to all DSO actors e.g. using the IEEE 2030.5 data structures for communicating dynamic operating envelopes.	**Not yet achieved** Project Symphony was focused on delivering its test four scenarios therefore, as discussed in earlier stages, **more work is necessary to deliver a scaled DER orchestration solution for the mainstream market** (Ernst & Young, 2023)**.** Work Package 5 (Synergy, Australian Energy Market Operator and Western Power, 2023a) identified the following processes and integrations that are not suitable for a mainstream or BAU application: • The tracking, change and validation of NSS provision, particularly when multiple requests were made at the same time • The limitations related to Facility registration preventing flexible exports from some participants with expanded PV and battery capacity who were not considered Market Participants • The DSO Platform is not robust enough for BAU operations with some parts of the solution being a single point of failure and manual system integrations are not yet sufficiently responsive • **There is not yet alignment with industry standards such as IEEE 2030.5 and CSIP-AUS**, and • There are other single points of failure and non-automated system integrations that should be addressed to maintain reliability. In addition, Synergy raised several concerns related to the long-term viability of the Aggregator Platform. In particular, the immaturity of the vendor platforms will likely lead to high costs to control large numbers (>100,000+) of DER assets, integrate those assets into the common platform and leverage legacy generation models that do not appear fit for purpose. It is important that the cost of the platforms is less than the value that DER orchestration provides to the key actors and the market. In the scale up of DER orchestration, AEMO (2023) argues that visibility of actions between actors will continue to be critical to provide Aggregators with "consistent, achievable obligations" and effectively operate the market within network limits.

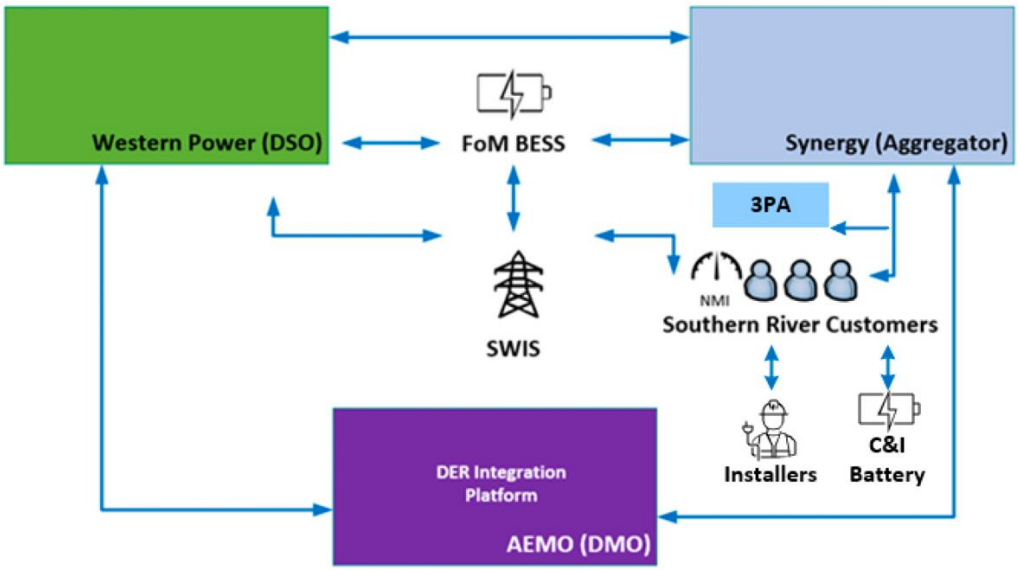


Figure 26. High-level interactions between Project Symphony actors (Australian Energy Market Operator, 2022a)

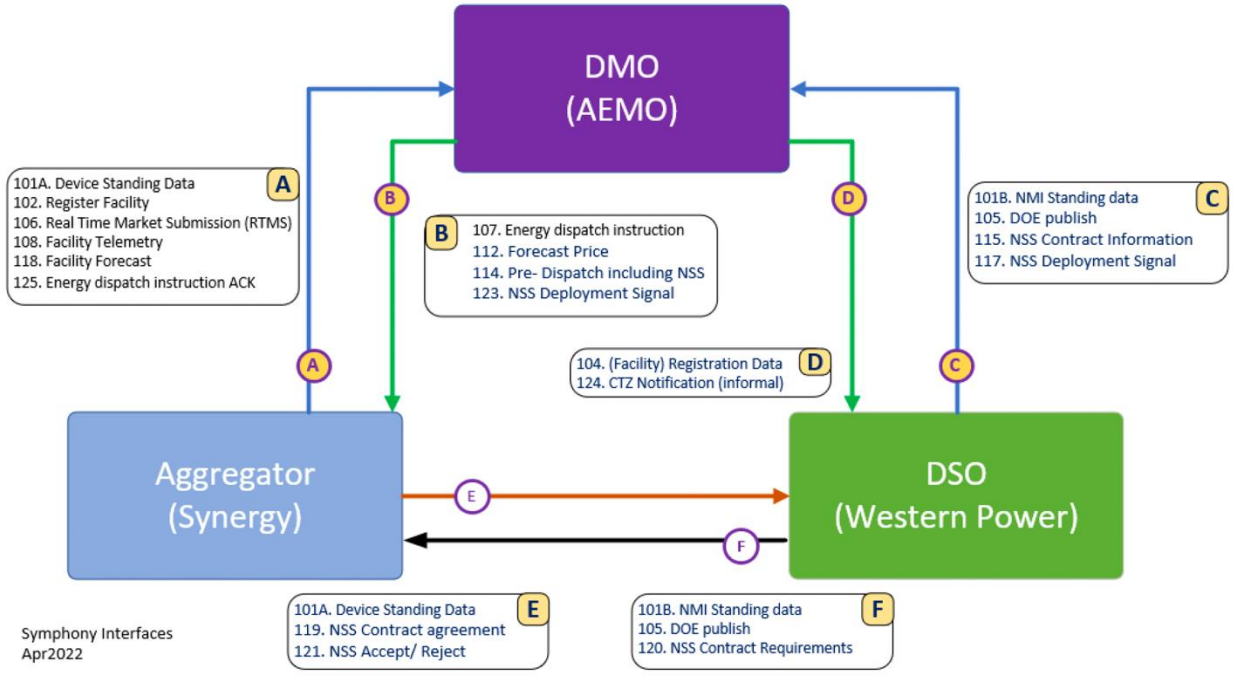


Figure 27. Diagram of platform-platform integrations (Australian Energy Market Operator, 2022a)

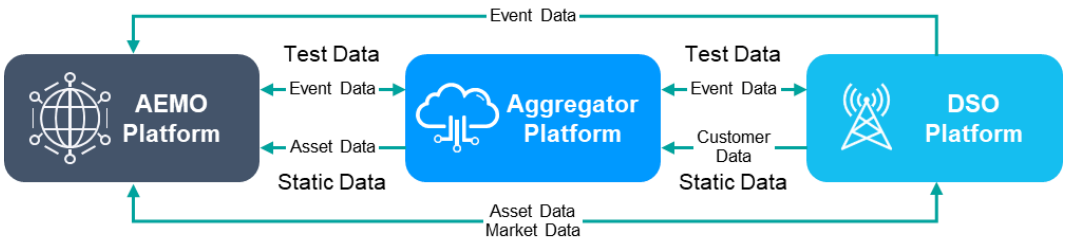


Figure 288. Static and Test Data for Project Symphony (Australian Energy Market Operator, 2022a)

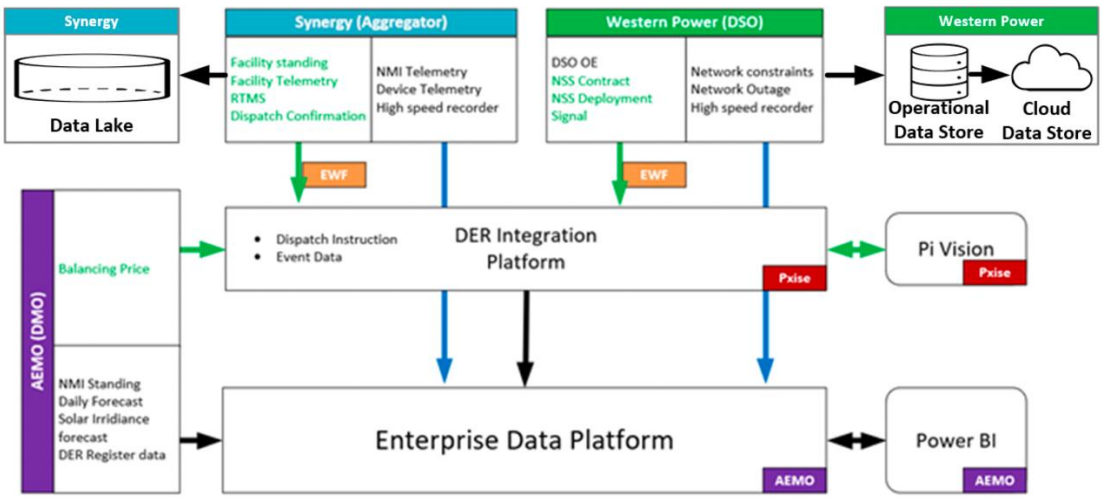
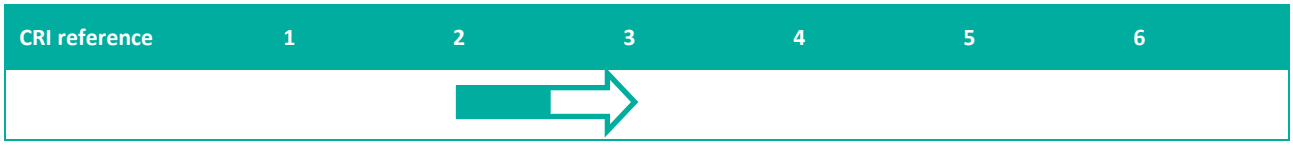


Figure 29. Data flow between the project partners (Australian Energy Market Operator, 2022a)

Commercial maturity

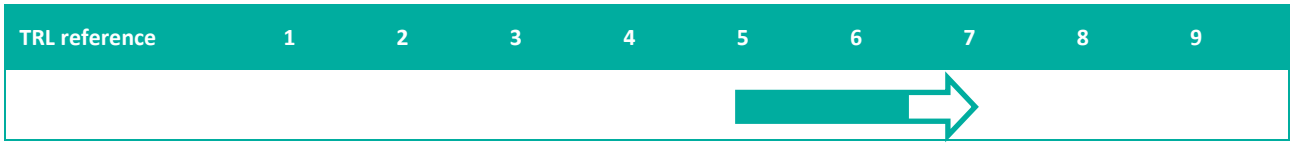


The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Integrating Platforms** moving from level 2 (commercial trials) to level 3 (commercial scale-up). The end of project assessment of the progress towards level 3 is summarised below.

CRI	Rubric component	Assessment
3	Commercially available software developed to integrate DMO-DSO-Aggregator platform(s)/tool(s) for specific network and/or market services e.g. components for delivering dynamic operating envelopes: - An IEEE2030.5 utility server core - Tools for simulating and validating server and client behaviour - An interface for device registration.	**Partially achieved** No commercially available solution was able to be procured to fully deliver the requirements for the three platforms required by Project Symphony. The partially customised solution that has been developed – for instance, to deliver DOEs – could be used again for scale-up in certain areas of WA, since the project partners remain the key actors in the DER orchestration. However, **there was not consensus amongst the partners whether the platforms as developed could be made commercially available to actors in other jurisdictions both in the wider state or the NEM**. One project partner stated, "I don't believe there is a product out there – I am about to do another market scan – or a suite of products that actually do what we need". For example, the Data Exchange Service did not meet the DSO solution architecture principles and Open Standards Integration (Synergy, Australian Energy Market Operator and Western Power, 2023a). Data exchange between the three platforms, in conjunction with **WEM registration for data visibility that is not yet in place** (Australian Energy Market Operator, 2023a), is considered a critical requirement for mainstream DER orchestration. Therefore CRI 3 is assessed partially achieved. **National standards and practice, such as IEEE2030.5 communications within a DER network building on CSIP, is being considered outside Project Symphony. However, AEMO acknowledged during an interview that the Pilot is informing what will be selected in WA.** An example of how Project Symphony is providing input was through Work Package 6.2 (Australian Energy Market Operator, 2022b), outlining recommendations related to data sharing, classification, obligations and compliance. These will need to be in place to progress to higher levels of commercial maturity (CRI 4). There are many DER standards that need to be considered in the scale-up of orchestration to cover physical safety, behavioural response, data interchanges and information models (Australian Energy Market Operator, 2023a). The AER has published a summary of those standards under consideration (Australian Energy Market Operator, 2022a). Alignment with the final standards is being prioritised to promote aggregator accessibility, customer product choice and reducing costs for product manufacturers. The selection of the SwitchDin Gateway Device promoted alignment given it complies with multiple standards including AS/NZS 4755 for demand response, IEEE2030.5 and IEC61850 interfaces. However, there has been some challenges building consensus amongst vendors for existing standards, including IEEE2030.5 and CSIP-AUS, that will require further industry engagement (Synergy, Australian Energy Market Operator and Western Power, 2023a).

Stage 7 – Transact service

Technology maturity



The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the technology readiness of **Transacting service** moving from between level 5 (a system model demonstrated in a relevant end-to-end environment) to level 7 (system validation in an operational environment). The end of project assessment of the progress towards level 7 is summarised below.

TRL	Rubric reference	Assessment
6	Demonstrate end-to-end transactions at full scale (e.g. VPP trials across a distribution network) for specific services. Functions include: uploading telemetry data, nullifying and archiving contracts, handling unavailability submissions, recording dispatch information and settling transactions. Automated operation validated.	**Achieved** **Transactions were demonstrated at full (a feeder within a zone substation) scale including the fundamentals of forecasting, measuring, scheduling and settlement** (Synergy, 2022a)**.** The Aggregator "successfully demonstrated the management of the complex process interactions required to deliver multiple services including planning and coordination to define each service, negotiation with customers, confirm co-existence or exclusivity of services, offer into central dispatch, and receive and respond to instructions". **Telemetry data was provided to measure aggregated injections or withdrawals from all connection points.** Gateway Controllers were installed at all sites and High Speed Data Recorders (HSDRs) were implemented to measure the response of a sub-set of customers to ESS-CRR (Synergy, Australian Energy Market Operator and Western Power, 2023a). Some HSDRs were installed to measure net power and a third of those sizes also measured battery performance. This allowed ESS-CRR to be measured in aggregate and also to understand individual asset performance. Both the Gateway Controllers and HSDRs used dedicated network to communicate with the DER Monitor & Control Platform. **The pilot was able to validate automated operation, but not at all times.** Despite the additional measures to ensure connectivity, underlying data was not always correct and some data was missing for parts of the Test and Learn period. The testing activities also uncovered that "the end-to-end solution was misaligned", which requiring re-planning. Further work is required to ensure critical data flows are available through orchestration in a mainstream environment.
7	Demonstrate end-to-end transactions at full scale (e.g. VPP trials across a distribution network) for DER orchestration. Automated operation with reliable operation (e.g. robust DER connectivity) validated.	**Partially achieved** **There was broad consensus among project partners that Project Symphony "successfully demonstrated capability and limitations of orchestration" at pilot scale** (Australian Energy Market Operator, 2023a). The metrics by which success of the Pilot was assessed from the perspective of the project partners is outlined in Table 5. As outlined in Stage 4, **the Pilot adopted API connection with both fully automated (API-API) and API-UI (file transfer options)** "to enhance the speed and automation of the end-to-end transactions" (Australian Energy Market Operator, 2022c).

TRL	Rubric reference	Assessment
		The categories of capabilities demonstrated in the Pilot, for the benefit of the network, market *and* customer, were: • Providing energy and capacity when the customer needed • Providing, or curtailing, energy and capacity in response to market signals • Providing, or curtailing, energy and capacity when the system needed • Providing or withdrawing energy capacity when the local network needed • Quickly injecting or withdrawing energy in response to system frequency excursions • Balancing power flows at the connection point to smooth fluctuations • Configuring and allowing new capabilities to be embedded to provide value when needed • Enhancing performance or compliance monitoring to aid system modelling and risk management **While there was agreement that the technical elements of the Pilot to deliver the scope of WEM functions had been delivered, there was also agreement that this did "not necessarily reflect ideal operational arrangements outside of the Pilot".** Challenges related to applying existing market concepts or, in other words, the structure of obligations of actors. Project Symphony needed to be piloted as a Scheduled Facility, simultaneously providing energy, ESS-CRR and NSS, since it was ineligible for registration as a Semi-Scheduled Facility (this would only have been possible if the aggregation solely included rooftop solar). Although this was not an ideal categorisation, it was able to focus on the technical capabilities and limitations of orchestration in context. For example, there were instances that a dispatch target was not achieved when customers had taken actions outside the Aggregator's control to optimise behind the meter. Another example relates to where a VPP operator autonomously controls its portfolio to respond to signals, such as an NSS request, in a way that prevents the aggregated DER from responding to a requested output target in the AEMO dispatch process. The latter issue is likely to compound with scale and could pose serious risk to power system security. **The key issue that must be resolved is that aggregated DER acts in a fundamentally different way to the existing Facility Classes in the WEM. Solutions to this include improved forecasting and optimisation by the Aggregator and establishing market structures or processes to better accommodate** improved capability. **Until this is resolved, DER orchestration will not be able to participate in the market and fully achieve TRL 7.** Project Symphony's findings have informed the technical capabilities of a new Facility Class, enabled by a DER Participation Framework encouraging WEM registrations of aggregated DER. These would: • Coordinate portfolios across many electrical locations spanning the SWIS

TRL	Rubric reference	Assessment
		• Accommodate changes to the size, composition and location of portfolios • Accommodate a diverse mix of resources and their associated capabilities • Aggregate both passive and active DER, including uncontrolled load, on a net (dispatching to and from a baseline) rather than an absolute basis • Reflect, and frequently update, baseline forecasts as market submissions to communicate expected Aggregator capability to AEMO • Derive value from multiple operation modes • Make constraints on portfolios, such as DOEs, visible to AEMO, and • Integrate and coordinate DSO and DMO requirements so portfolios can feasibly and reliably deliver network and market services.

Table 5. Performance measurements for Test and Learn (Australian Energy Market Operator, 2022b)

Category	Description
Platform functionality	Determine if the Pilot platform functionality operated as expected and within an acceptable threshold
Platform performance / response	Determine if the platform and integration responsiveness of DMO, DSO and Aggregator platforms meets the specified integration non-functional performance requirements
Market price	Determine the effect DER has on the market price and overall value
Energy supply & security	Determine the effect DER has on energy supply and system security
Operational cost and benefit	Determine the effect DER has to operating cost or benefit
Compliance	Determine the extent to which aggregated DER can comply with existing regulations, standards and policies to provide recommendations to enable DER to participate in the market
Contractual agreements	Determine the effect DER will have on contractual agreements
Scalability – transaction volume	Determine if Project Symphony's solution is scalable and able to cater for additional participants and increased data flows in a live production environment without any noticeable degradation in system performance or impact to services
Scalability – transaction concurrency	Determine if Project Symphony's solution is scalable with regard to the number of concurrent transactions that would be expected in a live market without any noticeable degradation in system performance or impact to services

Facility composition and service reliability	Determine the facility composition that is required for DER to reliably provide services

Commercial maturity

CRI reference	1	2	3	4	5	6

The preliminary assessment detailed in the Vision and Impact Pathway projected that Project Symphony would contribute to the commercial readiness of **Transacting service** moving from level 2 (commercial trials) to level 3 (commercial scale-up). The end of project assessment of the progress towards level 3 is summarised below.

CRI	Rubric component	Assessment
3	Automatic dispatch, aggregation and settlement of DER for network and/or market services at a sufficient scale to ensure reliability of response for key actors (network, retail, market). Metering and settlement arrangements for network-owned community batteries defined in the regulatory framework.	**Partially achieved** **There is consensus among the project partners that "DER aggregations demonstrate capability that can support system needs for the secure and reliable operation of the SWIS"** (Australian Energy Market Operator, 2023a). The Pilot substantiated the hybrid model's effectiveness by demonstrating real value for all four test scenarios. The Test and Learn period of the Pilot "demonstrated the capability of the Aggregator, in collaboration with the DMO and DSO, to execute the four core scenarios, and provided a wide range of observations that established the value DER can provide for all key stakeholders". **Western Power noted in an interview that, during the Test and Learn period, the DSO was "publishing DOEs on a day-to-day basis without manual intervention apart from registration prior to the Pilot and manual override actions"**. However, since "NSS is not presently contemplated by the WEM", the Pilot required some bespoke arrangements to coordinate with other WEM services. Thus, Project Symphony has recommended changes to market arrangements to derive greater value from, and in turn unlock the capacity of, DER aggregations. It is understood that a new foundational market arrangements should facilitate long-term development and improvement of DER orchestration, allowing Aggregators access to more complex services over time as the capability develops. Thus, the proposed new Facility Class is intended to promote, rather than create barriers to, Aggregator-led DER orchestration. This will allow Aggregators to prioritise services based on value, operational requirements and customer preferences. The building blocks and transition plan of a DER Participation Framework, and its associated value streams, is outlined in Figure 30. AEMO (2023) notes that it is critical, if and when it "goes live", that this framework and/or Facility Class delivers sufficient value for participation and does not otherwise create a barrier to entry for aggregators. **Given the way the Pilot was structured, the network battery did not provide real market services therefore there was no settlement required but rather compliance was analysed (project partner interview).**

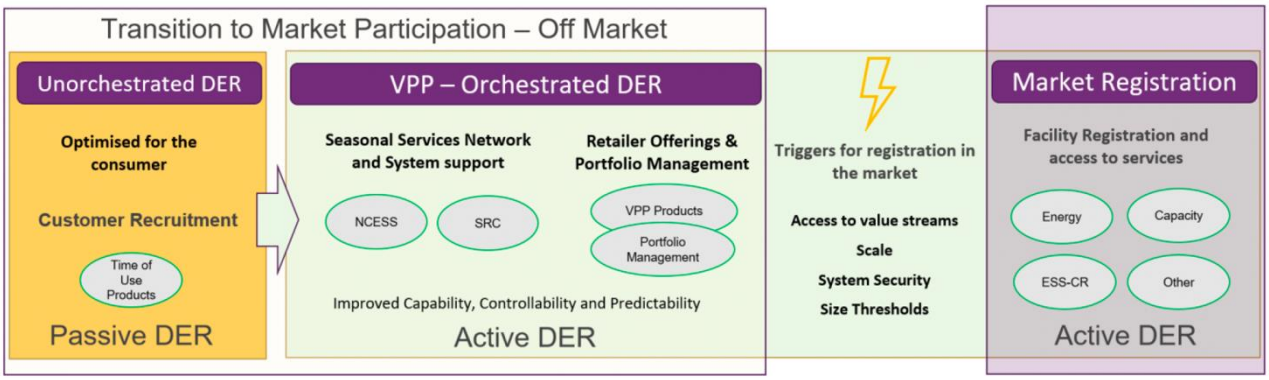


Figure 30. Transitional value streams for VPPs (Australian Energy Market Operator, 2023a)

Summary and conclusions

Summary

This assessment outlines the progress that Project Symphony has made towards technology and commercial maturity of DER orchestration and is summarised in Figure 31. The beginning of the arrow corresponds to the baseline analysis undertaken prior to the commencement of the Pilot and the end of the arrow corresponds to the level of maturity that was projected to be achieved by the project partners. The solid blue rectangle indicates progress during the Pilot.

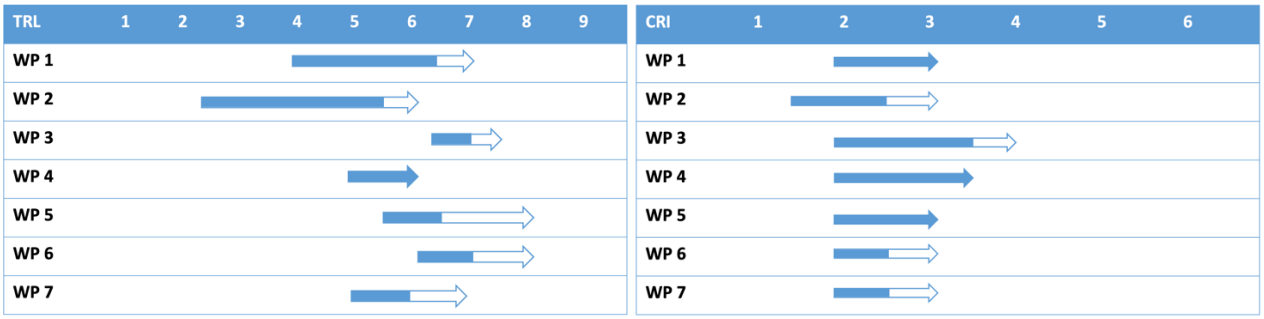


Figure 31. Summary of Project Symphony's progress towards technology and commercial maturity

Major contributors to the outcomes of the assessment are as follows.

Project Symphony recruited a total of 514 customers, with a total of 911 DER assets. The project partners agreed that this was sufficient to provide market and non-market services at 90% confidence levels to inform the scaled application of DER orchestration in WA. In order to orchestrate the DER assets, three platforms were successfully developed, integrated and implemented to support the roles and responsibilities agreed for the hybrid model – DSO, DMO, Aggregator – leading to the achievement of the planned levels of technology and commercial maturity for Stage 4.

Between April – June 2023, Project Symphony successfully conducted a 90 Day Clean Run for its four scenarios (Balancing Market, Network Support Services, Constrain to Zero and Essential System Services Contingency Raise) at the zone substation level. During all test periods, orchestration was fully operational for 99% of the time. However, an evaluation at the end of the test period suggested that there was a compliance rate of 85% for DOE, 40% for NSS and 46% for bi-directional energy. In addition, and as was considered possible at the outset of the Pilot that proposed stretch goals towards an “on-market” trial, the technology and commercial maturity of DER orchestration was constrained by many of these tests being undertaken in an “off-market” environment.

The Cost Benefit Analysis (CBA) on DER orchestration in WA undertaken by Ernst & Young found a positive Net Present Value (NPV) between $280 million to $920 million for the fully orchestrated scenario (Figure 11), which is a factor of “value stacking” or “co-optimising” network and market services. It is important to note that, although there was a positive NPV overall, sufficient value was not always demonstrated for the DSO and aggregators based on the pilot’s commercial arrangements. This will be a critical factor in the overall success of DER orchestration, given there must be a strong value proposition for all actors to secure their participation. If this is not the case, and some actors are deemed as enablers, policy needs to reflect an adequate cost-recovery mechanism. Another factor that must be considered is that the NPV could be significantly understated since many of the costs included in the CBA were related to Pilot expenses, such as battery subsidies and high installation expenses, that would not be expected in a business-as-usual context.

A key goal of Project Symphony was to explore what customers considered to be fair and attractive value for DER orchestration. User experience was documented through an extensive and longitudinal social science research project. Given the customers were offered higher-than-commercial incentives, including a large upfront subsidy for assets including batteries, the financial offer could not be validated and higher levels of technology and commercial maturity were not achieved across several Stages. However, the CBA provided information on what a valid offer could be in future DER orchestration projects. Customers were reported to have been confused and dissatisfied in the early stages of orchestration, particularly with the application of CTZ (gross) when zero self-consumption of solar PV was possible. The user experience improved over time as technical issues were resolved and customers understood more about DER orchestration. The social science study found that improving visibility would enhance user experience by allowing customers to monitor their assets more easily.

Significant regulatory barriers have already been addressed in the DER Roadmap that facilitate, and in some cases have been influenced by, the Project Symphony activities. Of significance, AEMO has made a recommendation to for enhanced visibility of VPP's. This will allow for AEMO to estimate the size and location of VPPs, to understand whether a DER aggregation must provide further information to avoid it compromising power system security or trigger participation in the market. Noting that "the current WEM registration framework does not readily enable the participation of Aggregated DER in the market", Project Symphony partners are continuing to work directly with EPWA to progress policy and regulatory activities in the DER Roadmap that will underpin DER orchestration in the WEM.

Conclusions

Figure 31 demonstrates the progress towards both technology and commercial maturity (TRL 9 and CRI 6) that must be made beyond Project Symphony to achieve mainstream DER orchestration. Goals in the assessment rubric (Appendices B and C) that were not addressed by Project Symphony are outlined in Table 6 to identify possible work that could be pursued to accelerate the mainstream orchestration of DER in WA. The WA DER Roadmap also identifies a series of actions that will be undertaken parallel to the Pilot to achieve this objective. The recommendations from Project Symphony could be used to supplement the DER Roadmap's existing actions.

Table 6. Activities that could accelerate mainstream orchestration of DER

Stage of life-cycle	Technology goals (TRL9)	Commercial goals (CRI6)	Possible activities
1. Identify opportunity	Target identification and/or DER visibility tool(s) are implemented online across the distribution network to automatically identify emerging constraints and develop multiple scenarios for the areas. The tool(s) and its outputs are fully integrated into DSO "BAU" operations including the completion of all user, training and maintenance documentation	DER orchestration is on a "level playing field" with traditional network-side solutions, fully integrated into BAU network planning.	Network opportunity maps updated in a more timely manner with more granularity to create opportunities for aggregated DER Review of incentives for network investment versus NCESS

Stage of life-cycle	Technology goals (TRL9)	Commercial goals (CRI6)	Possible activities
2. Validate and value DER services	DER is able to simultaneously and non-exclusively participate in multiple markets/schemes to access full potential value i.e. by addressing (at a minimum) thermal constraints, and voltage and frequency issues. Participation is proven in all jurisdictions.	The value of DER orchestration validated and verified, with the market driving new and existing product offerings i.e. similarly to retail offerings. Standards in place to ensure appropriate value pass-through achieved e.g. under energy and water ombudsman.	Methodology for non-exclusive participation of DER in multiple markets/schemes developed e.g. NCESS Energy and water ombudsman (or equivalent) provided training and/or standards to ensure value pass-through
3. Acquire DER customers	Recruit customers across jurisdictions for multiple services, achieving a target customer base to deliver an acceptable level of service. An automated system delivers offers, receives bids, evaluates contracts and dispatches service from registered DERs. All training and maintenance is available to support service delivery, including system design, site inspections and maintenance requirements.	DER orchestration products widely accepted by customers i.e. similarly to retail offerings. New product offerings and pricing driving customer uptake.	Establishing a long-term customer engagement process, accounting for the costs of such an engagement Policy commitment for mainstream deployment of DER orchestration beyond the life of Project Symphony with value demonstrated to customers Development of documents to support customer acquisition in the WEM for other aggregators and/or product offerings
4. Develop platforms	Platform(s)/tool(s) to deliver the DMO-DSO-Aggregator roles and responsibilities are available off-the-shelf across network/market services and jurisdictions. Decision-support tools to inform network investment decisions are overhauled to place DER orchestration on a level playing field with traditional network solutions.	DMO-DSO-Aggregator platform(s)/tool(s) widely available, accessible and comparable e.g. through standard procurement processes for key actors (network, retail, market).	Investment in the development of commercial tools and/or platforms, or sharing platforms/tools developed in Project Symphony beyond the Pilot partners

Stage of life-cycle	Technology goals (TRL9)	Commercial goals (CRI6)	Possible activities
5. Orchestrate DER	DER orchestration platform(s)/tool(s) delivered for all DMO-DSO-Aggregator actors across jurisdictions for the suite of network/market services. Certification of vendors is standardised to ensure compatibility across all commercial offerings.	DER orchestration widely implemented across all jurisdictions, with options available for all DER asset types to deliver most types of network and market services. Selection of orchestration option driven by cost and effectiveness.	Policy commitment for mainstream deployment of DER orchestration beyond the life of Project Symphony with value demonstrated to customers Standard for vendor certification established
6. Integrate platforms	DER orchestration platform(s)/tool(s) integrated for all DMO-DSO-Aggregator actors across jurisdictions for the suite of network/market services. New computational techniques are installed into operating processes to continuously calculate optimal operating conditions that may or may not move beyond existing ADMS e.g. functional modules.	DMO-DSO-Aggregators in all jurisdictions have integrated platforms that are interchangeable. Network modelling for DER orchestration within and between platforms is standard driving further improvements in cost and effectiveness.	Investment in the development of commercial tools and/or platforms, or sharing platforms/tools developed in Project Symphony beyond the Pilot partners Commitment to integrate platforms/tools developed in Project Symphony into BAU operations of DMO/DSO/ Aggregator
7. Transact service	End-to-end transactions for DER orchestration for the suite of network/market services with benefits demonstrated for customers and DMO-DSO-Aggregators in all jurisdictions. Standardised documentation available for all actors to participate in end-to-end transactions.	Transactions for end-to-end DER orchestration are embedded into financial systems of key actors (network, retail, market). Benefits and effectiveness are easily verifiable by customers, network and market to drive investment decisions.	Commitment to explore further network and/or market services beyond the four scenarios investigated in Project Symphony A methodology to account for non-financial benefits developed to promote broader system benefits of DER orchestration

Based on the above analysis and interviews with the project partners, the interim assessment undertaken prior to the stability period identified the following activities that could accelerate DER orchestration in WA in parallel or beyond Project Symphony:

- Establishing a long-term customer engagement process to support the transition to a high-DER energy network
- Developing a methodology:
    - For non-exclusive participation of DER in multiple markets/schemes, and
    - To account for non-financial benefits developed to promote broader system benefits of DER orchestration

- Developing documents to support customer acquisition in the WEM for other aggregators and/or commercial operators
- Promoting business model development by:
    - Providing regulation and policy support to balance network incentives, and
    - Updating the network opportunity maps in near real-time
- Establishing a standard for DER orchestration certification, to promote reliable vendors in the marketplace
- Investing in the development of commercial tools and/or platforms, or sharing platforms/tools developed in Project Symphony beyond the Pilot partners
- Conducting a review of organisational incentives for network and market investment versus NCESS
- A policy and organisational (DSO/DMO/Aggregator) commitment:
    - To explore further network and/or market services beyond the four scenarios investigated in Project Symphony
    - To integrate platforms/tools developed in Project Symphony into BAU operations (with supporting and funded work plan)
- Providing training and/or standards to the energy and water ombudsman (or equivalent) to ensure customers are protected when engaging with aggregators (including third party aggregators) as they are with retailers

Following the conclusion of Project Symphony, the project partners have agreed on a series of recommendations to pursue beyond the Pilot. These recommendations are included in the Final Project report (final reference) and summarised in Appendix E.

Project objectives

A final element of the end of project assessment is to cross reference the findings for the work packages, against the project objectives outlined in the Project Management Plan (PMP). The PMP outlines five categories of objectives, which are listed in Table 7 along with a summary of the assessment. In addition to the data collected to assess the work packages, an interview with the Symphony Project Management Office (PMO) was also conducted to support the assessment.

Table 7. End of project assessment of Project Symphony's progress against its defined objectives

No.	Description of objective	End-of-project assessment
	Technical objectives	
T1	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.	**Close to achieved, with a basis to understand how to fully meet this objective** Progress towards this objective can be mapped to work packages 1 and 5, along with the supplementary Test and Learn phase. Project Symphony has facilitated the partners' ability to identify the type, location concentration of DERs that is critical for achieving the four scenarios. For all scenarios, the technical feasibility of DER to provide system and local level services was demonstrated. This was not a simple task, and was a major achievement of the project. In practice, the ability to curtail generation is an important system level objective that was technically tested in the project. PMO acknowledged "further work is required to show a Facility's compliance with dispatch instructions and DOEs".
T2	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).	**Close to achieved, with a basis to understand how to fully meet this objective** Progress towards this objective can be mapped to work packages 5 and 7, along with the supplementary Test and Learn phase. Project Symphony sought to demonstrate that DER orchestration can be a "trusted" capability: reliable, available and firm. As above, the Pilot demonstrated the technical feasibility of end-to-end orchestration (including cybersecurity and latency) and close to a viable product, that will be achieved once compliance rates are consistently met.

No.	Description of objective	End-of-project assessment
T3	Inform the standards, processes, planning, systems, interoperability and security frameworks required to maintain system security and reliability.	**Achieved** Progress towards this objective can be mapped to all work packages, which informed DER orchestration at scale. Nationally-significant progress was made in certain areas including security frameworks, via the end-to-end cybersecurity assessment. The Final Report identifies the communications protocols and standards (including CSIP-AUS and AS4755 that will be mandated) that are required in order to scale DER orchestration in the SWIS. This is likely to be in advance of a national approach, noting that South Australia has also already implemented AS4755.
New energy market objectives		
NM1	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.	**Achieved** Progress towards this objective can be mapped to work packages 2, 3, 5 and 7. While not all services are being delivered on-market, Project Symphony met this objective by replicating market systems in the off-market Pilot. The Pilot demonstrated how DER can perform as a Facility in the market (albeit a simulated market) by measuring the impact of DER against existing Facilities. The NSS and CTZ scenarios specifically were measured successfully under pilot conditions, however this was not consistent with existing requirements for measurement in a mainstream environment. The CBA demonstrated that DER orchestration is viable in WA but further work is required to determine the appropriate distribution of value between aggregators and customers.
NM2	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.	**Achieved** Progress towards this objective can be mapped to work packages 2, 3, 5 and 7. DER orchestration was conducted in a context where the market rules do not change. However, the findings of the pilot informed future policy and regulatory reform. For example, work package 7 identified that DER needed to have a new market mechanism to accommodate it as a Facility.
Customer experience objectives		

No.	Description of objective	End-of-project assessment
CX1	Explore the residential and commercial customer preferences regarding DER, including willingness to engage, level of engagement, value drivers and the customer value proposition.	**Achieved** Progress towards this objective can be mapped to work packages 2 and 3. Customer recruitment targets were met with over 500 households participating in the Pilot, however the offering was not intended to scale. This objective was specifically supported by the longitudinal social science study undertaken by the University of Tasmania. This study documented the customer experience providing access to their assets for orchestration and outlined customer preferences towards DER orchestration in the future, informing three final recommendations: 1) customers need clear, simple, trusted and timely information, 2) this information must be delivered via appropriate channels, and 3) greater awareness of the benefits of participating in orchestration/VPPs is needed. Future scalable models will need to be based on customer values and motivations, along with these preference for engagement. In addition, future policy changes (e.g. greater solar curtailment) may also impact the attractiveness of incentives and should be considered.
CX2	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.	**Achieved** Progress towards this objective can be mapped to all work packages. Project Symphony piloted the role, scaled up over the stability period. However, the Aggregator role specifically was found to be a highly complex role compared to the traditional energy retailer role, requiring a trusted relationship with the customer. PMO noted that valuable lessons were learned on how the Aggregator can better facilitate customer involvement. The extent to which the technical and cultural elements of this role expansion can be achieved remains to be demonstrated beyond Project Symphony.
Roles and responsibilities objectives		

No.	Description of objective	End-of-project assessment
RR1	Project Symphony has an objective to 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.	**Achieved** Progress towards this objective can be mapped to all work packages. In June 2022, Energy Policy WA published its "DER Orchestration Roles and Responsibilities Information Paper" as an activity under the DER Roadmap. As mentioned in relation to the second customer objective, the extension of the retailer role to become an aggregator appears to be the most complex of the three transitions. The role of the retailer in developing new business models (i.e. productising DER orchestration) and in engaging customers in novel ways was considered. The roles of the DMO (AEMO) and DSO (Western Power) were more straightforward, although there were technical and organisational challenges to overcome e.g. AEMO delivering Bids and Offers (Boffers) effectively and Western Power dispatching NSS efficiently. An outcome of Project Symphony is that the OpEN Hybrid model may be improved, specifically to allow dispatch of NSS directly between the DSO and Aggregator rather than via the DMO.
Policy and regulation objectives		
PR1	Project Symphony also has an objective to 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).	**Achieved** Progress towards this objective can be mapped to all work packages. Commercial maturity is often dependent on policy and regulatory reform as outlined in the detailed rubric. Project Symphony has made progress on several fronts given the close relationship between the partners including Energy Policy WA. The project is also feeding into multiple interdependences with the WA DER Roadmap more broadly e.g. the aforementioned paper on roles and responsibilities. Progress was also made in the CBA and work package 7 specifically. The final report made six policy recommendations that can be found at Appendix E.

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Appendix A – Descriptors for TRL and CRI matrices

Technology Readiness Level (TRL) descriptors

TRL	Title	Descriptor
1	Basic principles observed and reported	Transition from scientific research to applied research. Essential characteristics and behaviours of systems and architectures. Descriptive tools are mathematical formulations or algorithms.
2	Technology concept and/or application formulated	Applied research. Theory and scientific principles are focused on a specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.
3	Analytical and experimental critical function and/or characteristic proof of concept	Proof of concept validation. Active research and development is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brass board implementations that are exercised with representative data.
4	Component/subsystem validation in laboratory environment	Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.
5	System/subsystem/component validation in relevant environment	Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.
6	System/subsystem model or prototyping demonstration in a relevant end-to-end environment	Prototyping implementations of full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.
7	System prototyping demonstration in an operational environment	System prototyping demonstration in operational environment. System is at or near scale of the operational system with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.
8	Actual system completed and qualified through test and demonstration in an operational environment	End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation completed.
9	Actual system proven through successful operations	Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operation experience. Sustaining engineering support in place.

Commercial Readiness Index (CRI) descriptors

CRI	Title	Descriptor
1	Hypothetical commercial proposition	Technically ready – commercially untested and unproven. Commercial proposition driven by technology advocates with little or no evidence of verifiable technical or financial data to substantiate claims.
2	Commercial trial	Small scale, first of a kind project funded by equity and government project support. Commercial proposition backed by evidence of verifiable data typically not in the public domain.
3	Commercial scale-up	Driven by specific policy and emerging debt finance. Commercial proposition being driven by technology proponents and market segment participants – publicly discoverable data driving emerging interest from finance and regulatory sectors.
4	Multiple commercial applications	Becoming evident locally although still subsidised. Verifiable data on technical and financial performance in the public domain driving interest from variety of debt and equity sources however still requiring government support. Regulatory challenges being addressed in multiple jurisdictions.
5	Market competition driving widespread deployment	In context of long-term policy settings. Competition emerging across all areas of supply chain with commoditisation of key components and financial products occurring.
6	"Bankable" grade asset class	Driven by the same criteria as other mature technologies. Considered as "bankable" grade asset class with known standards and performance expectations. Market and technology risks not driving investment decisions. Proponent capability, pricing and other typical market forces driving uptake.

Appendix B – Technology maturity matrix (impact pathway) for DER orchestration

TRL	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Develop platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
1 **Basic principles observed and reported**	Transition from scientific research to applied research. Essential characteristics and behaviours of systems and architectures. Descriptive tools are mathematical formulations or algorithms.	Desktop research to identify Ideal target areas, using theoretical locational data (e.g. network typology), constraints and customers.	Desktop research to calculate the hypothetical value of DER for customers, networks, markets and retailers and the risk that increased DER uptake could pose to the wholesale market(s).	Research to investigate customer values, motivations, preferences for DER as well as using that DER to provide services to the network and market. Desktop modelling to forecast likely DER uptake and capability to provide services.	Consultative customer research into the necessary roles and responsibilities of key actors (network, retail, market) required to facilitate DER orchestration to deliver system services i.e. DMO-DSO-Aggregator roles and responsibilities.	Desktop research to model the likely impacts of DER uptake on the distribution network under different scenarios e.g. no services provided, simple services delivered (e.g. active power reduction to address thermal constraints), DER orchestration.	Consultative industry research into the necessary roles and responsibilities of key actors (network, retail, market) required to facilitate DER orchestration to deliver system services i.e. DMO-DSO-Aggregator roles and responsibilities.	Research to develop algorithms that can optimise DER dispatch to maximise shared benefit to customers and key actors (network, retail, market).
2 **Technology concept and/or application formulated**	Applied research. Theory and scientific principles are focused on a specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.	Desktop research to identify potential target areas, using historical locational data (e.g. network typology), constraints and customers. Tool(s) developed to analyse capabilities for network augmentation, energy forecasts, customer profiles and scenario evaluation.	Development of effective DER valuation methodologies that are applied to specific scenarios e.g. testing the payback periods for DER under simulated and hypothetical valuations of active and reactive power.	Research to investigate experience of DER owners and interest and/or preference to engage with additional network or market offers (A). Desktop modelling to estimate minimum viable number of assets needed to provide key services e.g. addressing a thermal constraint, responding to a voltage envelope, providing frequency services.	Investigate the requirements, and propose the conceptual design, for a platform/tool that enables DER orchestration via the DMO-DSO-Aggregator roles and responsibilities.	Desktop research to simulate the behaviour of DER assets on the distribution network using time-series data under different scenarios.	Investigate the minimum requirements, and propose the conceptual design, for key actors (network, retail, market) to theoretically integrate DER orchestration e.g. aggregator platforms that can integrate with distribution SCADA systems to defer planned network expenditure.	Development of prototype infrastructure that can monitor, measure and settle dispatched DER. Validation of prototype using market, network and DER simulations.

TRL	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Develop platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
3 **Analytical and experimental critical function and/or characteristic proof of concept**	Proof of concept validation. Active research and development is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brass board implementations that are exercised with representative data.	A proof of concept tools (including supporting software systems) test the feasibility of identifying target areas e.g. by using historical theoretical network augmentation and historical energy trends and customer profiles.	Experiments to apply DER valuation methodologies to real-life scenarios using representative data e.g. quantifying the value of using DER to address hypothetical voltage excursions on the distribution network to defer replacement/upgrading expenditure.	Experiments to test hypothetical customer uptake of specific offers e.g. designing incentives and testing their attractiveness/validity with representative customer groups.	Desktop application of platform(s)/tool(s) to deliver network and market services through DER orchestration using hypothetical scenarios and representative data e.g. model customer load curves, voltage/frequency assumptions, high-level energy use trends.	Desktop experiments with representative data to test the outcomes of prototype DER orchestration platform(s)/tool(s) under different scenarios e.g. geographic variance, levels of DER uptake, network/market services provided, customer acquisition levels.	Desktop simulations of DMO-DSO-Aggregator integration with specific network and/or market services using representative data e.g. voltage support using active and/or reactive power from solar and/or batteries.	Desktop simulations of end-to-end transactions with representative data, backcasting value propositions for customers and key actors (network, retail, market).
4 **Component/ subsystem validation in laboratory environment**	Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.	Target area identification tool(s) implemented at scale with real data to experiment with different problems/scenarios e.g. calculating hosting capacity, and potential dynamic operating envelopes, for real locations using historical data.	Experiments to apply DER valuation methodologies to real-life scenarios using real data e.g. quantifying the value of using DER to address real voltage excursions on the distribution network to defer replacement/upgrading expenditure.	Develop a model to output fair awards for customers that provide network or market services from DER (RB, SE). Build the model at sufficient scale for a subset of services (e.g. thermal, voltage, frequency).	Desktop application of platform(s)/tool(s) to deliver network and market services through DER orchestration using hypothetical future scenarios and model/historical data e.g. customer metering (e.g. smart meters), recent voltage/frequency levels, real energy forecasts.	Desktop experiments with model/historical data to test the outcomes of prototype DER orchestration platform(s)/tool(s) under different scenarios e.g. geographic variance, levels of DER uptake, network/market services provided, customer acquisition levels, energy consumption trend trajectories.	Desktop trials to integrate the platform(s) with real data (consumption, DER performance, generation etc.) on offline versions of network planning systems e.g. PSS®SINCAL.	Desktop simulations of end-to-end transactions with full scale model/historical data , backcasting value propositions for customers and key actors (network, retail, market).
5 **System/subsystem/component validation in relevant environment**	Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations	Tool(s) to provide automatic visibility of target area(s) and DER assets on the distribution network tested in a representative environment including near real-time (~5 min), accurate and	Prototype valuations tested in a pilot environment using commercially available technologies with testing visibility needs to key actors (customers, network, market, retailers) e.g. real-time visibility of	Implement the model to manually output fair awards for customers that provide network or market services from DER. Demonstrate the model in a representative environment to	Prototype platform(s)/tool(s) designed and developed for piloting specific services (e.g. frequency or voltage support) for DMO-DSO-Aggregator functions in representative areas	Pilot the prototype DER orchestration platform(s)/tool(s) at a small scale (e.g. one edge-of-grid community). Specific technical solutions tested in the representative environment e.g. solar	Pilot the prototype DER orchestration platform(s)/tool(s) at a small scale with specific first-mover partners that cover the DMO-DSO-Aggregator roles. Bespoke (designed-for-trial) solutions	Pilot prototype infrastructure at a small scale (e.g. network monitoring, advanced metering infrastructure (AMI), battery state of charge (SoC) monitor/controllers). Manual operation for

TRL	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Develop platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
	conform to target environment and interfaces.	dynamic data on capability, telemetry and potential impact. Outputs of tool(s) conform to DSO/DMO requirements.	the financial performance of batteries providing network support services to a VPP.	validate desktop findings for a subset of services. Measure uptake rates to validate best offers that provide value to key actors i.e. the customer, network, market, retailer.	(e.g. an edge-of-grid community).Additional support provided to key actors (network, market, retail, service providers) to clarify technical requirements and performance expectations.	capacity limits, maximising onsite solar consumption, optimum battery charging profiles.	tested in the representative environment e.g. solar capacity limits, maximising onsite solar consumption, optimum battery charging profiles.	end-to-end transaction.
6 **System/subsystem model or prototyping demonstration in a relevant end-to-end environment**	Prototyping implementations of full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.	Target identification and/or DER visibility tool(s) are implemented at the zone substation level of a hypothetical constraint. Minimum functionality includes: internet connection, 5-minute interval telemetry and control, a default safety mechanism when disconnected, and the ability to be scheduled. Basic troubleshooting mechanisms are established e.g. managing interim offline DER devices. The tool(s) and/or its outputs are aligned with DSO "BAU" operations.	Prototype valuations tested in an end-to-end environment using commercially available technologies with testing visibility needs to key actors (customers, network, market, retailers).	Implement a model to automatically output fair and attractive awards for customers that provide network or market services from DER. Implement the model at full-scale (e.g. feeder level) under a standard API with a suite of services (e.g. thermal, voltage, frequency). Recruit a minimum viable number of DER assets at pilot scale. Validate offer by measuring uptake, user experience and service delivery.	Prototype platform(s)/tool(s) designed and developed for specific DER use cases and/or network scenarios (RB). In the case of DER orchestration via DMO-DSO-Aggregator roles (i.e. not vertically-integrated utilities), this entails function beyond "command and control" to more complex solutions such as dynamic operating envelopes.	Demonstrate DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for specific services. Prototype can: respond to DSO contracts including real and reactive power dispatch; participate in the ESS-CRR / FCAS market; integrate with AEMO's VPP demonstration API; and produce operational and telemetry data from VPPs. DER is optimised behind-the-meter.	Demonstrate bespoke orchestration at full-scale (e.g. zone substation level) for specific services e.g. VPP for frequency or voltage support services using unique platforms (such as an "aggregator or aggregators"). Validate orchestration by achieving target levels of services (e.g. battery generation/export or achieved voltage envelopes) with a satisfactory level of reliability.	Demonstrate end-to-end transactions at full scale (e.g. VPP trials across a distribution network) for specific services. Functions include: uploading telemetry data, nullifying and archiving contracts, handling unavailability submissions, recording dispatch information and settling transactions. Automated operation validated.

TRL	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Develop platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
7 **System prototyping demonstration in an operational environment**	System prototyping demonstration in operational environment. System is at or near scale of the operational system with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.	Target identification and/or DER visibility tool(s) are implemented at the zone substation level of an emerging constraint to develop scenarios for the area. The tool(s) and/or its outputs are managed, and potentially hosted by, the DSO to integrate it into "BAU" operations (including a functional user interface).	Valuations tested in an end-to-end operational environment using commercially available and viable technologies with sufficient visibility to key actors (customers, network, market, retailers). Additional monitoring and optimisation of the system implemented including: sizing the system, adaptive programming (self-learning) of the system, access to cost-reflective pricing, control of discretionary loads and potentially islanding options.	Test DER recruitment in an operational environment, achieving a target customer base to deliver an acceptable level of service. Determine a minimum viable number of DER assets and their reliability (Ergon Energy argues 95% reliability) to account for inconsistent customer "drop outs" e.g. opting out or technical outages. Test automated system to deliver offers, receive bids, evaluate contracts and dispatch service from registered DERs.	Complementary systems designed and developed to support the platform(s)/tool(s) in for mainstream operation across multiple jurisdictions and multiple network/market services e.g. real-time network and sensor data, and centralised DER forecasting (accessible to third parties) for long-term planning.	Demonstrate DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for suite of network/market services. DER is made available for "business as usual" network management/	Demonstrate the integration of DER orchestration platform(s)/tool(s) at full-scale (e.g. zone substation level) for suite of network/market services. Orchestration automated including receiving, accepting and rejecting a DER request (potentially including forward option contracts). Detail for standards determined in consultation with key actors e.g. data hosting and sharing agreements and specifications for API's linking the DMO-DSO-Aggregator platforms determined.	Demonstrate end-to-end transactions at full scale (e.g. VPP trials across a distribution network) for DER orchestration. Automated operation with reliable operation (e.g. robust DER connectivity) validated.
8 **Actual system completed and qualified through test and demonstration in an operational environment**	End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation completed.	Target identification and/or DER visibility tool(s) are implemented and validated offline across the distribution network to manually identify emerging constraints and develop multiple scenarios for the areas. The tool(s) and its outputs are fully integrated into DSO "BAU" operations including the completion of most	Multiple value streams (e.g. thermal constraints, frequency, voltage) to be validated in an operational demonstration over at least one representative period e.g. a calendar year to account for seasonal variation. DER is demonstrated to simultaneously and non-exclusively participate in multiple markets/schemes.	Recruit customers in the market to demonstrate operational service delivery from DER assets. A target customer base is achieved without additional technical or marketing support. An automated system delivers offers, receives bids, evaluates contracts and dispatches service from registered DERs. Most training and	Platform(s)/tool(s) to deliver the DMO-DSO-Aggregator roles and responsibilities are validated across network/market services and jurisdictions. Decision-support tools to inform network investment decisions are modified ad hoc to accommodate DER orchestration.	DER orchestration platform(s)/tool(s) delivered on the entire DSO value chain for the suite of network/market services. Test and validation of standardised approaches e.g. IEEE 2030.5 communication protocol to transport DER commands to inverters.	DER orchestration platform(s)/tool(s) integrated across DMO-DSO-Aggregator systems (including ADMS and GIS). Standard communication mechanism (a consistent API for communication) is available to all DSO actors e.g. using the IEEE 2030.5 data structures for communicating	End-to-end transactions for DER orchestration for the suite of network/market services with benefits demonstrated for customers as well as DMO-DSO-Aggregators. Test and validation of standardised approaches including telemetry, contracting, dispatch and settling.

TRL	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Develop platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
		user, training and maintenance documentation.		maintenance information is developed to support service delivery, including system design, site inspections and maintenance requirements (A).			dynamic operating envelopes.	
9 **Actual system proven through successful operations**	Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operation experience. Sustaining engineering support in place.	Target identification and/or DER visibility tool(s) are implemented online across the distribution network to automatically identify emerging constraints and develop multiple scenarios for the areas. The tool(s) and its outputs are fully integrated into DSO "BAU" operations including the completion of all user, training and maintenance documentation.	DER is able to simultaneously and non-exclusively participate in multiple markets/schemes to access full potential value i.e. by addressing (at a minimum) thermal constraints, and voltage and frequency issues. Participation is proven in all jurisdictions.	Recruit customers across jurisdictions for multiple services, achieving a target customer base to deliver an acceptable level of service. An automated system delivers offers, receives bids, evaluates contracts and dispatches service from registered DERs. All training and maintenance is available to support service delivery, including system design, site inspections and maintenance requirements.	Platform(s)/tool(s) to deliver the DMO-DSO-Aggregator roles and responsibilities are available off-the-shelf across network/market services and jurisdictions. Decision-support tools to inform network investment decisions are overhauled to place DER orchestration on a level playing field with traditional network solutions.	DER orchestration platform(s)/tool(s) delivered for all DMO-DSO-Aggregator actors across jurisdictions for the suite of network/market services. Certification of vendors is standardised to ensure compatibility across all commercial offerings.	DER orchestration platform(s)/tool(s) integrated for all DMO-DSO-Aggregator actors across jurisdictions for the suite of network/market services. New computational techniques are installed into operating processes to continuously calculate optimal operating conditions that may or may not move beyond existing ADMS e.g. functional modules.	End-to-end transactions for DER orchestration for the suite of network/market services with benefits demonstrated for customers and DMO-DSO-Aggregators in all jurisdictions. Standardised documentation available for all actors to participate in end-to-end transactions.

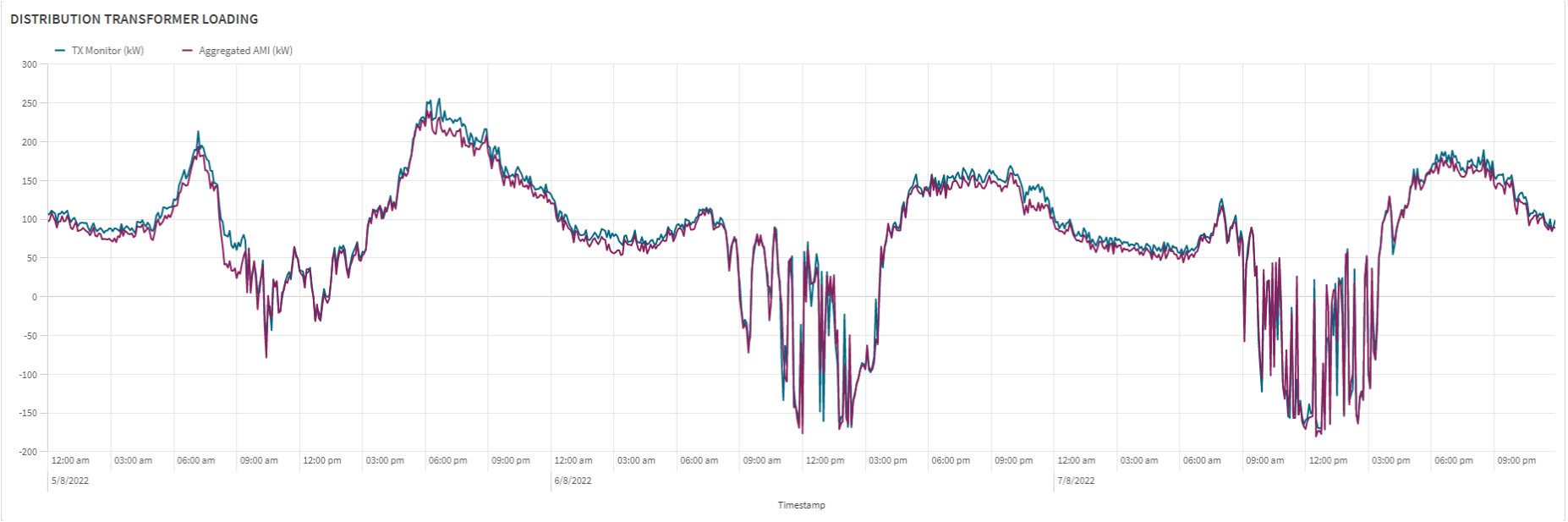
Appendix C – Commercial maturity matrix (impact pathway) for DER orchestration

CRI	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Select platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
1 **Hypothetical commercial proposition**	Technically ready – commercially untested and unproven. Commercial proposition driven by technology advocates with little or no evidence of verifiable technical or financial data to substantiate claims.	Targets areas identified by using high-level desktop information (e.g. AREMI network opportunity maps) and/or via conversations with key actors e.g. network planners.	Hypothetical value proposed derived from theoretical data e.g. DER performance, levels of customer engagement, quality of service delivery	Participant recruitment estimated based on informed hypothetical uptake e.g. interviews, surveys, proxy/dummy offerings on social media.	Conceptual DMO-DSO-Aggregator platform requirements determined through consultative research with key actors (network, market, retail, aggregators).	Desktop simulations of DER orchestration using model network, customer and generation data to deliver technical estimates of network and market service delivery.	Conceptual integration requirements for DMO-DSO-Aggregator platform(s)/tool(s) determined through consultative research with key actors (network, market, retail, aggregators).	Hypothetical transactions modelling in a desktop environment to test the effectiveness, and elucidate challenges, of theoretical DER orchestration.
2 **Commercial trial**	Small scale, first of a kind project funded by equity and government project support. Commercial proposition backed by evidence of verifiable data typically not in the public domain.	Pilot project, supported by government grant(s), to publish static DER asset data and dynamic sensor data in at least one jurisdiction.	Pilot project to test incentives (funded by government grant(s)) for network and/or market services from DER e.g. one-off payments for DER monitoring and control (RB). Trials demonstrate a positive value proposition / business case for customer and key actors (network, retail, market).	Pilot project, supported by government, to test acquisition rates for a range of product offerings / value propositions. A sufficient number of customers recruited to deliver network and/or market services in a test environment.	Pilots of precursors of DMO-DSO-Aggregator platforms tested in the field for specific network and/or market services. Performance validation and design of platform(s)/tool(s) for end-to-end DER orchestration.	Pilots of DER aggregation to deliver specific network and/or market services. Performance validation to inform the design of end-to-end DER orchestration trials.	Pilots of platform integration tested in the field for specific network and/or market services e.g. bespoke aggregator platforms integrating with network SCADA systems to provide voltage support from DER.	Pilot project of end-to-end transactions in a real-world environment requiring manual dispatch from key actors (aggregators, network, retail, market).

CRI	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Select platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
3 **Commercial scale-up**	driven by specific policy and emerging debt finance. Commercial proposition being driven by technology proponents and market segment participants – publicly discoverable data driving emerging interest from finance and regulatory sectors.	DER (batteries, solar, loads, generators etc.) data required for orchestration made available for a demonstration project, following agreed interim regulations for sharing customer/network/market participation data. Development of preliminary standards related to network modelling, data measurement, DER asset communications and device registration.	Commercial product(s) available and economically viable (including balance of system costs) for DER owners to provide network and/or market services through registered platform(s). Policies/regulations developing to remove barriers to multiple value streams e.g. direct load control, VPP establishment and delivery, dynamic export limits, dynamic operating envelopes, universal access to cost-reflective pricing.	Sufficient customers recruited to deliver network and market services for trials with multiple types of DER. Value offerings are commercially available (i.e. are not government-funded) and incorporate understanding of customer values and motivations. Business model is accessible to all key actors (customers, network, retail, market). Policies/regulations developed to address customer protection and technical risks.	Commercial trial of platform(s)/tool(s) delivering insightful data. Data ownership and confidentiality arrangements in negotiation.	Commercial trial of DER orchestration, validating the network and market services can be delivered to a standard required for key actors (network, retail, market). Operational telemetry collected and made available to participants at a minimum.	Software developed to integrate DMO-DSO-Aggregator platform(s)/tool(s) for specific network and/or market services e.g. components for delivering dynamic operating envelopes: - An IEEE2030.5 utility server core - Tools for simulating and validating server and client behaviour - An interface for device registration	Automatic dispatch, aggregation and settlement of DER for network and/or market services at a sufficient scale to ensure reliability of response for key actors (network, retail, market). Metering and settlement arrangements for network-owned community batteries defined in the regulatory framework.
4 **Multiple commercial applications**	becoming evident locally although still subsidised. Verifiable data on technical and financial performance in the public domain driving interest from variety of debt and equity sources however still requiring government support. Regulatory challenges being addressed in multiple jurisdictions.	Regulations allow customers to share their energy data with third parties, rather than having to seek approval from their distributor. DER (batteries, solar, loads, generators etc.) data required for orchestration made publicly available in several jurisdictions following resolution of data security (including cyber security) and privacy issues.	Several commercial products available and economically viable for DER owners to provide multiple network and market services through registered platform(s). Verifiable performance data from platforms is available for investors. No regulatory barriers to accessing and passing through multiple value streams for customers and key actors (network, retail, market).	Sufficient customers recruited to deliver commercial network and market services in multiple jurisdictions with multiple types of DER. Multiple value offerings without lock-in clauses are commercially available, in multiple jurisdictions. Information available for customers e.g. comparable products, tiered options, clear risk profiles. Standards for equipment installation and “set and forget”	Commercial trial of platform(s)/tool(s) in multiple jurisdictions delivering regular verifiable data on performance. Technical and operational standards in development e.g. DSO (e.g. DERMS) product offerings, transporting envelopes to third party aggregators, new network planning approaches to incorporate DER orchestration.	Commercial trial of DER orchestration in multiple jurisdictions. Operational telemetry collected and made publicly available, to the extent that customer data is sufficiently protected and the costs for collection, storage and validation can be distributed. Standard approaches to DER orchestration (e.g. IEEE2030.5 protocol) investigated in consultation with key actors (network, retail, market, aggregators).	Software developed to integrate DMO-DSO-Aggregator platform(s)/tool(s) for the suite of network and market services. Interoperability standards in place consistency across jurisdictions including (but not limited to) data interchange and electrical network modelling.	Automatic dispatch, aggregation and settlement of DER at a sufficient scale to ensure reliability of response for multiple network and market services. Regulatory framework allow DSO contracting and orchestration of DER. Market reforms include: a transparent demand response mechanism; emergency reserve capacity

CRI	ARENA description	1. Identify opportunity	2. Validate and value DER services	3. Acquire DER customers	4. Select platforms	5. Orchestrate DER	6. Integrate platforms	7. Transact service
				functionality established.				contracts; and other DER service markets.
5 **Market competition driving widespread deployment**	in context of long-term policy settings. Competition emerging across all areas of supply chain with commoditisation of key components and financial products occurring.	A high percentage of active DER is enabled and visible to the market, promoted by incentives and/or regulatory obligations. Standards in place for network modelling, data measurement, DER asset communications and device registration. Data (including cyber) security overseen by an independent organisation.	Competing commercial products available and economically viable for DER owners to provide multiple network and market services through registered platform(s). No regulatory barriers to developing new DER orchestration products. Customers and key actors (network, retail, market) familiar with products and services.	Sufficient customers recruited for DER orchestration in all jurisdictions. Aggregator market for DER orchestration established with dynamic membership and non-exclusivity, and ideally with short-term options. Risks attributed and managed by appropriate actors e.g. risks of non-performance, adverse impacts and customer protection.	A range of platforms and tools available in all jurisdictions, complying with agreed DER operating standards for service delivery.	Options for DER orchestration available in all jurisdictions, complying with agreed operating standards. Regulatory biases addressed to ensure that OPEX for demand-side solutions are easily recoverable under the regulated asset base i.e. a "level playing field".	DMO-DSO-Aggregators in all jurisdictions have integrated platforms, with switching of products becoming easier and more commonplace e.g. for different services and/or DER use cases.	Automatic dispatch, aggregation and settlement of DER at a sufficient scale to ensure reliability of response for suite of network/market services in all jurisdictions. Benefits of DER services validated for customers, network and market.
6 **"Bankable" grade asset class**	driven by the same criteria as other mature technologies. Considered as "bankable" grade asset class with known standards and performance expectations. Market and technology risks not driving investment decisions. Proponent capability, pricing and other typical market forces driving uptake.	DER orchestration is on a "level playing field" with traditional network-side solutions, fully integrated into BAU network planning.	The value of DER orchestration validated and verified, with the market driving new and existing product offerings i.e. similarly to retail offerings (RL). Standards in place to ensure appropriate value pass-through achieved e.g. under energy and water ombudsman.	DER orchestration products widely accepted by customers i.e. similarly to retail offerings. New product offerings and pricing driving customer uptake.	DMO-DSO-Aggregator platform(s)/tool(s) widely available, accessible and comparable e.g. through standard procurement processes for key actors (network, retail, market).	DER orchestration widely implemented across all jurisdictions, with options available for all DER asset types to deliver most types of network and market services. Selection of orchestration option driven by cost and effectiveness.	DMO-DSO-Aggregators in all jurisdictions have integrated platforms that are interchangeable. Network modelling for DER orchestration within and between platforms is standard driving further improvements in cost and effectiveness.	Transactions for end-to-end DER orchestration are embedded into financial systems of key actors (network, retail, market). Benefits and effectiveness are easily verifiable by customers, network and market to drive investment decisions.

Appendix D – Sample of Transformer Monitoring Data



Appendix E – Endorsed recommendations from the results of Project Symphony

Pillar	**1. Technical**	**2. Customer Experience**	**3. Value (New Energy Market)**	**4. Policy & Regulation**
Overview	*Focused on maturing technical aspects of DER orchestration, including platform build, integration, data etc.*	*Focused on improving all elements related to achieving customer 'buy-in'.*	*Focused on creation / facilitation of all types of value from DER orchestration*	*Focused on changing / implementing regulation or policy settings to enable DER orchestration*
Tier 1 Recommendation *– Critical enabler*	1.1 Adopt a single communications protocol for all inverter-based DER (CSIP-AUS) to maximise asset interoperability. 1.2 Develop the business case for a 'DER Data Hub' to facilitate effective and efficient data exchange between the DMO, DSO and Aggregators. 1.3 Develop specifications around parent Aggregator service delivery standards to accelerate compliance to service delivery standards in the WEM.	2.1 Create simple, transparent and accurate customer facing information on VPP participation for communication throughout the customer journey to improve customer experience, buy-in and retention. 2.2 Develop end-to-end customer engagement tools to manage and improve the customer experience of VPP participation.	3.1 Commence work on policy solutions to establish market frameworks that support the participation of DER aggregations in the WEM. 3.2 Deliver a Network Support Service that achieves deferral of network augmentation, to confirm existing funding, recovery, incentivisation and coordination mechanisms are adequate at scale.	4.1 Support VPP visibility for the DMO and DSO through implementing amendments to wholesale electricity market rules as required. 4.2 Establish policy positions that appropriately incentivise aggregators to participate, and ensure value is passed through to customers. 4.3 Review and reform end to end DER installation, connection, commissioning and compliance processes.
Tier 2 Recommendation *– Enabler*	1.4 Explore opportunities to establish platform and communications solutions such as AMI to lower risk and achieve greater efficiencies. 1.5 Establish a 'DER Test Lab' accessible by DSO, Aggregator and DMO to prototype and test DER integration products and solutions prior to rollout.	2.3 Establish a SWIS-wide customer engagement strategy and plan to achieve a consistent and cohesive approach to improving general customer awareness of VPPs.	3.3 Quantify the actual value of DER asset participation for non-contestable customers (>12 months data and without pilot participation costs) to better inform value streams and the distribution of value between DER owners and the aggregator. 3.4 Establish clear frameworks to enable 3PAs to engage with the parent aggregator Synergy for non-contestable customers, to reduce barriers of entry and ensure consistent customer experience.	4.4 Develop incentives to accelerate the take-up of energy storage, bringing forward power system and decarbonisation benefits. 4.5 Mandate adoption of *AS4755 Demand Response Standard* by OEMs to enable greater interoperability of air conditioners for load management by aggregators. 4.6 Introduce dynamic network connections to enable unconstrained connection of DER onto Western Power's network to improve customer choice and flexibility whilst contributing to decarbonisation.