Project Symphony

Our energy future

DER Participation: Pilot Results and Recommendations

Project Symphony Final Report

April 2024

In partnership with:

western power synergy AEMO GOVERNMENT OF WESTERN AUSTRALIA Energy Policy WA

Project Symphony

Our energy future

Table of Contents

List of figures and tables

List of Figures

List of Tables

Project Symphony

Our energy future

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Project Symphony

Our energy future

1. Minister for Energy Foreword

Western Australia (WA) is committed to an efficient and fair energy transition, delivering outcomes for both decarbonisation and customers. As a critical part of the transition, WA is leading the nation when it comes to ensuring that Distributed Energy Resources (DER) will be able to play its part. At the heart of this effort is Project Symphony, the WA Government's flagship virtual power plant (VPP) pilot under the ambitious DER Roadmap.

In December 2019, the Western Australian Government released the DER Roadmap as part of its broader Energy Transformation Strategy. Originally comprising 36 core actions, the Roadmap is an ambitious, Australian-first plan to learn, plan, and implement the changes necessary for a high-DER future that benefits all electricity customers. Key actions within the DER Roadmap called for the piloting of consumer DER assets to provide services to the grid and broader power system, for the direct benefit of households and businesses. Project Symphony, Australia's most comprehensive VPP pilot, was the response to this call.

After more than two years of planning, development, and testing I am pleased to introduce the Project Symphony Final Report. The Final Report provides invaluable insights on the pathway to true integration of DER in our power systems. We now have the opportunity to take the lessons learned and recommendations from Project Symphony to fully integrate DER in WA's power system, supporting power system security and reliability and providing consumers with access to new and affordable electricity services.

Project Symphony was delivered in partnership by Western Power, the Australian Energy Market Operator (AEMO), Synergy, and Energy Policy WA (Department of Energy, Mines, Industry Regulation and Safety). I commend the substantial contribution made by participating households and businesses and the unwavering commitment to innovation and collaboration shown by each project partner. I would also like to give my thanks for the support provided by the Australian Renewable Energy Agency (ARENA) through its Advancing Renewables Program. ARENA's dedication to sharing research has meant that other jurisdictions will also be able to benefit from the lessons learned through the ground-breaking achievements of Project Symphony.

The WA Government is committed to putting this research into action. Critically, the Final Report includes 18 enabling recommendations relating directly to the lessons learned throughout the development and implementation of Project Symphony. These recommendations are designed to complement and build-upon the program of work being undertaken as part of the DER Roadmap and complement the WA Government's commitment to transform and decarbonise our energy sector. These commitments include the retirement of Synergy's coal-fired generators, investment in large-scale storage and renewables, and the passage of once-in-a-generation reforms to the state's electricity legislation.

The impact of Project Symphony has already begun to be felt. Technical achievements and the simulation of new energy market roles have become key inputs into policy decisions being made for electricity sector reform. Project Symphony demonstrates WA's expertise at the cutting edge of the energy transformation and has demonstrated its position as a leader both nationally and internationally.

WA has embraced a high-DER future. I look forward to the next stages of our journey as we continue the energy transformation, together.

Hon Reece Whitby MLA
Minister for Energy

Project Symphony
Our energy future

2. Partners' Joint Statement

Project Symphony was a unique pilot where customer distributed energy resources (DER) including rooftop solar, batteries and major appliances were orchestrated as a Virtual Power Plant (VPP) to participate in a simulated energy market. Project Symphony's objective was to understand how VPPs could unlock benefits for participating customers, and how these benefits could then be scaled to greater economic and environmental benefits for the Western Australian community.

The two-year pilot was centred in the Perth region of Southern River, where more than 50% of households have rooftop solar – making it one of Perth's top solar districts. Project Symphony sought to orchestrate the DER of around 500 WA homes and 900 assets as a VPP.

Project Symphony partners thank our customers for participating in this innovative pilot and providing the insight needed to support customers to continue embracing DER and experience the full economic and environmental benefits from their assets. This involvement was central in allowing us to pilot, test and shape WA's energy future.

A collaboration between Western Power, Synergy, and the Australian Energy Market Operator (AEMO), the project partners acknowledge the role of Third-Party Aggregators and the support from the Australian Renewable Energy Agency's (ARENA) Advanced Renewables Program, as well as policy and regulatory support from Energy Policy WA.

One of the enduring elements to emerge from Project Symphony is the invaluable collaboration between our agencies. Working together we've successfully delivered an ambitious program of work that saw existing and new customer DER participate in a simulated energy market while also providing a support service to the distribution network.

Project Symphony is a major step towards a future where the full capabilities of DER can deliver sustainable value to all customers and the stability of WA's power system. Recommendations from the pilot include a series of actions that can be delivered over the next three years to enable greater DER participation via VPPs in WA.

We are all working together to ensure the power system and distribution network meet the needs of West Australians now and into the future.

Project Symphony

Our energy future

"Project Symphony provided valuable insights into customer awareness and expectations in participating in a VPP and these insights will be central in engagement strategies and product development for future VPPs. The pilot also demonstrated that value can be created from DER orchestration in the South West Interconnected System (SWIS) and that creating conditions for DER aggregation in the short to medium term is in the long term interests of customers." ***David Fyfe, CEO, Synergy***

"Collectively, rooftop solar is already the largest generator in the SWIS and is a key contributor in the energy transition towards net-zero. When customer assets are aggregated, they develop into a large and manageable power source. The integration of aggregated DER into electricity markets has the potential to unlock greater economic and environmental benefits for customers and the wider community. Project Symphony provided the opportunity to test this, providing valuable insights into how DER can be orchestrated for use in a future commercial environment, where customers can benefit."
Kate Ryan, Executive General Manager Western Australia & Strategy, AEMO

"Project Symphony has been critical in the identification of where policy and regulation require change to help drive WA's energy transformation and decarbonisation. It has highlighted the potential for DER orchestration through VPPs to provide real value to the system, network and customers alike. As the WA Government's flagship VPP project, as part of its Distributed Energy Resources Roadmap, Symphony has laid the foundation for how the distribution system can be leveraged to ensure the continued provision of reliable, secure, decarbonised and affordable electricity services for all Western Australians."
Jai Thomas, Deputy Director General – Coordinator of Energy, Energy Policy WA.

"Project Symphony demonstrated how customer owned DER can increasingly play a role in addressing both system and network challenges while providing benefits for the community and assisting in achieving WA's decarbonisation goals. We see our distribution system as the platform that enables customer generated energy to participate in energy markets and provide services to help manage the peaks and troughs of consumption on the network. The success of Project Symphony was only possible because of the strong collaboration between each of the partner organisations. It is through our continued working together with community that we will support greater participation of DER via VPPs and with it, the increasing decarbonisation of our energy system." ***Sam Barbaro, CEO Western Power***

Sam Barbaro,
Chief Executive Officer
Western Power

David Fyfe,
Chief Executive Officer
Synergy

Kate Ryan,
Executive General Manager Western Australia & Strategy
AEMO

Jai Thomas,
Deputy Director General - Coordinator of Energy
Energy Policy WA

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3. Executive Summary

In Western Australia (WA), the energy transition is progressing at pace. It's being driven by customer adoption of new technologies and government policy. This transformation is being enabled by key actors in the Wholesale Electricity Market (WEM) value chain in the South West Interconnected System (SWIS): Western Power, Synergy, the Australian Energy Market Operator (AEMO) and the WA State Government through Energy Policy WA (EPWA).

WA has some of the highest levels of Distributed Energy Resources (DER) globally, with 35% of homes having a rooftop solar system installed. WA is experiencing an increase in the adoption of distributed battery energy storage, while also actively preparing for the inevitable electrification of transport via the take up of electric vehicles (EVs) and associated charging equipment.

Broad macroeconomic and environmental factors are driving the transformation, with forecasted SWIS electricity demand growth necessitating significant new capacity by 2032[1], as indicated by AEMO's 2023 Electricity Statement of Opportunities process and EPWA's SWIS Demand Assessment. Additionally, changes in small customer consumption patterns resulting from continued growth in air-conditioning demand and the uptake of electric vehicles, are forecast to require significant and costly upgrades to the distribution network. Given these factors, cleaner energy sources, including DER, are required to assume a greater role in the power system to support growing demand and alleviate stress on the network, while also responding to the increasing sentiment from customers to decarbonise.

It is well-documented that high ratios of 'passive' or unmanaged DER can have both systemic and local impacts on power quality and reliability, particularly as electricity networks and systems for managing the power system were originally designed and built for one-way power flow. The impacts of increasing levels of unmanaged reverse power flow are exacerbated on large, isolated networks like the SWIS, where system operators must independently and instantaneously balance generation and demand at any given moment to maintain stability.

In 2019, resulting from DER growth in WA, the Energy Transformation Task-force was established by the State Government to develop an Energy Transformation Strategy (The Strategy). The Task-force provides oversight of the initiatives identified in the Strategy to manage the uptake of DER and Large-scale renewable generation. Following the publication of the Strategy, the Taskforce released the DER Roadmap (2019[2]), including subsequent updates (2022 and 2024[3]), which set out the actions required to improve the integration of DER into the SWIS and the WEM, unlock latent customer value, and progress the required policy and regulatory changes. In keeping with the Taskforce's vision, the central tenet of the DER Roadmap is:

A future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

[1] AEMO, 2023 Electricity Statement of Opportunities: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf
[2] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf
[3] Energy Policy WA, Distributed Energy Resources Roadmap Two-year Progress Report: https://www.wa.gov.au/system/files/2022-06/Distributed-Energy-Resources-Roadmap_second-year-update-WEB.pdf

Project Symphony

Our energy future

As part of the DER Roadmap, Project Symphony (Symphony) a $36 million pilot was established as the State's flagship DER initiative in 2021 to identify and implement ways address the opportunities and challenges that come with the increasing and sustained proliferation of DER in the SWIS.

Symphony was established under a joint agreement framework including Western Power, Synergy, AEMO and EPWA as project partners. The Australian Government also provided a funding contribution of $8 million through the Australian Renewable Energy Agency (ARENA) Advancing Renewables Program.

Western Power was the lead organisation accountable for overseeing the delivery of Symphony in accordance with the Funding Agreement executed with ARENA as part of the Advancing Renewables Program. Western Power established the Program Management Office (PMO) to oversee the delivery of the project, including the reporting requirements and knowledge sharing deliverables.

Through the recruitment of more than 500 residential electricity customers and their ~900 DER assets, Project Symphony tested a new model for Western Australia's energy future. Fundamentally, the project sought to define this model by answering one question:

What are the costs and benefits of having customer owned DER participate in the WEM while also providing other essential services to the electricity system and the distribution network?

To address this question, Symphony aggregated predominantly customer-owned DER – rooftop solar, battery energy storage and major smart appliances – into a Virtual Power Plant (VPP). These assets were orchestrated to participate in the energy system under several key scenarios, which tested the ability of DER to address the challenges associated with managing the 'peaks and troughs' of electricity demand at both the system and local levels.

Symphony contributes to the ongoing implementation of the WA Government's Energy Transformation Strategy and State decarbonisation objectives while realising additional value for DER owners.

Delivery Approach

As part of the Funding Agreement, various technical, customer participation and value objectives were established. The insights gained from achieving these objectives would inform the development of the necessary policy and regulatory changes required to enable the proliferation and scale of DER participation beyond Symphony should the overall benefits be found to outweigh the costs.

To achieve the objectives, four 'must-have' scenarios were defined, in which aggregated consumer DER[4] would participate, to be rigorously tested through Symphony:

1. ***Bi-Directional Energy – Balancing Market***: participation in the WEM's Balancing Market[5] which determines economic (most economically efficient) dispatch of generation to meet system demand as managed by AEMO.
2. ***Network Support Services (NSS)***: a contracted service provided to help manage network constraints – help manage distribution level peak demand and/or voltage issues as identified by the Distribution System Operator (DSO).[6]
3. ***Constrain to Zero (CTZ)***: the AEMO platform instructs the aggregator platform to constrain energy output from DER to zero export (net) or zero output (gross). This could be offered as a market or retailer service.
4. ***Essential System Service (ESS)***: Contingency Raise. DER response to help restore a deviation in frequency to normal levels (due to loss of a large generator).

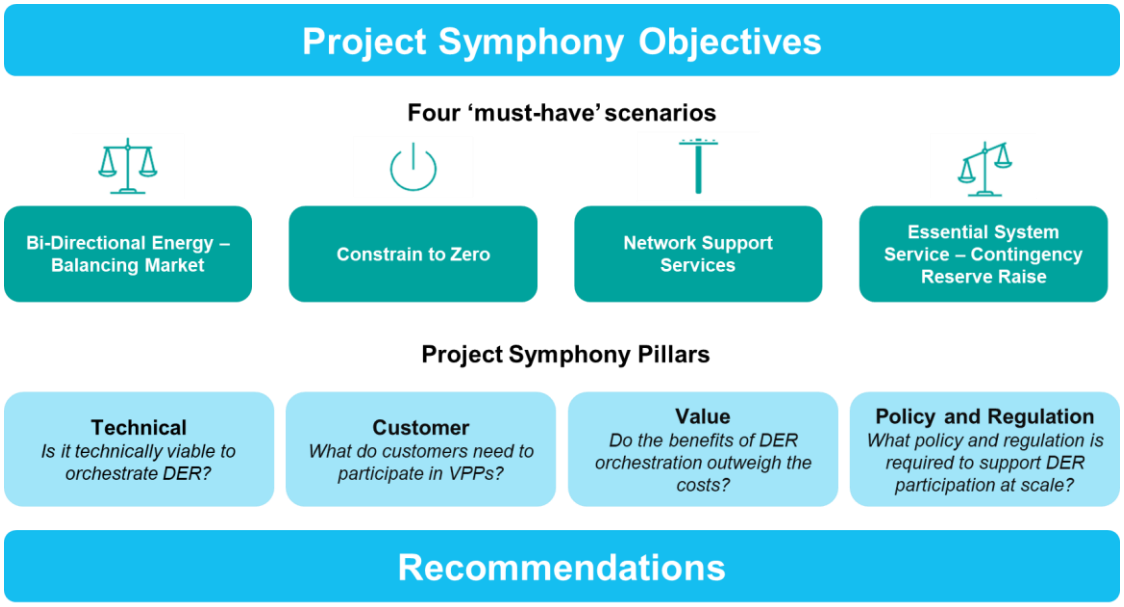


Figure 1: Project Symphony objectives

[4] Also known as Customer Energy Resources or CER.
[5] As part of the wholesale market reforms implemented under the Energy Transformation Strategy, the WEM's Balancing Market was replaced by the Real Time Market on 1 October 2023. This market includes a range of improvements, such as 5-minute dispatch, which will further reward fast-responding facilities such as customers' aggregated storage.
[6] NSS in the SWIS are contracted by Western Power and AEMO through the Non-Cooptimised Essential System Services (NCESS) framework.

Delivering on the objectives required definition and testing of the necessary evolution of the current roles and responsibilities of each of the project partners. As such, Project Symphony established and tested a version of the "Hybrid Model" developed in the Open Energy Networks (OpEN) project and outlined in the WA Government's DER Roadmap[7]. This approach evolves the current responsibilities of the existing network operator (Western Power), existing retailer (Synergy) and the power system and market operator (AEMO) to deliver the required functions to enable DER orchestration in the SWIS, as shown in Figure 2.

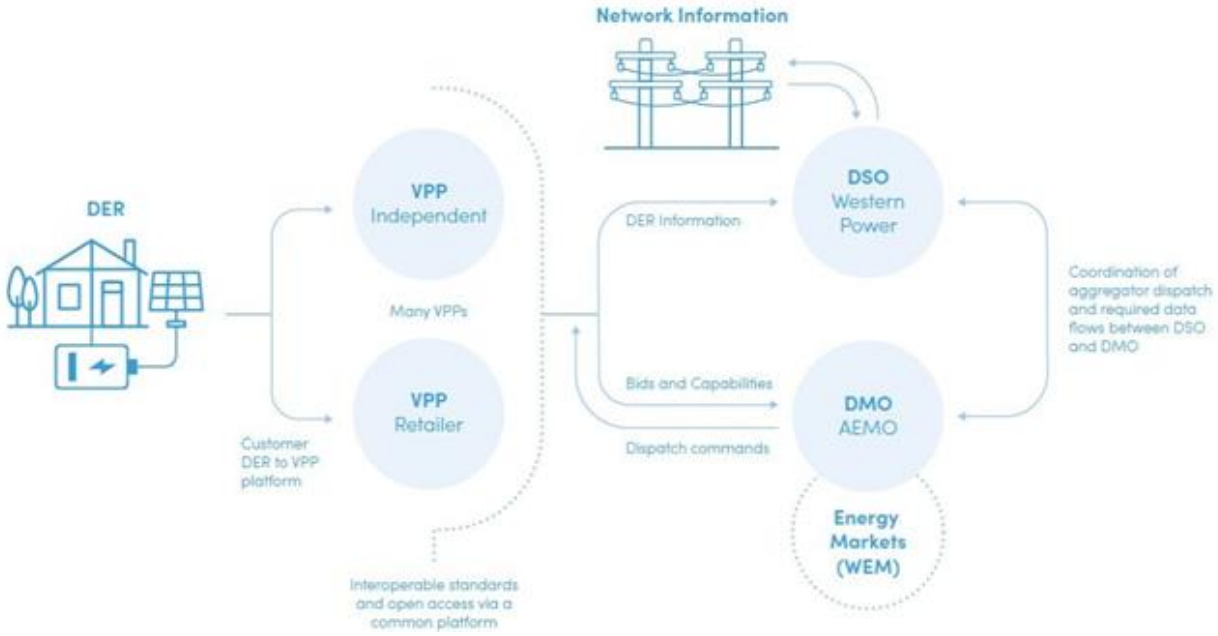


Figure 2: Project Symphony OpEN hybrid model

Project Symphony partners were required to fulfill three key roles as part of the Pilot.

Figure 3: DER orchestration roles

The roles of Third-Party Aggregators (TPAs) were also piloted to consider an alternative method to recruit customers and their DER into the VPP tested by Symphony, allowing TPAs to enter the market via contracts with Synergy.

[7] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf

Technical Outcomes

The technical pillar for Project Symphony focused on understanding the technical feasibility or viability (as two distinct measures) of having DER participate in the four 'must-have' scenarios. This included each of the project participants procuring, designing, building, and implementing their respective software-based platforms[8] before integrating and testing them together as a single end-to-end solution.

While establishment and integration of the platforms was largely successful, it was not without significant challenges. This ultimately contributed to a six month delay in performance testing for the VPP. In procuring platforms for each of the project partners, it was found that mature, off-the-shelf solutions were not available to meet the requirements of Symphony. This resulted in the need for platform customisation through co-development of solutions with vendors and multiple vendors being required to develop single platforms. Ultimately, a single and jointly agreed design of the end-to-end technical solution, including both functional and non-functional requirements, would have avoided some of the design and development errors and oversights experienced by partners. Critical to evaluating the performance of aggregated DER as a facility was the development, implementation, and testing of:

- Dynamic Operating Envelopes (DOEs)[9] by the DSO as the near real-time parameters within which DER can safely participate during any given five-minute interval.
- Dispatch Instructions (DIs) by the DMO as the required amount of energy to be injected or withdrawn by the facility (aggregated DER) during any given five-minute market interval.

Symphony included the design and execution of hundreds of test cases aligned with each of the four scenarios, culminating in the most intensive testing being conducted during a 90-day stability-period (April to June 2023). Maintenance of the stability period required that no new functionality was to be introduced and no critical defects were to be observed.

Once the challenging task of designing, installing, commissioning, and registering individual customer DER assets within the Parent Aggregator's platform was largely complete (also see customer outcomes and lessons), testing of each of the scenarios resulted in a number of lessons learned:

1. **Bi-Directional Energy – Balancing Market**
    - After initial issues were overcome with how price signals would be used to determine how customer DER would be orchestrated, testing showed successful control of the VPP particularly when price was below -$100 per megawatt hour (MWh) and when the price was positive.
    - DOEs were successfully calculated and published, however, compliance with them was inconsistent and achieved approximately 50% of the time.
    - Aggregator platform capability was limited to responding to pre-dispatch instructions, only providing for a period of computation ahead of the delivery of energy. Dispatch instructions were inconsistently met, with under-delivery of energy being the most common cause. This indicates that further focused development is required for National Metering Identifier (NMI) level aggregator forecasting and optimisation capability.

[8] Aggregator Platform – Synergy; DMO Platform – AEMO; and DSO Platform – Western Power.
[9] DOEs set the limits for exporting and importing to and from the network at a customer's connection point. They are dynamic in that they may be changed depending on prevailing conditions to enable efficient utilisation of the network.

2. **Network Support Services (NSS)**
    - Battery energy storage was utilised to provide a firm and flexible NSS outside of the 90-day stability period. During this time, +90% compliance with NSS contractual requirements was achieved. While encouraging, larger capacity and longer duration should be tested to better represent NSS requirements at times of peak demand.
    - NSS was unable to be tested during the summer peak period utilising load control of major appliances, particularly air conditioning as the main contributor to peak electricity demand. This was partly due to delays in delivering the required technical solution/s.
3. **Constrain to Zero (CTZ)**
    - The capabilities of the VPP in constraining customer rooftop solar to both net and gross zero was successfully tested, with compliance consistently between 86% to 98%.
    - Compliance with DOEs also improved for the CTZ tests achieving approximately 66% compliance.
4. **Essential System Service (ESS) – Contingency Raise**
    - The pilot explored the potential for customer and network-located batteries to be utilised to provide Contingency Reserve Raise frequency control and Essential System Service, with testing cycles being conducted under both simulated and real-world conditions.
    - Compliance with existing Contingency Raise requirements was identified as a major challenge for DER, requiring high-cost and high-speed measurement equipment. Lower-resolution measurement was introduced with testing identifying inconsistent responses from customer batteries.
    - Overall, the technical feasibility for Contingency Raise was observed, requiring further demonstration to confirm consistent delivery, measurement and compliance.
5. **Full Value Stacking**
    - Testing demonstrated the use of a VPP in interacting with the simulated market via a dispatch profile containing bids for energy, Contingency Reserve Raise and NSS.
    - Further testing also beyond the stability period demonstrated ongoing improvement in compliance with dispatch instructions as well as optimising delivery across all three services.

Overall, Symphony clearly demonstrated that it is technically feasible to aggregate and orchestrate DER to participate in each of the four test scenarios, with evidence to suggest technical viability can be achieved with further testing and optimisation. Indeed, the path to technical viability rests mostly with the Parent Aggregator's capability to optimise and orchestrate DER within defined parameters. Achieving improved compliance rates with Dynamic Operating Envelopes and Dispatch Instructions will be critical for the successful delivery of services in the future. Increasing the capacity and its duration, will also be required when it comes to providing a Network Support Service to reduce local peak demand.

Customer Outcomes

Customer participation is critical to the success of DER orchestration within VPPs. Without understanding and responding to the needs of customers as they register their DER assets, the potential value of DER orchestration in aggregate will remain inaccessible or unrealised, regardless of any achievement in technical feasibility or viability.

The customer pillar within Symphony sought to understand residential customer preferences regarding DER orchestration. This included the customer's willingness to engage, the level of engagement required to recruit the customer while providing a sustainable service, and the overall customer value proposition as a means of understanding what will be required to achieve mass participation in VPPs.

To test this, Symphony piloted the role of the retailer[10] (Synergy) as the Parent Aggregator in providing DER products and services to facilitate customer involvement. Symphony targeted recruitment of approximately 500 customers, including a large contestable commercial customer, and a suitable mix of 900 DER assets including rooftop solar, battery energy storage and major appliances (air conditioners and hot water systems) to be orchestrated as part of a VPP.

From a customer journey perspective, this required the Parent Aggregator to design and implement targeted engagement and recruitment campaigns to sign up customers to the Pilot. TPA's[11] were also contracted to assist in recruitment efforts and to test the ability for multiple parties to aggregate across the non-contestable retail market, adding additional assets to the program. Regulatory arrangements in the WEM require aggregators to be registered to access market value streams and testing was targeted towards understanding how this pathway could be enabled.

Customer recruitment was followed by a process of customer onboarding, as well as the installation of new, incentivised DER assets. Other DER required orchestration technology such as gateway devices, and high-speed data recorders.

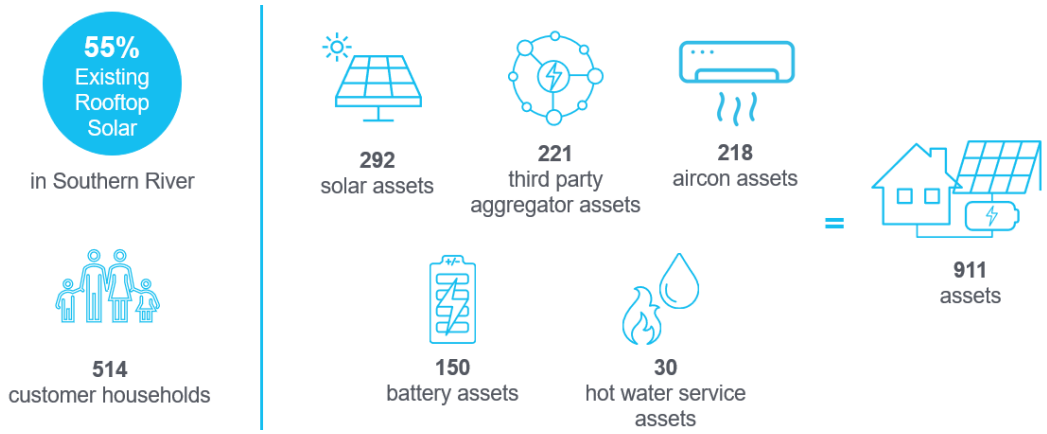


Figure 4: Breakdown of DER assets

[10] The monopoly retailer for non-contestable customers within the SWIS.

[11] WA Government Ministerial Announcement, Accord Struck in Project Symphony's Development: https://www.wa.gov.au/government/media-statements/McGowan-Labor-Government/Accord-struck-in-Project-Symphony's-development-20220927

As illustrated in Figure 4 above, the target for the total number of customers and their DER assets was met. This was a significant achievement given the extensive requirements for recruiting customers and their DER. These include:

- Ensuring a statistically relevant mix of DER assets to enable high levels of confidence that results would be repeatable in other locations and/or at a greater scale.
- Acknowledging the size, type, location, and geographic concentration of DER (generation and/or load), which are critical factors for the success of providing a Network Support Service. This involves achieving a sufficient reduction of demand at relevant distribution feeder or substation levels during peak times to defer costly augmentation, such as the construction of additional 'poles and wires' or larger capacity transformers, by at least one year.
- The recruitment of a minimum of two TPAs, including integration of their customer DER orchestration solutions with the Parent Aggregator platform.

Symphony was ambitious and unprecedented in terms of its scale, breadth, and end-to-end testing of DMO, DSO, and aggregator platforms in the context of a simulated market. Consistent with the novel nature of Symphony, not all goals could be met within the timeframe of the pilot, mainly resulting from not all recruited DER being available for testing during the 'stability period'. This ultimately contributed to Symphony achieving 'technical feasibility', as opposed to 'technical viability' of the developed solution.

To understand customer preferences and responses when it comes to DER orchestration, the University of Tasmania (UTAS) was engaged to conduct a multi method longitudinal study with Symphony participants. The key themes and findings of the study included that:

- Participants were largely unaware of what they were signing up for at the commencement of the project.
- The use of technical terms, such as 'orchestration' lacked explicit meaning for customers, hindering their initial understanding of the project.
- Participants desired clearer, graphical, and more timely information regarding how their assets were being orchestrated – particularly with regards to the impact of 'orchestration' on their assets or household energy use.
- A clearer value statement from participating in VPPs at the outset would have assisted in setting clearer expectations for customer.
- Challenges with installation and retrofitting of devices and assets through multiple site visits, including troubleshooting, were time consuming and detracted from customer experience.

While the above impacted customer satisfaction, particularly in the early phases of Symphony, Synergy as Parent Aggregator responded over time to better meet customer needs, particularly relating to providing more timely information on DER orchestration. This iterative approach saw customer satisfaction improve materially towards the end of the pilot.

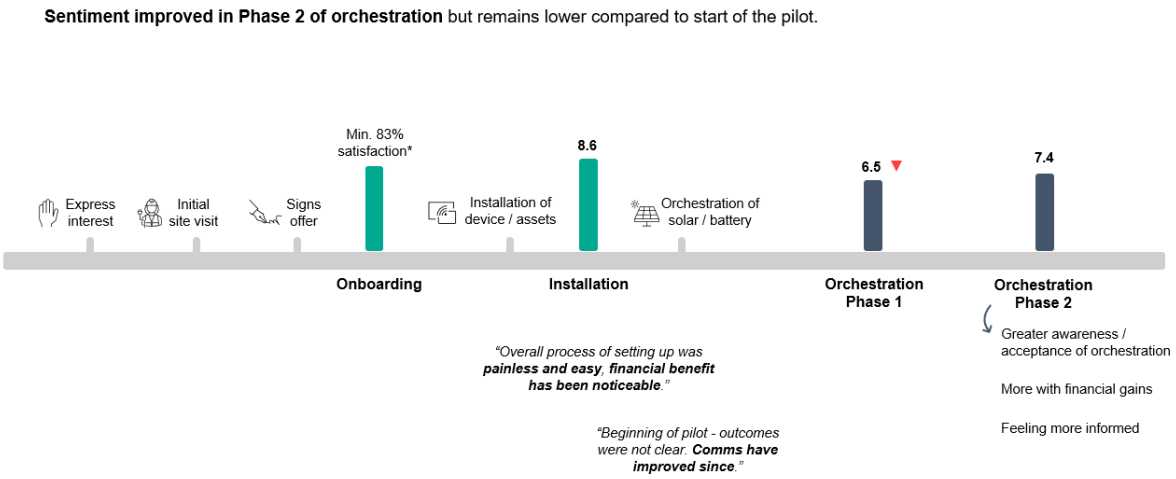


Figure 5: Customer sentiment

The refrain of 'simple, timely, trusted and valuable' being central to customer needs, as demonstrated through the work of UTAS, it remains challenging to achieve in practice. The lessons learned throughout the pilot and solutions developed by the aggregator should be central to engagement and recruitment strategies in support of future VPPs.

Value Outcomes

With customer participation and technical feasibility achieved as part of Symphony, the pilot was able to consider the financial costs and benefits of DER orchestration in the WEM and SWIS by extrapolating its results over a 10-year period. The resultant Cost Benefit Analysis (CBA) prepared by Ernst & Young (EY) quantitatively assessed the costs and benefits of each participant in the Pilot: customers, Aggregator/s, Western Power as DSO and AEMO as DMO in relation, and limited, to the available DER orchestrated and the four 'must-have' scenarios. Further, the CBA considered barriers to equitable distribution of value and provided high level recommendations for achieving the conditions under which VPPs could scale in the SWIS.

Limitations naturally exist in CBA modelling such as the dependency on how Symphony was rolled out (being the first time such end-to-end orchestration of assets had been attempted), the higher costs incurred in a pilot and development environment when compared with mature products and technology, and necessarily conservative assumptions used regarding future market constructs. However, the modelling showed that the combined cashflows for the DSO, DMO, aggregators, and customers still increased year on year, delivering a combined positive NPV of $450 million over 10-years in the 'Expected Growth' scenario (mid), with the NPV ranging from $280 million in the 'Limited Pilot' scenario (low) to $920 million in the 'Hyper Growth' scenario (high).

The analysis demonstrates that substantial value can be created from DER orchestration in the SWIS. This suggests that implementing enabling actions or recommendations and creating conditions for DER aggregation over the short to medium-term is in the long-term interests of customers. Additionally, sensitivity analysis around issues such as the cost of development and implementation suggest that the benefits of DER aggregation are likely to grow materially as technology, systems, processes, and underpinning policy and regulation matures.

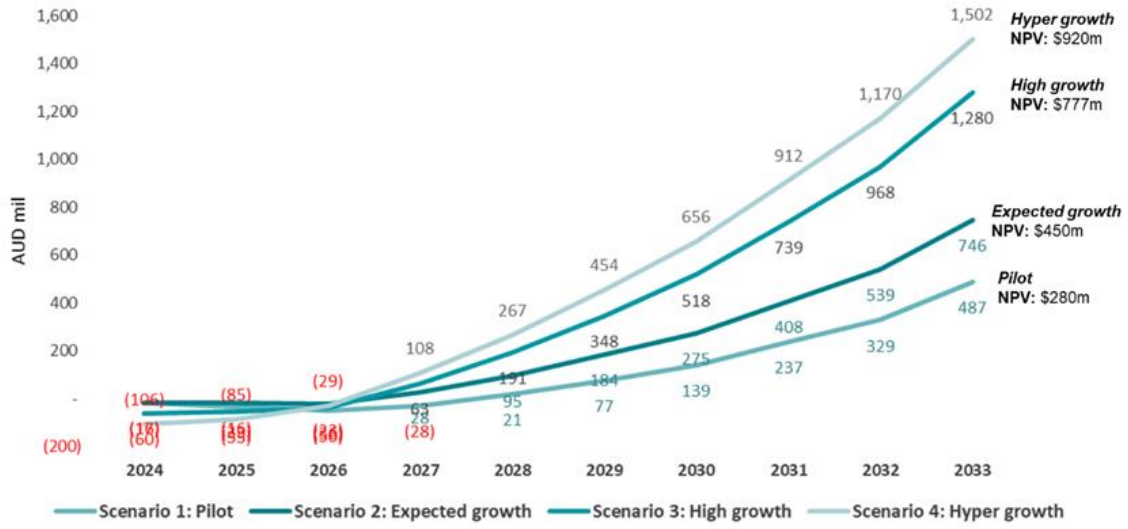


Figure 6: Combined undiscounted yearly cashflows for the Fully Orchestrated scenario.

Over and above the positive NPV achieved under the modelled scenarios, the most noteworthy outcomes of the CBA include:

- A net positive value across all participants can only be achieved when value stacking both network and market services, indicating the need for optimisation or sophistication in the participation of aggregated DER.
- The distribution of value across participants is sensitive to the costs associated with developing and maintaining DER orchestration and aggregator capabilities; however, significant upside potential can be realised as technology costs reduce, business capabilities mature, and customer engagement approaches become more commercially focused.
- The greater the number of customer DER assets that are recruited into a VPP, the greater the value generated per customer and the higher the opportunity to share benefits across all participants.
- Orchestrating DER through aggregation via a VPP can substantially reduce system costs and helps alleviate local network constraints, ultimately allowing a reduction in costs to be passed through to market participants and end-use customers.
- Further work is required to develop the commerciality of a VPP to equitably pass through the financial benefits of DER orchestration across participants and actors within a VPP while not passing-through additional costs to customers in the SWIS that do not own DER or elect not to participate in a VPP.
- The way in which payment for NSS and CTZ is provided requires further work to ensure it is priced to provide sufficient incentive for aggregators to invest in providing the service, whilst maintaining an acceptable distribution of benefits.
- Battery storage within a VPP can access multiple revenue streams from the market and non-market services, in contrast to other DER assets. Further value could be derived in VPPs by prioritising the recruitment of battery storage over other types of DER.

Policy and Regulation Outcomes

With Symphony having largely delivered on its objectives across the pillars of technical, customer and value, it was able to identify and inform some of the policy and regulatory changes required to enable DER orchestration as part of VPPs to continue its trajectory to scale.

Unique to Symphony and a key strength in its oversight and implementation was the purposeful and unflagging participation of EPWA at both a governance level as Chair of the Project Symphony Steering Committee and as imbedded subject matter experts as part of the broader project delivery team.

Further, while the progress, lessons and outcomes of Symphony have and will further inform the required regulatory and policy changes, parallel streams of work led by EPWA have brought greater clarity under the DER Roadmap and Energy Transformation Strategy.

These include defining DER orchestration roles and responsibilities in the WEM (see *DER Roles and Responsibilities Information Paper*[12]*)* and complimentary changes to the governance of the WA energy sector via the Electricity Industry (Distributed Energy Resources) Amendment Bill 2023[13] which together continue to provide for a well-coordinated and orderly transition to a high DER future in WA.

Project Symphony creates the basis for specific and deliberate regulatory and market reforms to enable the potential value of aggregated DER to be realised both in terms of supporting the efficient operation of the power system and providing benefit to customers.

Key policy and regulatory outcomes from Project Symphony include recommendations to:

- Further progress policy and WEM Rule development to establish market frameworks that support the participation of aggregated DER in the WEM.
- Support VPP visibility for the DMO and DSO, through implementing amendments to the WEM Rules.
- Establish policy positions and frameworks to appropriately incentivise aggregators to participate and ensure fair value is passed through to the customer.
- Review and reform end to end DER installation, connection, commissioning, monitoring, and compliance processes and associated underpinning regulatory framework.
- Develop incentives to accelerate the take-up of energy storage, bringing forward power system and decarbonisation benefits.

[12] Energy Policy WA Distributed Energy Resources (DER) Roadmap: DER Orchestration Roles and Responsibilities Information Paper: https://www.wa.gov.au/government/publications/distributed-energy-resources-der-roadmap-der-orchestration-roles-and-responsibilities-information-paper

[13] The Electricity Industry (Distributed Energy Resources) Amendment Bill 2023 was passed by the WA Legislative Assembly in October 2023. It is expected to pass the Legislative Council and become law in the first half of 2024.

Recommendations

Having delivered an ambitious program of work over the last two and a half years, including capturing key lessons and recommendations from each of the work packages along the way, the project participants collaboratively developed an overall set of recommendations in the form of actions that could pragmatically be delivered over the next one to three years, as the next critical steps in accomplishing greater DER participation as part of VPPs in WA.

Each recommended action (Table 1) is categorised into the pilot's objective areas, or pillars: Technical, Customer, Value and Policy & Regulation, and defined within two tiers:

- ***Tier 1:*** critically important actions, without which, an efficient pathway to operating VPPs at scale in the SWIS is likely to be unobtainable.
- ***Tier 2:*** enablers which will significantly ease constraints or barriers along the way.

Through the DER Roadmap, Symphony was intended to provide foundational insights to policy, regulation and technical implementation. Subsequently, where any recommendation is new or unique, it should also be considered for addition to an amended version of the DER Roadmap, with timing prioritisation, and allocation of their implementation governed by the DER Roadmap Coordination Committee (DERRCC), and further stakeholder consultation led by EPWA.

Project Symphony
Our energy future

Recommendation Overview	Tier 1 Recommendations: Critical enablers	Tier 2 Recommendations: Enablers
1. Technical Focused on simplifying and maturing the technology to operate VPP including platform build, integration, data etc.	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 DER data exchange between the DMO, DSO and Aggregators. 1.3 Develop specifications around Parent Aggregator service delivery standards to accelerate compliance with service delivery standards in the WEM.	1.4 Explore opportunities to establish platform and communication solutions, such as AMI, to lower risk and achieve greater efficiencies. 1.5 Establish a 'DER Test Lab' accessible by DSO, Aggregators and DMO to prototype and test DER integration products and solutions prior to rollout.
2. Customer Focused on improving all elements related to achieving customer 'buy-in'	2.1 Create simple, transparent, accurate and timely 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.	2.3 Establish a SWIS-wide customer engagement strategy and plan to achieve a consistent and cohesive approach to improve general customer awareness of VPPs.
3. Value (New Market Energy) Focused on creation / facilitation of all types of value from DER orchestration	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.	3.3 Quantify the actual value of DER asset participation for non-contestable customers (>12 months data and without pilot costs) to better inform value streams and the distribution of value between DER owners and the aggregator(s). 3.4 Establish clear frameworks to enable TPAs to engage with the Parent Aggregator for non-contestable customers, to reduce barriers to entry and ensure consistent customer experience.
4. Policy and Regulation Focused on changing / implementing regulation or policy settings to enable DER orchestration	4.1 Support VPP visibility for the DMO and DSO, through implementing amendments to the WEM rules. 4.2 Establish policy positions that appropriately incentivise aggregators to participate, and ensure value is passed through to the customer. 4.3 Review and reform end-to-end DER installation, connection, commissioning, and compliance.	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 Standards by OEMs to enable greater interoperability of air conditioners for load management by aggregators. 4.6 Introduce dynamic network connections to enable the flexible connection of DER onto Western Power's network to improve customer choice whilst contributing to decarbonisation.

Table 1: Summary of recommendations

Summary Conclusion

Over the past two and a half years Western Power, AEMO, Synergy and EPWA have successfully delivered an ambitious program of work that saw existing and new customer DER successfully participate in four different ways within a simulated energy market while also providing a support service to the distribution network.

Comprehensive lessons and knowledge have been gained and shared from building, operating, and evaluating the technical solutions, while going a long way to understanding customer preferences and quantifying the benefits from orchestrating customer owned DER assets.

Through Symphony and its 18 actionable recommendations, WA has taken a significant stride towards realising 'a future where DER is integral to a safe, reliable, and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers'[14], while also making a material and enduring contribution to decarbonisation of the electricity sector.

Building on the achievements of Symphony is now the opportunity in front of us. Critical to our ongoing success will be our collective ability to place the electricity customer at the centre of our ambition, retain and strengthen our capability, while remaining committed to the vision of DER participation and continuing to build trust through close collaboration.

How to use this document

This document is recommendations-led. While highlighting the progress and outcomes of Symphony against its objectives, its core focus is on the 18 recommendations as actionable next steps to be prioritised and implemented as the essential for enabling DER participation to gather pace in the WEM and SWIS towards scaled application. The Recommendations have been informed by progress and lessons across four main pillars: Technical (section 5), Customer (section 6), Value (section 7) and Policy and Regulation (section 8).

Each recommendation is evidence based, being informed by documented results and information derived from the Work Packages (see Appendix B) delivered as part of the Funding Agreement with ARENA. Each Work Package provides detailed information across each area of Symphony, accessible on ARENAs website. For the purposes of this report a summary of each work package is provided in Appendix D.

The energy transition environment is relatively fast and dynamic, and this is reflected in the new, emerging and changing terms and definitions used as part of building a new language in support of establishing new capability, such as 'DER orchestration'. At the time of writing this document we have attempted to use the most current and common terms in use; however, they remain dynamic and subject to change. Additionally, some terms in use in WA reflect differences in industry structure and system-wide focus on power system security and participation. An illustration of this is the use of 'DER' as the acronym for Distributed Energy Resources; however, there is a current trend towards renaming them as Consumer Energy Resources or CER to reflect the fact that VPP participation requires the integration of customer-owned energy assets. In the case of WA, the term DER has been retained, reflecting the potential contribution of distributed network-based assets (such as 'community batteries') to meeting the needs of the power system, as well as the complex back-end infrastructure required for the DSO, DMO, and aggregators to facilitate the participation of DER.

[14] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf

4. Project Overview

4.1. The case for Project Symphony

In WA, the energy transition is progressing at pace, being driven by customer adoption of new technologies, and government policy. This transformation is being enabled by key actors in the Wholesale Electricity Market (WEM) value chain in the SWIS: Western Power, Synergy, the Australian Energy Market Operator (AEMO) and the WA State Government through Energy Policy WA (EPWA).

WA has some of the highest levels of Distributed Energy Resources (DER) globally, with 35% of homes having a rooftop solar system installed. WA is also experiencing an increase in the adoption of distributed battery energy storage, while actively preparing for the inevitable electrification of transport via the take up of electric vehicles (EVs) and associated charging equipment.

Broad macroeconomic and environmental factors are driving the transformation. With material demand growth in SWIS electricity demand has been forecast by AEMO in its 2023 Electricity Statement of Opportunities (ESOO) process and EPWA's SWIS Demand Assessment, indicating the need for significant new capacity by 2032[15]. Additionally, changes in customer consumption patterns resulting from continued growth in air-conditioning demand and the uptake of electric vehicles are forecast to require significant and costly upgrades to the distribution network. Given these factors, cleaner energy sources, including DER, will be required to play an increasing role in the power system, supporting growing demand and relieving stress on the network while being underpinned by growing customer sentiment to decarbonise[16].

With near perfect climatic conditions for the adoption of rooftop solar and other DERs, in addition to Government directives and incentives[17], WA continues to experience sustained growth in the adoption of DER, particularly in the SWIS, with total number of DER in Western Australia increasing by 22% from 2020 to 2022 alone.

As with previous years, AEMO's 2023 WEM ESOO[18] provides forecasts for DER uptake, forecasting a doubling of solar PV installations over the coming decade, in parallel with potentially major growth in residential batteries (estimate of 1,530% growth over the period of 2023 – 2032) and electric vehicle charging equipment (26,000% growth over 2023 – 2032).

Solar PV is now the single largest generator in the SWIS with installed capacity of 2,453MW (2,084MW residential and 369MW commercial) as of December 2023. With an expected average annual growth rate of 7.2%, residential solar PV is set to reach 4,189MW by 2033, and 848MW for commercial solar PV at an average annual growth rate of 10.4%[19].

[15] AEMO, 2023 Electricity Statement of Opportunities: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf
[16] The Australia Institute, Climate of the Nation 2022: https://australiainstitute.org.au/wp-content/uploads/2022/11/Climate-of-the-Nation-2022.pdf
[17] Energy Policy WA, Distributed Energy Buyback Schemes (DEBS): https://www.wa.gov.au/organisation/energy-policy-wa/energy-buyback-schemes#distributed-energy-buyback-scheme-debs
[18] AEMO, 2023 Electricity Statement of Opportunities: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf
[19] AEMO, 2023 Electricity Statement of Opportunities: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf

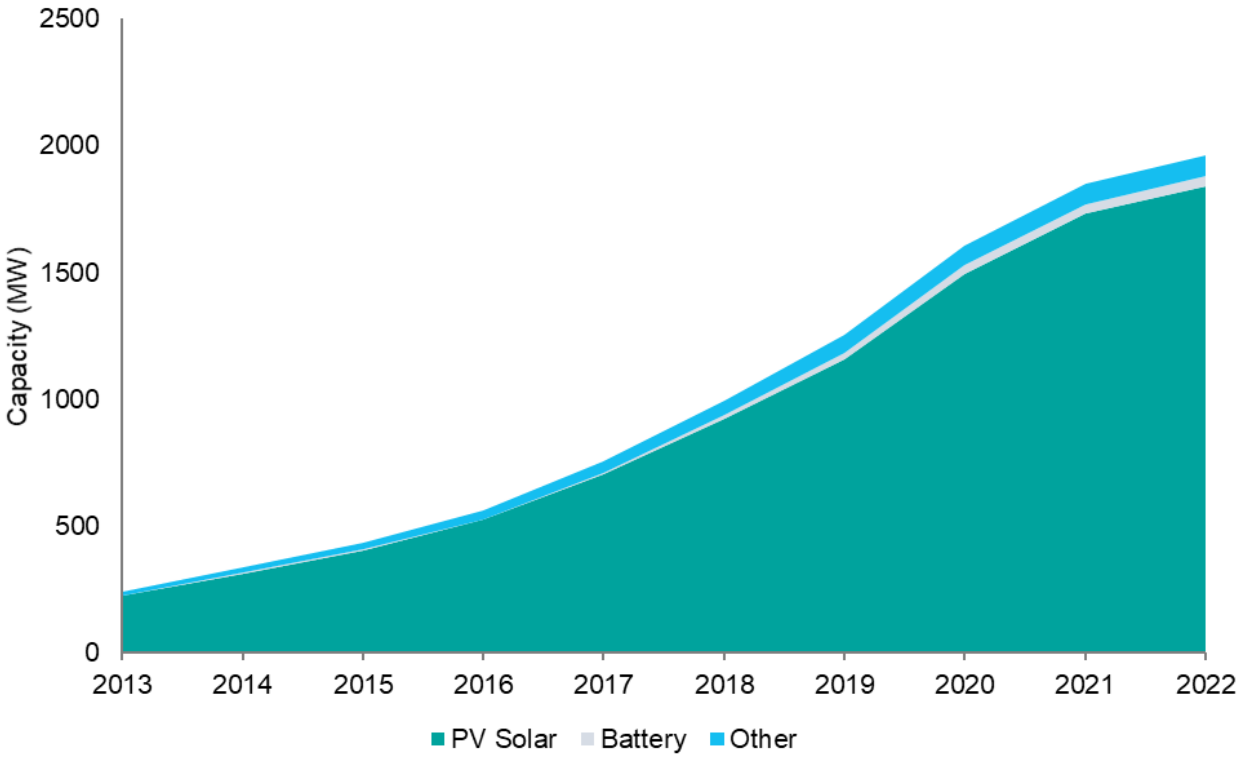


Figure 7: Growth of DER in WA[20]

It is well-documented that high ratios of passive or unmanaged DER can have both *systemic* and *local* impacts on power quality and reliability, particularly as electricity networks were designed and built for one-way power flow to meet demand. The impacts of increasing levels of unmanaged reverse power flow are further exacerbated on large, isolated networks such as the SWIS in which system operators must be self-reliant in balancing generation and demand at any given moment.

Whilst the growth in DER is encouraging and creates value in many ways, it also presents significant challenges. Increasing volumes of DER on the SWIS accentuates the 'peaks' and 'troughs' of the SWIS daily load profile, which represents the energy drawn from the grid by consumers. Over the past number of years, this profile has evolved to resemble what is now known as the 'duck curve'.

As seen in Figure 8, the uptake of, self-consumption and export of energy generated by DER, particularly solar PV, is leading to 'lower lows' of customer demand from the grid during the middle of the day, followed by a sharp increase in demand, particularly in summer as customers cool their homes, and solar PV generation decreases to zero as the sun sets.

[20] AEMO, 2023 Electricity Statement of Opportunities: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/2023-electricity-statement-of-opportunities.pdf

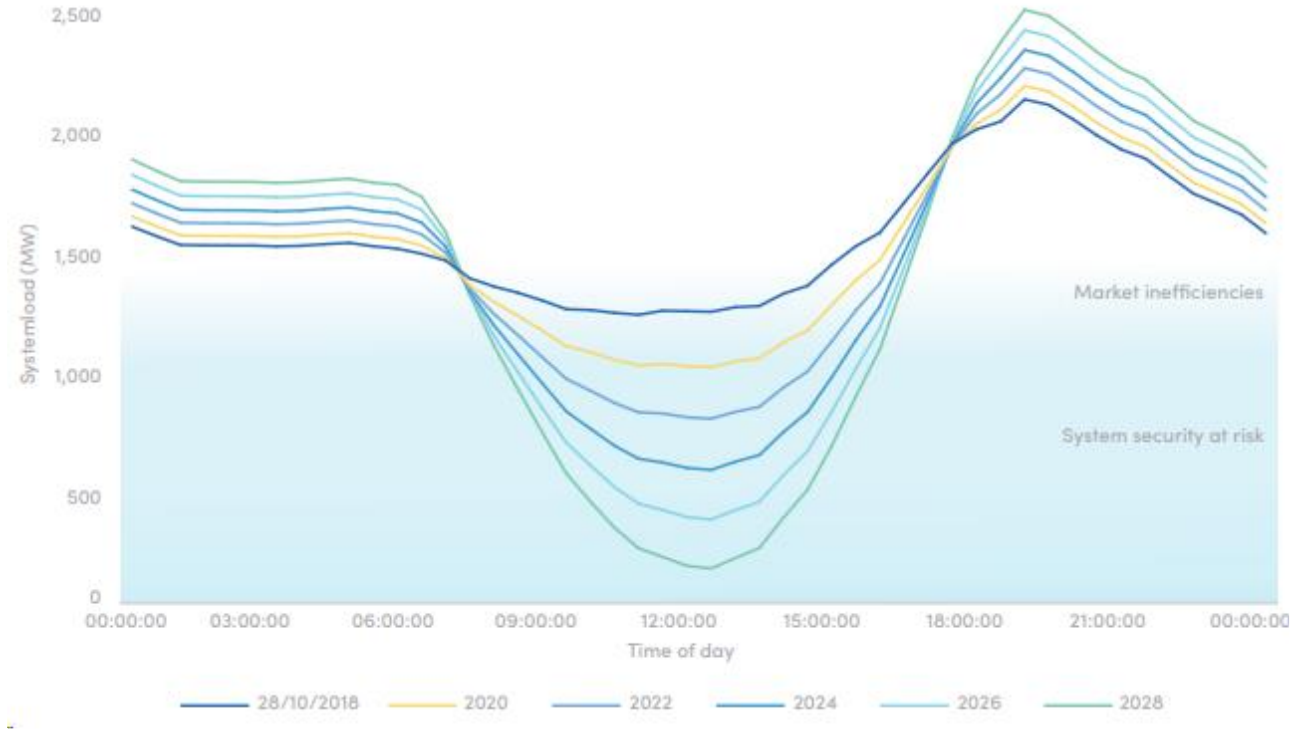


Figure 8: AEMO analysis on the shape of the load curve on the minimum demand days – the Duck Curve[21]

The trend of increasing variance between daily 'peak load' and 'low load' (as well as growth in their extremes) has the potential to cause various system and local stability and reliability issues. It also has ongoing economic implications for some of the key actors in the WEM, particularly Western Power and Synergy.

For Western Power, increases in peak demand directly increases the need for costly new infrastructure to be built, while at the same time customers' use of DER means the overall utilisation of that infrastructure is lower, reducing its efficiency and creating challenges for traditional methods of cost recovery. Whilst this is somewhat mitigated by fixed network charges for connecting to the network, as well as a regulatory regime in which a guaranteed rate of return on the regulated asset base is maintained, the economic opportunity presented by harnessing DER is one where the same or improved level of reliability can be achieved with less capital expenditure. This can have a positive effect on State Debt, with Western Power needing to borrow less from government to maintain its network[22]. For Synergy as the 'gentailer' the traditional business model has been fundamentally disrupted by DER.

As customers increasingly take up DER, particularly rooftop solar, their generation enables them to avoid paying the regulated A1 flat tariff resulting in less and less revenue to Synergy[23], while also being paid for their excess energy via feed in tariffs not necessarily reflective of its actual value to the energy system at the time of export.

[21] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf
[22] While costs are ultimately recovered from end-use customers, as a Government Trading Enterprise, Western Power's debt is funded through the WA Treasury Corporation, with flow-on effects for WA Government finances.
[23] Synergy Annual Report, 2022. The A1 flat tariff is available to all residential customers in the SWIS consuming less than 50MWh per year. The tariff is weighted towards the variable component, meaning that reductions in grid consumption resulting from DER use can impact Synergy's ability to efficiently recover costs.

Further, the very nature of the flat A1 tariff means residential customers pay the same cost for energy regardless of the time of use and avoid exposure to the relatively high cost of generating and transporting energy at times of peak demand. This may have the effect of over-incentivising some types of DER, such as rooftop solar (which mainly produces energy when network congestion and wholesale energy prices are low), while under-incentivising other types, such as energy storage (which could be used during periods of peak pricing and network congestion).

4.2. The commitment to a DER orchestration pilot

As a direct result of the challenges and opportunities that DER growth brings in WA, the Energy Transformation Taskforce was established by the WA Government in 2019 to develop an Energy Transformation Strategy (the Strategy) for the State, provide oversight of the initiatives identified in the Strategy and ensure that the benefits and challenges of DER uptake and large-scale renewable generation are appropriately managed. The Taskforce's tenure ended in mid-2021, with responsibility for progressing initiatives under the Energy Transformation Strategy being allocated to EPWA.

Following the publication of the Strategy, the Taskforce released the DER Roadmap (2019[24]), including subsequent updates (2021 and 2022)[25], which set out the actions required to improve the integration of DER into the SWIS and the WEM and progress the required policy and regulatory changes.

In keeping with the Taskforce's vision, the central tenet of the DER Roadmap is:

A future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

In practise, this translated to focused objectives where Technology Integration, Tariffs, DER Participation and Customer Protection and Engagement all act to achieve greater opportunities and benefits from DER participation. More specifically, the actions under the DER Roadmap are intended to produce a future where:

- Challenges associated with increasing adoption and uptake of DER have been resolved;
- DER are technically integrated, supported by regulatory and rule settings, to actively provide services to support the power system, with customers being rewarded for doing so;
- Tariff structures are adopted that incentivise efficient use of the system and customers with and without DER share in the benefit; and
- Customers are supported with clear and simple information to understand the changes and can select innovative products and services knowing customer protections are in place to support them, whilst the market is transitioning to a high-DER future.

[24] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf
[25] DER Roadmap one-year progress report and DER Roadmap two-year progress report. A third progress report is planned to be released in the first half of 2024.

To achieve the vision, the DER roadmap established four key themes, with 14 elements:

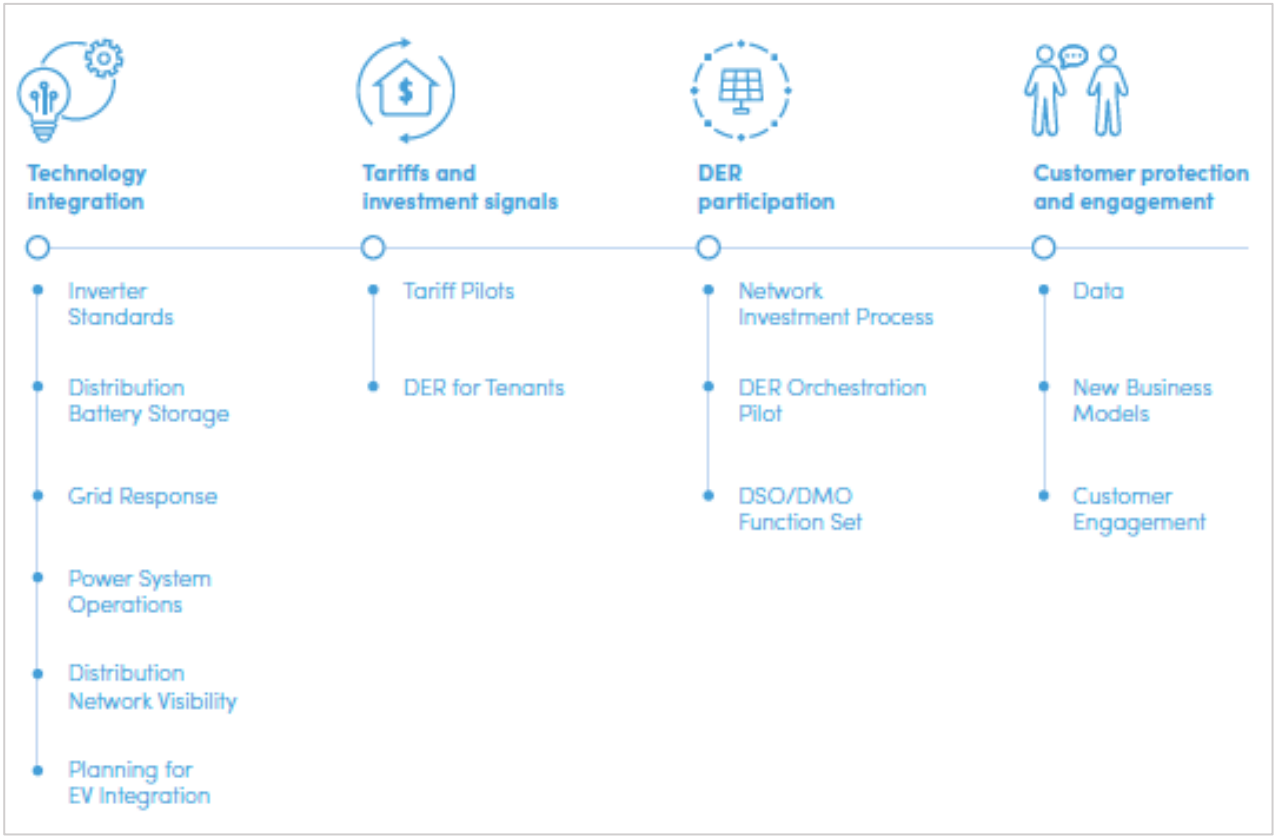


Figure 9: Distributed Energy Resources Roadmap

Under the DER Participation theme within the DER Roadmap, there was recognition of the value of conducting a **DER Orchestration Pilot** in the SWIS to demonstrate the benefits for customers, the state, significant actors in the WEM value chain, and the broader community. The DER Orchestration Pilot was further delineated into two key actions: Actions 22 and 23 – which split the pilot into first assessing the technical viability of DER orchestration, and then engagement and testing with customer via a market participation phase.

Figure 10: DER Roadmap pilot actions

As a result, Project Symphony, a budgeted $36 million pilot – involving Western Power, Synergy, AEMO, EPWA as project partners and with funding from ARENA's advancing renewables program – was established as the State's flagship DER initiative in 2021 to address the opportunities and challenges that come with the increasing and sustained proliferation of DER in the SWIS.

As a microcosm representing a future state in which DER actively and dynamically participates in the WEM, while also providing services in the SWIS, the outcomes of Symphony would inform the development and implementation of other actions outlined in the DER Roadmap see Figure 11.

Since its inception, two DER Roadmap progress reports[26][27] have been completed, providing general progress on actions and highlighting any changes or additions to DER Roadmap actions.

Further, during the delivery of Symphony additional work has been completed on defining and clarifying DER orchestration roles and responsibilities in the WEM (see *DER Roles and Responsibilities Information Paper*[28]*)*.

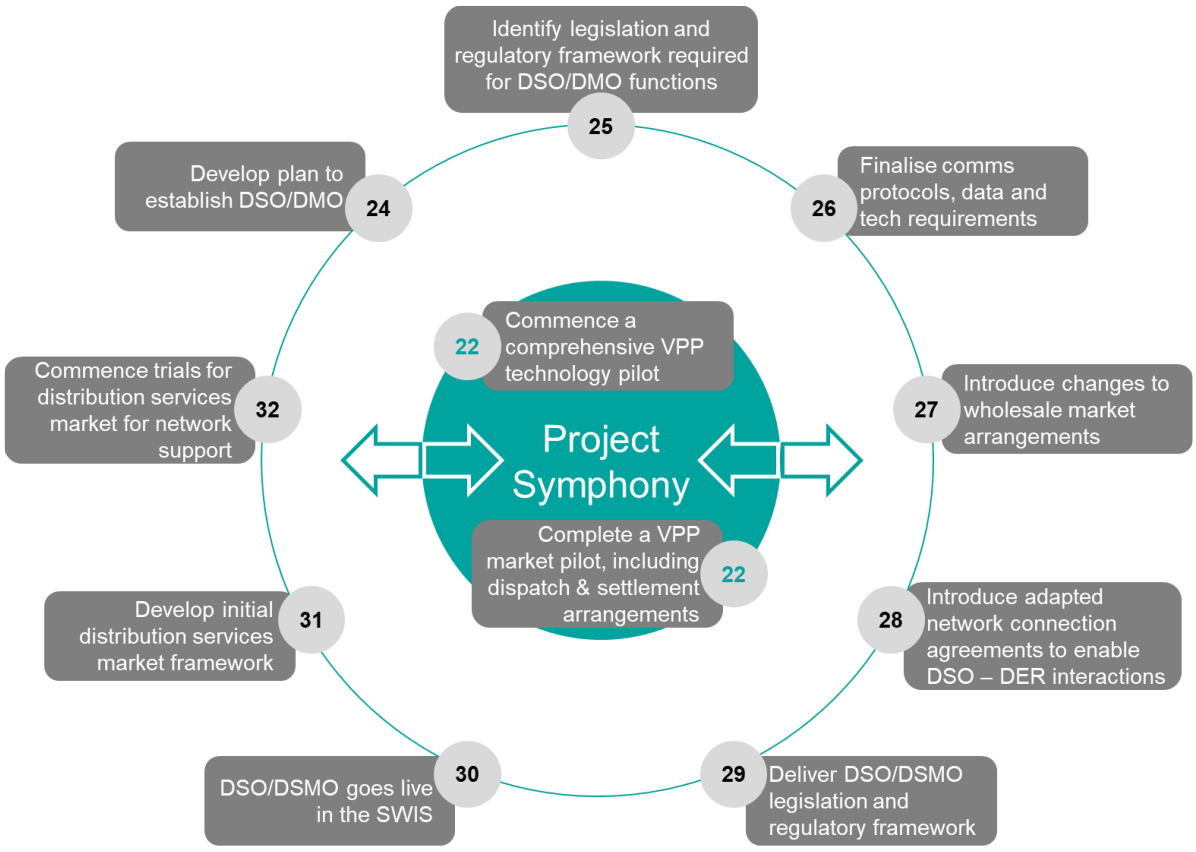


Figure 11: Project Symphony's direct and indirect links to other DER Roadmap actions.

[26] Energy Transformation Taskforce, DER Roadmap Progress Report: https://www.wa.gov.au/government/publications/distributed-energy-resources-roadmap-progress-report
[27] Energy Policy WA, Distributed Energy Resources Roadmap Two-year Progress Report: https://www.wa.gov.au/system/files/2022-06/Distributed-Energy-Resources-Roadmap_second-year-update-WEB.pdf
[28] Energy Policy WA, Distributed Energy Resources (DER) Roadmap: DER Orchestration Roles and Responsibilities Information Paper: https://www.wa.gov.au/government/publications/distributed-energy-resources-der-roadmap-der-orchestration-roles-and-responsibilities-information-paper

4.3. Symphony's Objectives and Approach

In July 2021, Western Power as lead agency signed the Project Symphony Funding Agreement with ARENA as part of the advancing renewables program. Western Power subsequently established back-to-back Joint Development Agreements (JDAs) with Synergy, AEMO and Energy Policy WA (EPWA).

Symphony was unique to previous DER pilots and trials in Australia, seeking to test a new end-to-end energy market, combining both new and existing DER assets orchestrated as one energy entity/facility within a VPP. It sought to value these services and to understand if these services allow for value stacking. Its primary focus was testing a new model for Western Australia's energy future. A model that could be defined by answering one fundamental question:

What are the costs and benefits of having customer owned DER participate in the WEM while also providing other essential services to the electricity system and the distribution network?

Figure 12 below was developed by the Symphony team to illustrate the concept of a VPP showing how customers and their aggregated assets could participate in future markets and services via the existing energy grid. Ultimately, a VPP is a collection of small-scale energy resources that, aggregated together and coordinated with grid operations, can provide the same kind of reliability and economic value to the grid as traditional power plants.

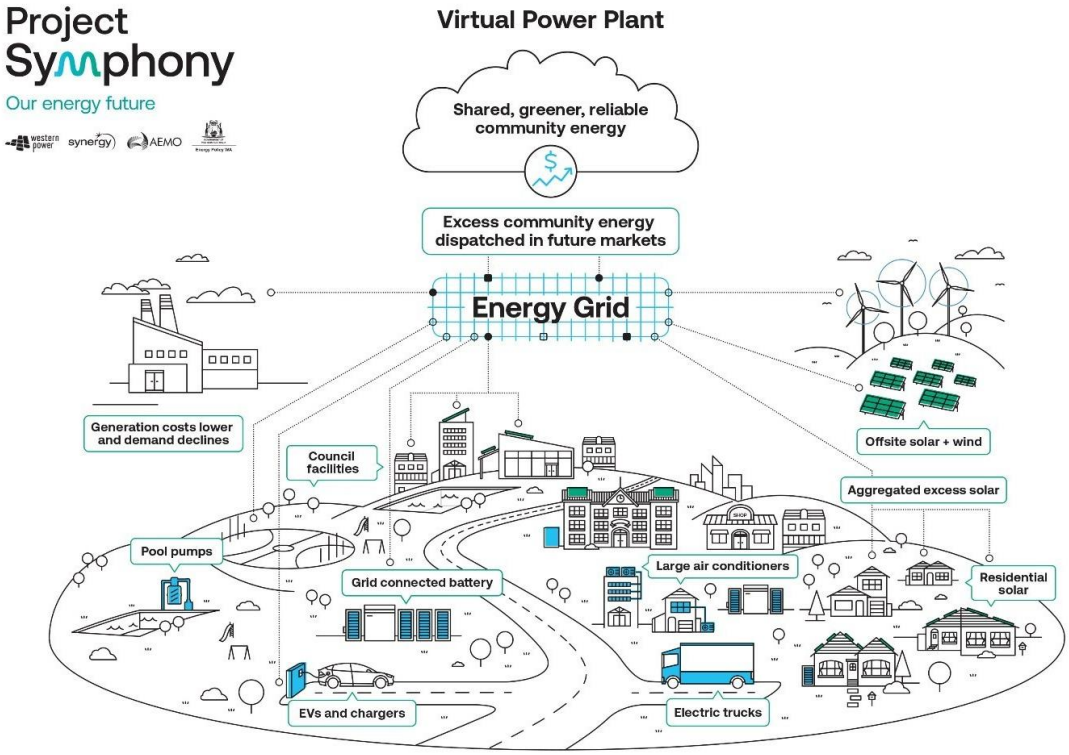


Figure 12: Representation of a Virtual Power Plant[29]

[29] AEMO, Project Symphony: https://aemo.com.au/initiatives/major-programs/wa-der-program/project-symphony

The Symphony team was structured to ensure that roles and responsibilities were well understood with clear decision making and escalation paths. A Steering Committee was established to govern the Project and included Western Power, Synergy, AEMO and Energy Policy WA as voting members. ARENA and the Principal Policy Adviser to the WA Minister for Energy attend as observers. The Steering Committee provided a mechanism to monitor and coordinate the delivery of Project Symphony and was responsible for providing the strategic guidance and decisions necessary to ensure that the Project met its intended objectives and timeframes.

To manage the overall delivery of the Project including the Knowledge Sharing, as the funding lead Western Power established a 'ring-fenced' Project Management Office (PMO) to oversee and coordinate delivery across all Project and research partners. The Core Project Team consisted of Product Owners, Project Managers, Solution Architects and respective subject matter experts from Western Power, Synergy, AEMO and Energy Policy WA. Several working groups were established to ensure effective coordination and collaboration between the different Project teams including:

- Communication Working Group
- Project Managers Working Group
- Finance Working Group
- Architecture Working Group
- Cross Partner Working Group
- Joint Design Working Group
- Technical Implementation Working Group
- Test and Learn Working Group
- Cyber Security Working Group

Led by the PMO, and after extensive partner collaboration a delivery approach was established whereby the objectives (Table 2) of the pilot were to be achieved through the testing of four 'must have' scenarios in which an aggregated mix of customer DER assets could participate. See the detail of Symphony's objectives in Table 2 on the following pages.

The scenarios were selected based on being 'deliverable' given the time and technical constraints, and 'valuable' in terms of their potential to access value streams in the near to mid-term via existing or planned market services as well as services to the distribution network.

Four 'pillars' or areas which are collectively essential to successful DER participation and aligned with the objectives of the pilot were established as Technical, Customer, Value and Policy & Regulation. The overall approach is illustrated in Figure 13.

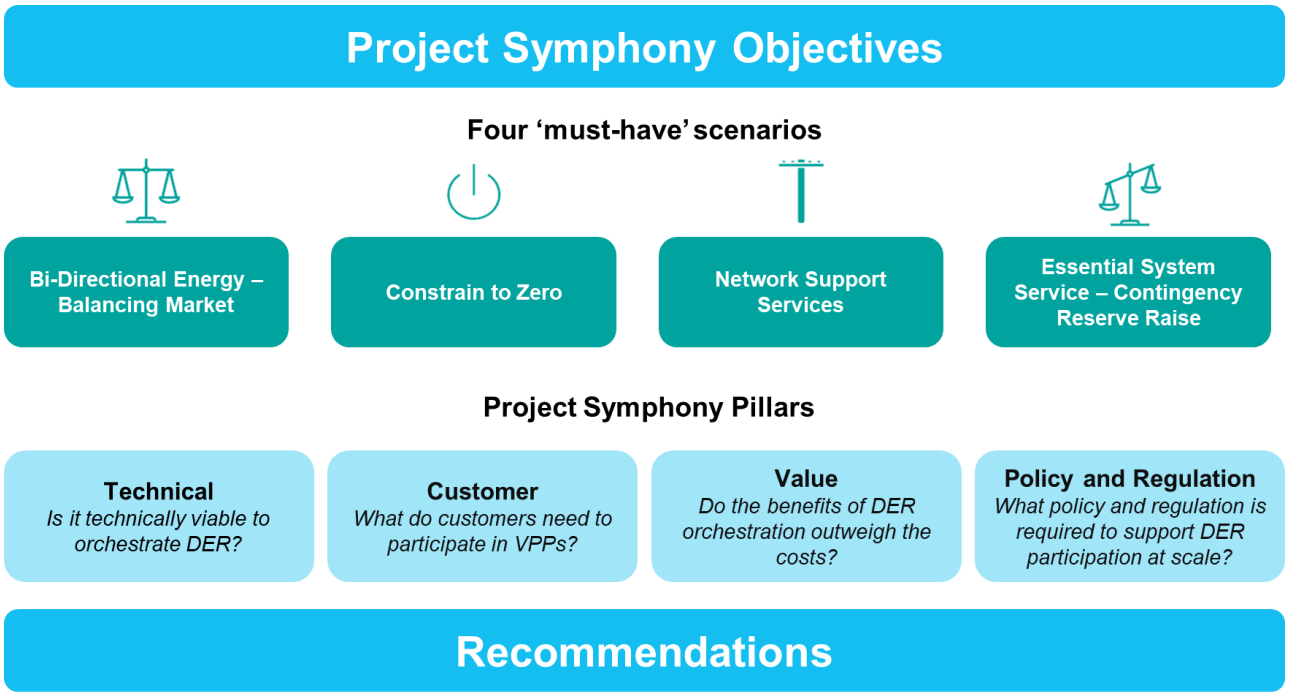


Figure 13: Project Symphony Delivery Approach

For further information on the project vision and objectives, see Work Package 8.1 Project Symphony vision and impact pathway

Project Symphony Objectives

Pillar	Objectives
Technical	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. • 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). • This work will inform the standards, processes, planning, systems, interoperability, and security frameworks required to maintain system security and reliability.
Customer	• Explore the residential and commercial customer preferences regarding DER, including willingness to engage, level of engagement, value drivers and the customer value proposition. • Pilot the role of the retailer/aggregator in facilitating customers' involvement in providing DER products and services.
Value	• 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. • This will also 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 where DER aggregators act as the intermediary to customer DER.
Policy and Regulation	• The Project will test and measure the extent to which the Open Energy Network (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. • 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).

Table 2: Project Symphony Objectives

4.4. Symphony's Test Scenarios

To demonstrate measurable achievement of each of Symphony's objectives, the project team identified the scenarios in which customer DER could participate. Considering time and technical constraints as well as potential value, four 'must-have' scenarios and two 'nice to have' scenarios were identified followed by the design and development of the technical functionality to be tested for each.

The four 'must-have' scenarios that were developed and rigorously tested through Symphony were:

Figure 14: Project Symphony test scenarios

1. ***Bi-Directional Energy – Balancing Market***: participation in the balancing market which determines economic (most economically efficient) dispatch of generation to meet system demand as managed by AEMO.
2. ***Network Support Services (NSS)***: a contracted service provided to help manage network constraints – help manage distribution level peak demand and/or voltage issues as identified by the Distribution System Operator (DSO)
3. ***Constrain to Zero (CTZ)***: AEMO instructs the aggregator platform to constrain energy output from DER to zero export (net) or zero output (gross). This could be offered as a market or retailer service.
4. ***Essential System Service (ESS)***: Contingency Raise- DER response to help restore a local deviation in frequency to normal levels (due to loss of a large generator).

The two 'nice to have' scenarios that were to be developed and tested should time, resources, and budget permit were:

1. ***Essential System Service (ESS)*** - Contingency lower: opposite of raise DER response to help restore a local deviation in frequency to normal levels (due to excess generation or insufficient load).
2. ***Essential System Service (ESS)*** - Regulation Raise/Lower: Market provided response to automatic generation control signals to correct for small deviations in frequency during a dispatch interval. This is considered the most technically complex of the scenarios given the likely requirements for ~4 second communication capability between the partners.

4.5. High Level Scope

The high-level scope included:

- Development and implementation of marketing and communications strategies and plans to acquire approximately 500 mostly residential customers and a mix of approximately 900 DER assets.
- The recruitment of a minimum of two TPAs, including integration of their customer DER orchestration solutions and customers with the Parent Aggregator platform.
- The recruitment of a contestable customer with the ability to connect a 500MWh behind the meter battery.
- The connection of a 1.2MW community battery.
- The delivery of network monitoring capability including Advanced Metering Infrastructure (AMI) and 69 high speed data recorders.
- Procurement and/or installation or recruitment of the appropriate mix of DER assets in participant premises.
- Planning, procurement, design, build, integration, testing and deployment of the software based DMO, DSO and aggregator 'platforms', including the hardware and services required to aggregate and orchestrate customer DER as part of a VPP.
- System integration testing of the DMO, DSO and aggregator platforms ensuring two-way flow of requisite data end-to-end from customer DER, to enable all activities required for the scenarios.
- Identification, development and testing of all scenarios – or services – to be tested and evaluated. Contribution to, facilitation and development of relevant reports as required by ARENA as part of knowledge sharing arrangements. For a full list of work packages, refer to Appendix B – Where to find more information.

Symphony ran from July 2021 with the signing of the Funding Agreement with ARENA to delivery of the Final Report in February 2024. Implementation of key activities and deliverables completed across four major milestones (see Figure 15):

- Milestone 1: Scoping & Planning
- Milestone 2: Build & Integrate
- Milestone 3: Testing
- Milestone 4: Completion

Successful recruitment of 514 customers and 911 DER assets, as well as each technology platform being designed, built, integrated and tested was achieved by July 2023. Significant analysis and reporting was completed between August and December 2023 including a financial cost benefit analysis (CBA), and End of Project Assessment using Technological Readiness Level and Commercial Readiness indices as used by ARENA, with the Final Report delivered in February 2024.

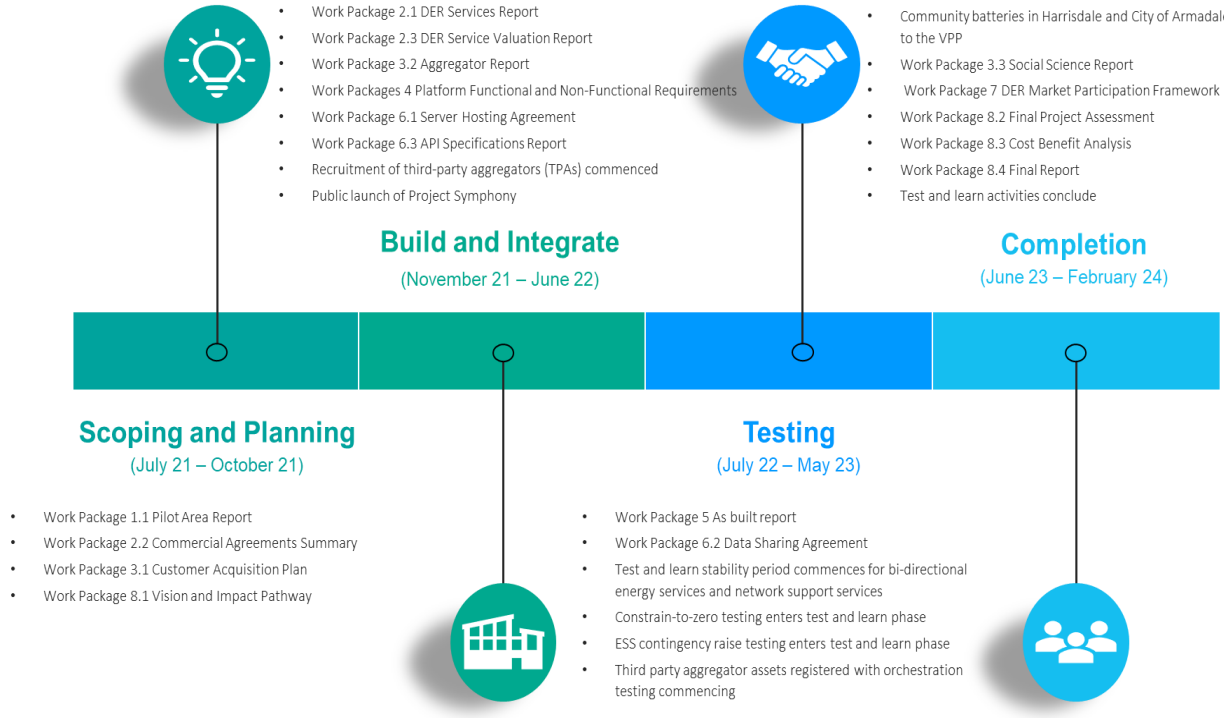


Figure 15: Project Symphony's timeline and key activities

4.6. Defining new roles and responsibilities

To facilitate Symphony, new market models and evolved roles and responsibilities of the significant actors in the WEM value chain were required.

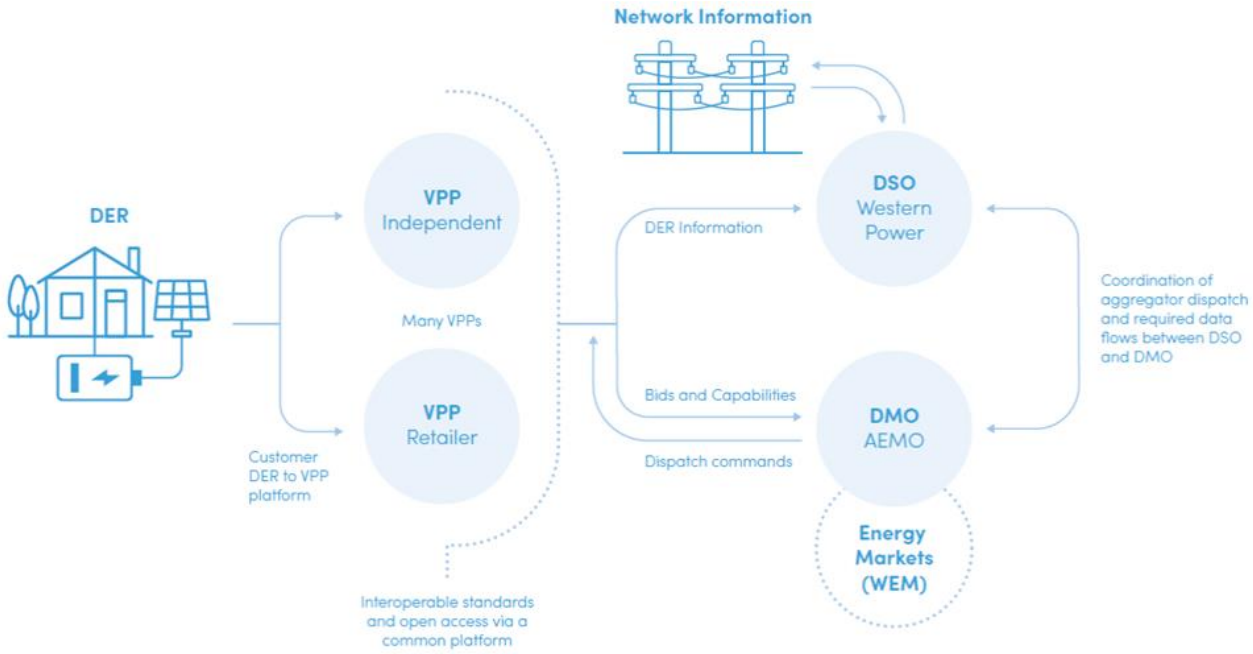


Figure 16: Project Symphony tested 'Hybrid model'

The market model tested in Symphony was referred to as a 'hybrid model'[30] which includes a two-sided market platform, as established, and designed by the Open Energy Network (OpEN). The hybrid model sees the evolution of the existing network operator (Western Power) and power system and market operator (AEMO) to deliver the required functions. Under this model, the individual customers have a relationship with a VPP provider (aggregator), who may be their retailer. Information about customer DER is passed from various VPP operators to the DSO. The DSO takes this information and combines it with the information it receives from its own network monitoring capability to map constraints and power quality across the distribution network. In the short term the DSO can use this information to procure network support services directly or from DER by way of VPPs.

This model requires the roles of traditional electricity market actors to augment their capability and processes to meet the needs of the 'hybrid model' and is the most suitable for the SWIS. As part of Symphony, these roles were fulfilled and collectively evaluated by AEMO, Western Power and Synergy respectively. As noted, this was further consolidated during the delivery of Symphony by the EPWA led DER Roles and Responsibilities work which formalised the respective roles and responsibilities following extensive public consultation.

[30] Open Energy Networks, Hybrid Model: https://www.energynetworks.com.au/sgam/hybrid/index.htm

4.6.1. Distribution Market Operator (AEMO)

The Australian Energy Market Operator (AEMO), manages the electricity and gas systems and markets across Australia, helping to ensure Australians have access to affordable, secure, and reliable energy.

AEMO is responsible under the WEM Rules for ensuring the security and reliability of the SWIS, as well as operation of the WA gas and wholesale electricity markets. AEMO operates within a broader energy market governance structure, alongside the Coordinator of Energy and the Economic Regulation Authority (ERA) in Western Australia. AEMO plays an important role in Identifying, forecasting and communicating the investment needs to meet future electricity and gas demand. This includes procuring generation, storage and demand side capacity such that supply meets demand at all times, in the context of a rapidly decarbonising SWIS, and the increasingly important role played by DER in this mix.

In ensuring system security and reliability, AEMO is responsible for the market's provision of adequate frequency control ESS, such as Contingency Reserve Raise, and system related NCESS, such as the Minimum Demand Service, is available in the system. It also plans and administers the Reserve Capacity Mechanism (RCM) to ensure sufficient capacity is invested in and delivered to the WEM to meet peak demand.

4.6.1.1. AEMO's role within Project Symphony

AEMO fulfilled the role of the Distribution Market Operator (DMO) in the hybrid model. In the project the DMO role was independent of existing WEM functions and participants representing a future expansion of AEMO's existing role of the market and system operator overseeing the WEM and progressive integration of small-scale generators, such as DER, to be orchestrated and dispatched at appropriate scale.

As part of managing the market and power system, the DMO also oversees the different elements, including electricity dispatch, ESS, and reserve capacity. It must be able to manage aggregation of DER and larger generators simultaneously, providing security and reliability for the entire system and co-optimised dispatch. For aggregated DER to scale it is important that the DMO seamlessly integrate with the DSO to co-optimise dispatch of electricity with FCESS whilst integrating Non-Cooptimised Essential System Services (NCESS) requirements. With the rapid growth of DER, the DMO is also responsible for providing access to the electricity, capacity, and ESS markets for aggregators.

As the DMO, AEMO was responsible for the development of a two-sided market platform, comprised of wholesale and system support services that are organised and operated by the DMO. The platform facilitated Aggregator access to simulations of the wholesale energy and Essential System Service markets. AEMO made decisions for whole of system optimisation based on the economic merit order of bids and offers for system services and provided dispatch instructions to the aggregated DER facilities via the Parent Aggregator to be fulfilled, and then verified and settled.

4.6.2. Distribution System Operator (Western Power)

Western Power is a Western Australian State Government owned corporation responsible for building, maintaining, and operating an electricity network that connects 2.3 million customers to thermal and renewable energy sources.

The Western Power Transmission and Distribution Network forms the vast majority of the South West Interconnected Network (SWIN), which together with all of the electricity generators, comprises the SWIS.

Western Power operates the distribution network within its safety and reliability limits, while optimising value to the community it serves and supporting the renewable energy transition. This requires building the capability to dynamically manage 'hosting' capacity and integrate participating customer DER assets into active network management.

As per the hybrid model, to deliver DER integration an evolution of Western Power's roles and capability to become the DSO was pursued in Symphony.

4.6.2.1. Western Power's role within Project Symphony

In its role as the Distribution System Operator (DSO), Western Power's key role was enabling access to the network, securely operating and developing an active and dynamic distribution system comprising networks, demand, and other flexible DER.

Under the roles and responsibilities of the 'hybrid' model, Western Power's functional capability will need to evolve beyond its existing network operations capability. This is required to support the functionality of the DSO and the optimal use of active DER on the distribution network, in collaboration with the DMO and aggregator, in the delivery of secure, sustainable, and affordable electricity as part of whole-of-system optimisation.

More specifically key focus areas of the DSO included:

- Providing a DSO 'platform' enabled by increased distribution network visibility and comprising the DOE calculator and the DOE algorithm to:
- Forecast passive energy.
- Identify network constraints in the system.
- Determine the available hosting capacity of the distribution network.
- Allocate spare capacity using an allocation method to calculate the DOEs.
- Validate compliance with DOEs and NSS.
- Installation of Network Monitoring which includes distribution transformer monitors as well as advanced meters within the pilot area.

4.6.3. Aggregator (Synergy)

Synergy is Western Australia's largest electricity generator and retailer of gas and electricity with more than one million residential, business and industry customers. Like Western Power, Synergy is owned by the Government of Western Australia.

Under the State Government contestability policy, Synergy is the sole retailer available non-contestable customers (customers using less that 50MWh/year) in the SWIS. Retail and export tariffs are regulated and set by the State Government for most small use customers, with Synergy's purpose being 'to lead Western Australians to their intelligent energy future'.

In the role of retailer, Synergy also leads and manages all non-contestable customer engagement activities, from communications and onboarding, to billing management.

As per the hybrid model, to deliver DER integration an evolution of Synergy's roles and capability to become the Parent Aggregator for non-contestable customers was pursued in Symphony.

4.6.3.1. Synergy's role within Project Symphony

Under the roles and responsibilities of the 'hybrid' model and in alignment with the subsequent DER Roles and Responsibilities work led by EPWA, Synergy's functional capability will need to evolve beyond its existing capabilities of a retailer, to support the functionality of the Parent Aggregator in the SWIS. This includes developing and maturing technical capability as well as innovation in DER product development and the engagement strategies required by an aggregator as opposed to a traditional retailer. As per the roles and responsibilities the Parent Aggregator can also build capability to enable TPAs who can assist in the recruitment of DER into the VPP. Regulatory arrangements in the WEM require aggregators to be market participants in order to access market value streams. Further, it provides the opportunity to understand the business model and value streams required to underpin DER orchestration at scale.

In line with its existing role, a critical contribution of Synergy was to lead the customer interactions as part of Symphony to achieve the recruitment target of ~500 customers and their ~900 DER assets participating in the pilot. This included the co-development of branding, and the overall lead in marketing and general recruitment collateral. Synergy's responsibility included the installation of some new DER, mostly battery energy storage systems, and associated communications and measurement equipment - such as gateway devices and site meters required to register and orchestrate the DER via Synergy's aggregator platform.

Synergy's establishment of the Parent Aggregator platform involved the procurement, design, build, integration, and testing of the required functionality, along with AEMO's DMO platform and Western Power's DSO platform, to facilitate the testing of the 'must-have' scenarios.

Synergy was also required to recruit a minimum of two TPAs, including integration of their customer DER orchestration solutions and customers with the Parent Aggregator platform.

Lastly, Synergy was responsible for several research deliverables aimed at understanding customer sentiment in relation to DER orchestration, as well as producing an analysis of the overall potential economic value from DER orchestration in the SWIS.

4.6.4. Energy Policy WA

Energy Policy WA is the government agency responsible for the delivery of energy policy advice to the WA Minister for Energy. It is also responsible for supporting the delivery of the government's Energy Transformation Strategy. Additionally, EPWA supports the Coordinator of Energy who is responsible for overseeing the development and maintenance of the WEM rules and electricity sector regulations. The Coordinator of Energy also plays an important role in the procurement of NSS, including via DER.

4.6.4.1. EPWA's role within Project Symphony

Unique to Symphony and a key strength in its oversight and implementation was the purposeful and unflagging participation of EPWA at both a governance level as Chair of the Symphony Steering Committee and as imbedded subject matter experts as part of the broader project delivery team.

Further, while the progress, lessons and outcomes of Symphony have and will further inform the required regulatory and policy changes, parallel streams of work led by EPWA have brought greater clarity under the DER Roadmap and Energy Transformation Strategy. These include defining DER orchestration roles and responsibilities in the WEM (see *DER Roles and Responsibilities Information Paper*[31]*)* and complimentary changes to the governance of the WA energy sector via the Electricity Industry Amendment (Distributed Energy Resources) Bill which together continue to provide for a well-coordinated and orderly transition to a high DER future in WA.

[31] Energy Policy WA, Distributed Energy Resources (DER) Roadmap: DER Orchestration Roles and Responsibilities Information Paper: https://www.wa.gov.au/government/publications/distributed-energy-resources-der-roadmap-der-orchestration-roles-and-responsibilities-information-paper

4.7. Pilot Area

The geographic area selected for Symphony included the suburbs of Harrisdale, Piara Waters and Forrestdale – which covers over 4,900 customers (see figure 17). This area is also supplied by Western Power's Southern River (SNR) zone substation, and more specifically distribution 'feeder' SNR540.

The selection of this area was informed by the local characteristics of this distribution network segment, such as network construction, forecast demand, customer types, level of existing solar PV penetration (55% of households). Network monitoring was conducted on SNR 540 to provide real time information on how DER was impacting on the local network (see figure 18).

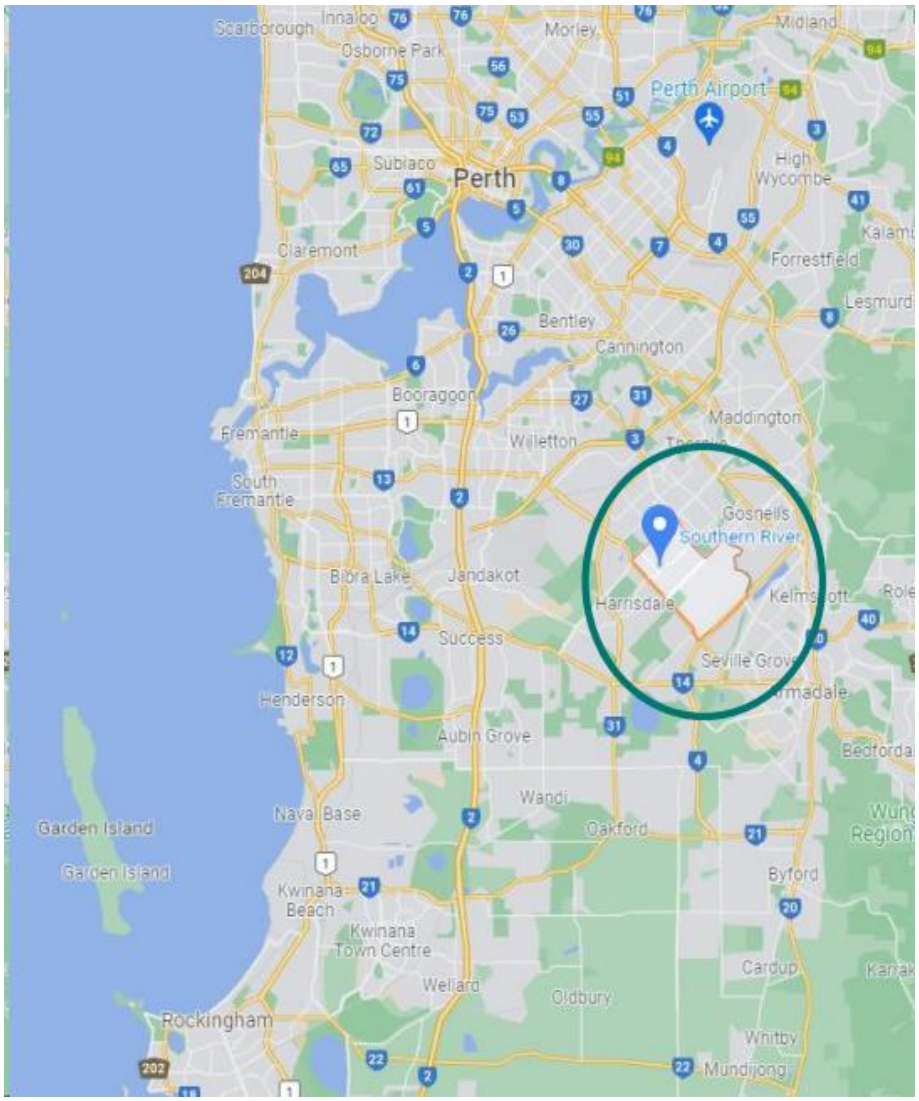


Figure 17: Geographical area of Project Symphony

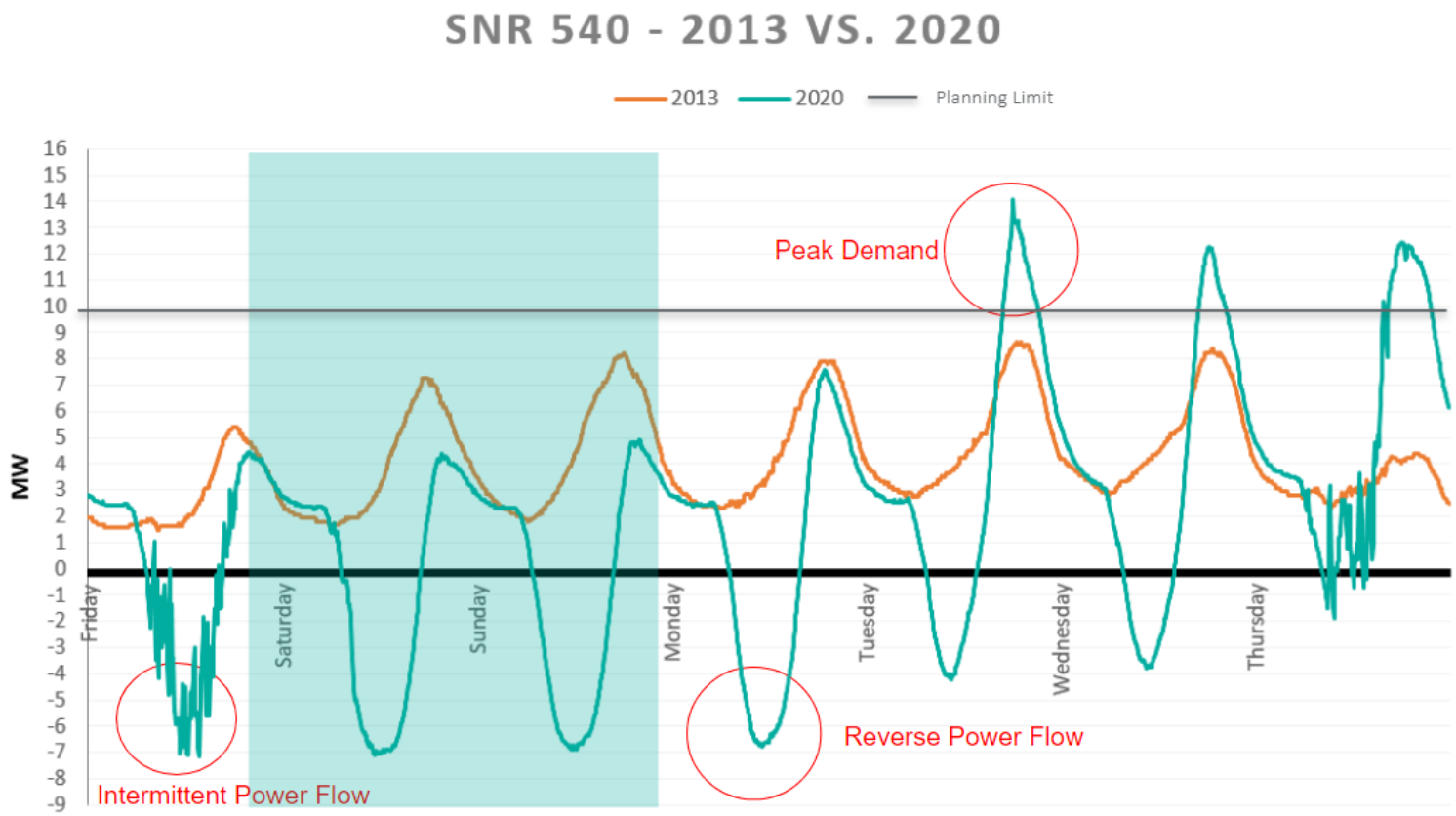


Figure 18: Challenges and opportunities of DER on SNR540

The SNR 540 feeder has a capacity rating of 10MW however, with peak demand growing year on year the capacity limits of the feeder are breached during summer months when peak loads are observed. This has meant that Western Power has switched customer loads onto other parts of the network to manage the peak and started planning for significant capacity augmentation of the sub-station to manage the load. In addition, the network monitoring showed that reverse power flows are now occurring on the feeder. As early as 6:30am some local transformers become net generators on Western Power's LV network making the management of voltage more challenging. Finally, when there is cloud cover the generation from PV systems rapidly reduces causing very large swings in required load, which is described as intermittency. Orchestrated DER has the capability to help Western Power manage these network challenges.

5. Technical

The technical pillar of Symphony included the design, procurement, development, integration and testing of three separate software-based platforms which were then rigorously tested as a single end-to-end solution. The solution needed to be capable of registering, aggregating, and then orchestrating customer DER to participate in the four 'must-have' scenarios as described in section 2.4 of this report representing both 'on-market' and 'off-market' services.

The orchestration of each partner's 'platform' were implemented as an 'aggregator platform' (Synergy), a market or 'DMO platform' (AEMO) and a 'DSO platform' (Western Power). The DSO platform analysed network conditions and DER monitoring data and published DOE at prescribed intervals to maximise the renewable energy (predominantly rooftop solar) hosting capacity on the local medium voltage (MV) and low voltage (LV) networks.

The end-to-end solution required a significant systems interface and integration effort between the different platforms, as aggregated customer DER at multiple levels (DER assets, connection point, management and optimisation systems and market interface) responds to AEMO dispatch requests via the aggregator platform and within the constraints of the local network including settlement of market transactions[32]. Unique to Symphony, the platform build also facilitated the Aggregator to value stack services, enabling its customers to optimise value by participating in multiple market and off-market services.

The following sections will restate the *technical* objectives of Symphony, will provide an overview of the technical aspects of integrating customer DER as well as the approach to, and results of testing across each scenario, while exploring key technical concepts such as Dynamic Operating Envelopes. Finally, an overview of the key testing outcomes will be provided before presenting each technical recommendation required to enable DER participation at greater scale.

5.1. Technical Objectives

The technical objectives of Symphony included:

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.

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).

Measure the extent to which this work will inform the standards, processes, planning, systems, interoperability, and security frameworks required to maintain system security and reliability.

[32] 'Off market' settlement for the purposes and duration of this Project.

5.2. Integrating Customer DER

While technology plays an important role in realising the safe and reliable integration of increasing DER, customer participation in sufficient numbers was critical to the success of the pilot. The pilot included installing and securing a statistically relevant number and mix of customer DER assets via direct engagement and multiple TPAs.

Overall, the pilot recruited 911 DER assets from 514 customers, with a mix of assets including: generation management of rooftop solar (PV), air conditioning (HVAC) control and battery storage as outlined in Table 3. This included assets secured via TPAs. TPAs were used as an alternative method to recruit customers and their DER into the VPP, rather than only via their existing electricity retailer. This expanded the pool of assets able to be recruited. Of all the assets recruited, 715 were orchestrated in the Symphony VPP.

DER Asset Type	Total #	PV	Batteries	HVAC	HWS	TPA
Target	900	300	150	280	30	140
Acquired	911	292	150	218	30	221
Commissioned	815	285	150	188	25	167
Orchestrated	715	258	149	119	22	167

Table 3: DER Assets within Project Symphony

The discrepancy between assets recruited (911) and assets orchestrated (715) as part of the Symphony VPP was largely caused by technical issues associated with lack of reliable interoperability and therefore registration in the aggregator platform (see Recommendation 1.1).

Registering and orchestrating customer owned DER for the purposes of the pilot required the procurement and installation of ancillary or supporting assets that enabled the communication, control, and ongoing monitoring and measurement of performance and compliance of the DER assets – such as third-party power meters, high-speed data recorders, 4G SIM cards and gateway devices.

Further, the recruitment and integration of a diverse range of DER assets – of differing age, functionality, locations, capacities / sizes, and other distinctive attributes – provided valuable insights and lessons as to the compatibility (or lack thereof) of existing DER assets, as well as the requirements for reducing technical barriers to scaling DER participation as part of VPPs in the future.

From a technical perspective the diverse asset base, which was purposefully targeted to understand current state, added further rigour to VPP product development through requiring consideration of differing compatibility and interoperability requirements, and the resultant communication with customers (see Recommendation 1.1).

5.3. Dynamic Operating Envelopes

In the current state, management of the safe operating limits at a connection point is governed by 'static' operating envelopes, captured in Western Power's Basic Embedded Generator Connection Technical Requirements[33]. Static export limits are based on the design limits of the network and are static over time, with operating limits at a connection point not changing over time or dependent on network challenges.

Whilst simple to calculate and fit-for-purpose in the past, static operating envelopes result in one main drawback – they can understate the available 'hosting capacity' of the network at certain times, resulting in sub-optimal (less than may actually be available) capacity allocation.

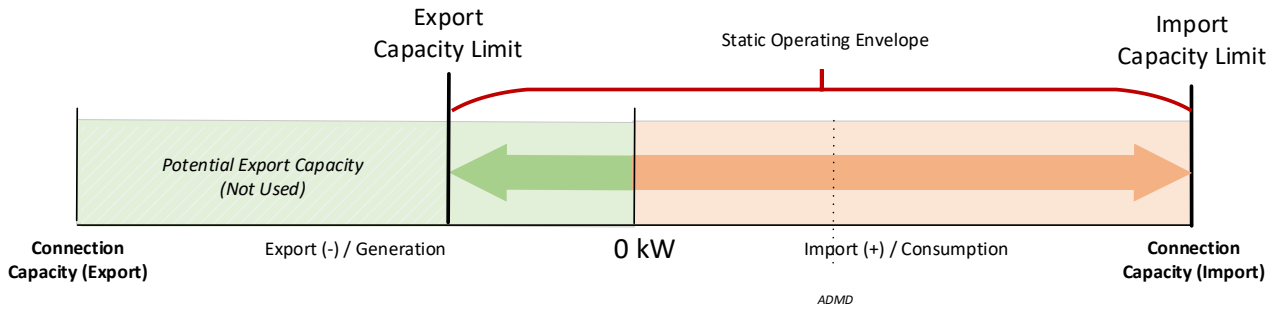


Figure 19: Static operating envelopes – current state

Given the increase and growth in DER – which uses up hosting capacity – in the SWIS over the past number of years, static operating envelopes places potential constraints on additional DER being installed and connected to the network.

In alignment with the key technical objective of measuring the extent to which DER can address local, regional and system wide challenges in the SWIS, the key is to reduce the technical barriers to DER connecting (such as increasing hosting capacity) and then participating (within the constraints of the network). As a potential solution, Symphony worked to determine a way to most equitably distribute *all* available hosting capacity to connection points, and how to develop and calculate DOEs for the purpose of managing physical distribution network constraints.

Converse to static operating envelopes, DOEs utilise timely and granular data, reflecting the changing operating condition of the network to flex the operating limits. This 'flex' enables network security and stability to be maximised by assigning available network capacity at the connection point of active participants in the VPP and allows more and *larger* system sizes to connect to the grid.

[33] Western Power, Basic Embedded Generator (EG) Connection Technical Requirements: https://www.westernpower.com.au/media/6551/basic-eg-generator-technical-requirements-20230411.pdf

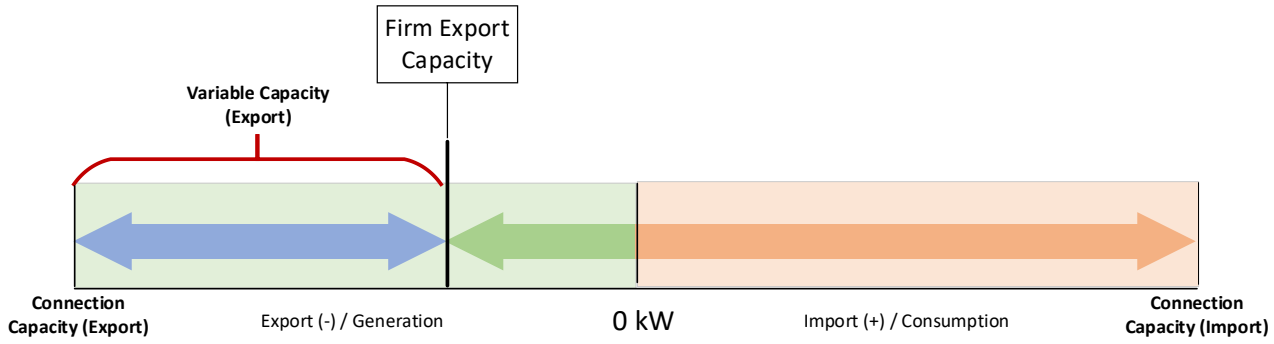


Figure 20: Project Symphony - Dynamic operating envelopes

Whilst theoretically DOEs can be used to manage both export and import limits, Symphony only tested DOE's ability to manage exports per the scope of the pilot. Through testing of DOEs, there were examples of DER demonstrating compliance with DOE instructions, however also evidence of non-compliance. Overall, it can be summarised that performance was inconsistent. This is highlighted in the below graphs (Figure 21),where in the graph on the left, it can be evidenced that DOE instructions (light blue line), which limited the ability to export energy in the middle of the day, was complied with at the connection point (purple line).

Converse to this, the graph on the right indicates DER(s) at the connection point did not comply with the DOE instruction, exported more onto the grid than the DOE instruction suggested was safe to do.

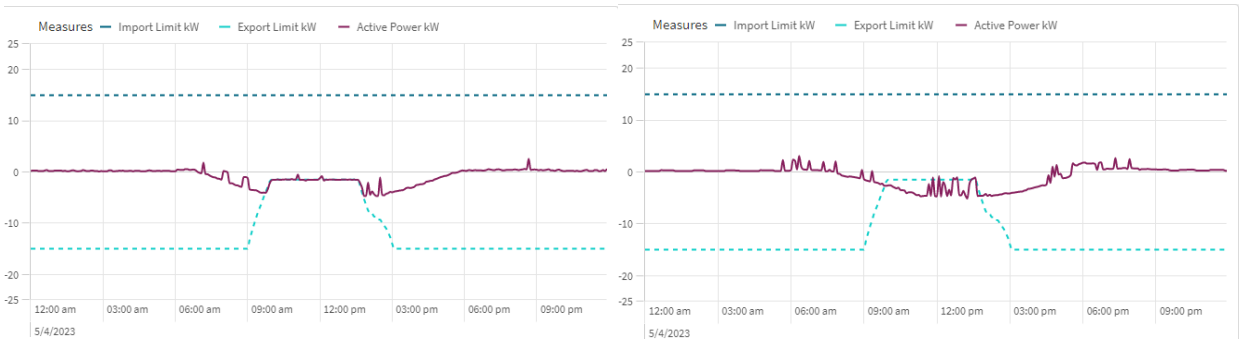


Figure 21: Dynamic operating envelope examples of compliance (left) and non-compliance (right)

While the results of the work undertaken in testing hosting capacity, hosting capacity allocation, and DOEs lends itself to making the recommendation of introducing dynamic network connections (see Recommendation 4.6), the following technical insights highlight:

- That reliable estimates are required to calculate available network capacity daily. However, it was noted that significant supporting infrastructure (e.g., AMI, network monitoring and ICT support), accurate source data and forecasts are required to enable this to occur.
- Identification of a preferred hosting capacity allocation methodology, which enabled available hosting capacity to be most *equitably* distributed and utilised – particularly in a high VPP participation scenario.
- Identification that to calculate viable DOEs, significant amounts of accurate and timely information will be required. This is to be enabled by greater visibility of the low voltage / distribution network, and seamless integration between aggregators, the DSO, and the DMO and their respective technology platforms.
- Recognition that service performance standards are required to be developed, to provide the baseline in which technical compliance of dynamic operating envelopes instructions can be measured and assessed against.

For further information and evidence on the testing of hosting capacity, equitable distribution of hosting capacity dynamic operating envelopes and Western Power's Basic Embedded Generator Connection Technical Requirements see: Work Package 4.1 Distribution constraints optimisation algorithm report[34]

5.4. Test Methodology

A combination of *Agile,* better suited to the iterative development of the software solutions, and *Waterfall*, better suited to the business-to-business deployment requirements, were used to deliver Symphony. This culminated in a final testing period being the 90-day 'stability period' or Test & Learn (T&L) see Figure 22.

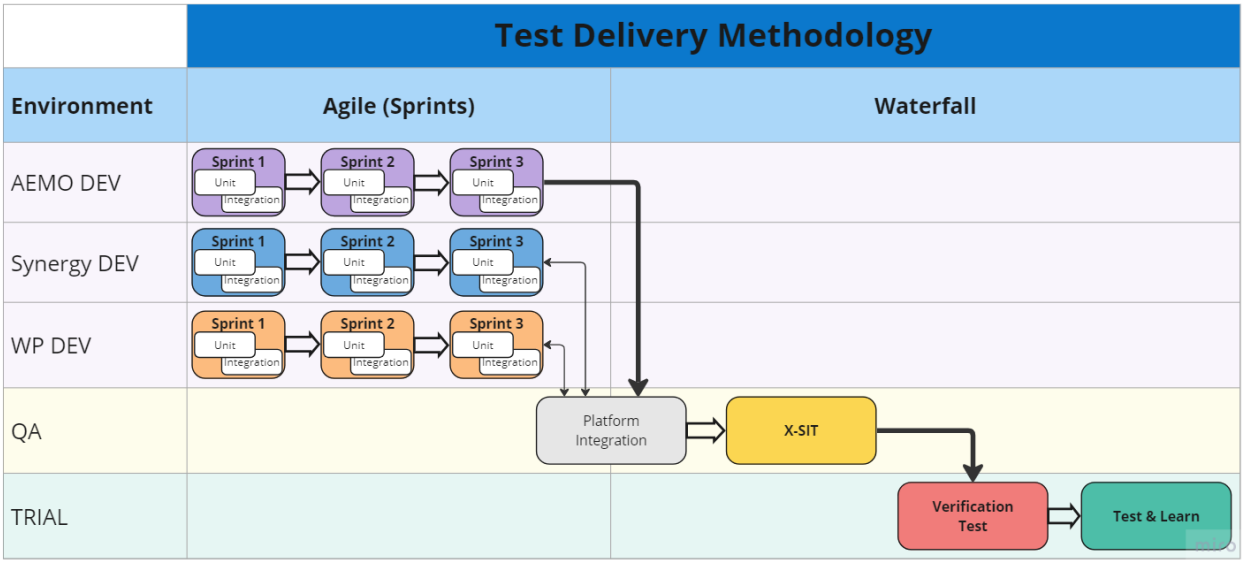


Figure 22: Project Symphony Testing Methodologies

All three project participants, implemented Agile practices, scrum methodology and delivered using incremental sprints, which were developed to form a drop (a phase of project that included development of new functionality) from each organisation and deployed in a Waterfall approach aligned with an X-SIT (Cross Organisation System Integration testing) testing cycle.

Once internal development and testing was completed by AEMO (as DMO), they deployed the market platform into the QA environment, which Western Power (as the DSO) and Synergy (as Parent Aggregator) would then integrate via their development (DEV) environments to complete any final integrations sprints before deploying in a waterfall approach to the quality assurance (QA) environment prior to X-SIT commencing.

From X-SIT in the QA environment through to Stability Period testing in the trial environment, all testing followed a traditional waterfall delivery methodology.

[34] Project Symphony Distribution constraints optimisation algorithm report: https://arena.gov.au/knowledge-bank/project-symphony-distribution-constraints-optimisation-algorithm-report/

5.4.1. Build & Integration Test

Test teams specific to each project participant, conducted system testing of platforms and system integration testing (SIT) with integrated vendor applications. Multiple build and integration phases were conducted on each of the project partners' platforms, as per the agreed project scope and drop delivery schedule.

Internal test plans for each drop were developed in line with the technical design and business requirements. As an entry criterion for Cross Partner System Integration Testing (X-SIT) test summary reports were produced and presented by each organisation to document the scope of testing completed and the platform capability being delivered into X-SIT.

The key technical lessons learned from the build and integrate phase include:

- The software and hardware-based solutions necessary for managing DER and renewable energy, such as communication, integration, aggregation, and settlement of DER services, are still in a relatively immature state of development.
- Each project partner developed their own non-functional and functional requirements, and these were brought together in the *Platform Functional and Non-Functional Requirements Report*.[35] Procurement processes were not well coordinated across the project partners with three independent approaches, causing some confusion in the vendor market.
- Assumptions of shared understanding on functional requirements amongst project partners was tested during the build phase with a misalignment in platform build. The platform build was remedied and delivered - with timeline and budget impacts.
- During the execution, the pilot clearly demonstrated the technical *feasibility* of integrating, aggregating and orchestrating a facility comprised of customer owned DER assets, but the project partners faced the challenge of not finding complete 'off the shelf' software solutions that met their specific needs. As a result, the pilot had to prepare for and rely on some co-development of solutions in parallel to the pilots' implementation.

5.4.2. Cross system integration testing (X-SIT)

Cross organisational testing was coordinated by the X-SIT Working Group, which ***included subject matter experts from each*** participating organisation who ***were responsible for*** the definition and execution of the test scenarios. An end-to-end test manager within the project PMO, was responsible for defining the test process, facilitating the cross-organisational test delivery, and producing test summary reports.

Cross platform integration testing was conducted across multiple drops based on delivering platform capability aligned with project scenarios (bi-directional energy, NSS, CTZ and ESS-CRR). Test plans were developed based on the requirements defined for each drop specific to the scenario integrations and were executed, reviewed, and signed off by all partners. End-to-end test scenarios were derived from a combination of use cases, plus cross platform integration sequence diagrams and from which 'happy path' – a path to achieve the desired result without encountering any error with run sheets – was defined.

[35]Project Symphony Platform Functional and Non-Functional Requirements: https://arena.gov.au/assets/2022/02/project-symphony-platform-functional-and-non-functional-requirements-report.pdf

5.4.3. Verification Test

Verification testing was conducted in the trial environment and served as the entry gate to commence Stability Period or Test & Learn execution phases. The first execution cycle of verification testing in October 2022 was used to ensure all integrations were correctly configured in the trial environment in preparations for stability testing to commence.

Following the first execution cycle, the aim of verification testing was to prove that the platforms could be operated end-to-end with minimal manual intervention, so that the Test & Learn phase would be able to execute tests which would inform whether the requirements and platform capabilities had been met.

The final cycle of verification testing was an opportunity to complete a practice run required to support the stability period phase and included data verification to ensure that data analysis and reporting requirements were met. Finally, verification test provided the opportunity to baseline platform integration performance.

5.4.4. 90-Day Stability Period

The 90-Day 'stability period' was the final stage of the Test & Learn phase, with the objective of completing 90 consecutive calendar days of testing across the 4 scenarios (bi-directional energy, NSS, CTZ and ESS-CRR), with no Severity 1 or 2 platform capability defects. In the event of a defect of this severity being raised, the 90 consecutive day period would be restarted.

While there was a small number of severity 1 or 2 defects raised and resolved with minimal impact, these defects were caused by environmental infrastructure issues, largely beyond control of the project and therefore not a result of the platform design, implementation, or operation. This will need to be considered when scaling as dependency systems can and could have an impact on availability and reliability of performance.

Each test cycle consisted of the activities detailed in Figure 23 below, which covered a 16-day cycle, responsibilities of which were split between the test execution teams and the data analysis & reporting teams. This allowed test execution to run back-to-back in weekly cycles.

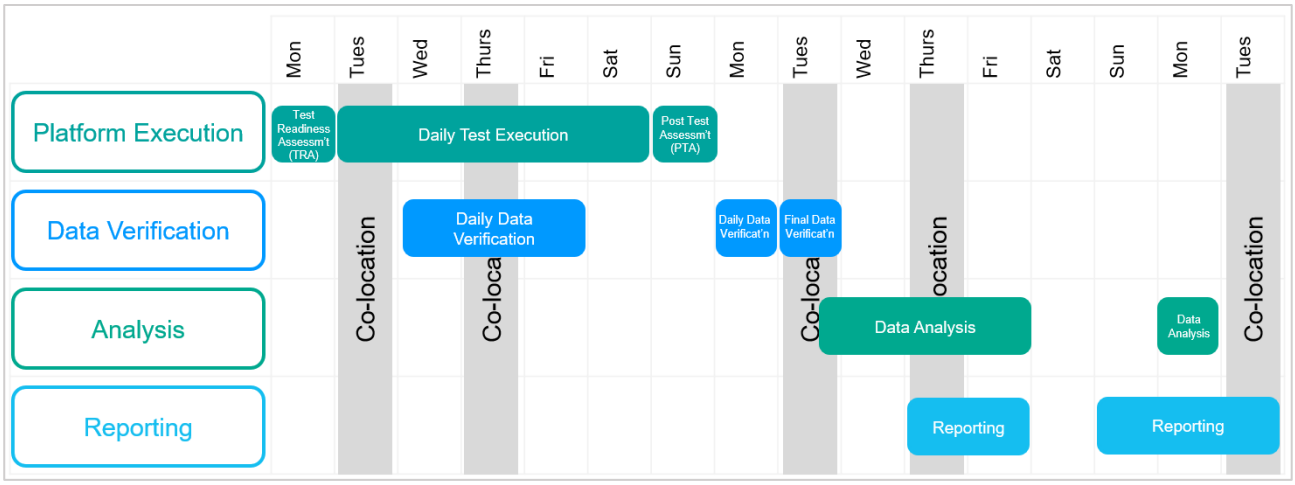


Figure 23: Test Cycle Activities

5.5. Test Results

Overall, testing focused on understanding the technical feasibility or viability (as two distinct measures) of having DER participate in the four 'must-have' scenarios. Simply, feasibility is achieved when all planning, designing, coding, and testing necessary to determine that the solution can perform in a way that meets the technical specification and the functional requirements has been completed.

Technical viability is achieved when the solution is readily available and capable of performing consistently or reliably in actual operating conditions.

Figure 24 below illustrates the level of testing conducted during Symphony.

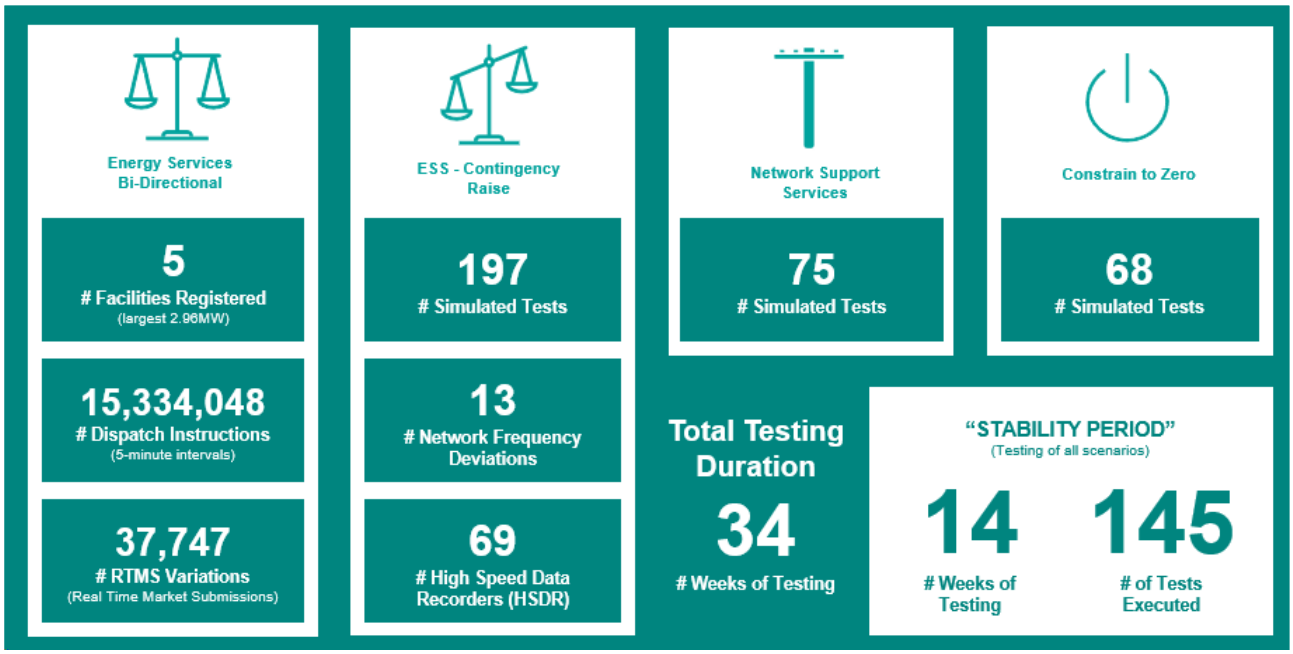


Figure 24: Summary of testing conducted.

The following sections detail test results from each 'must-have' scenario.

5.5.1. Energy Services – Bi-Directional – Balancing Market Offer (BMO)

The bi-directional energy scenario involved the simulated registration and dispatch of an aggregated facility with access to real time market prices while adhering to network requirements through DOEs. The energy scenario represents the foundational capability of aggregated DER to schedule collective energy management actions coordinated with network and market operation.

The two other market scenarios, Essential Systems Services (ESS) and Network Support Services (NSS) integrate with the bi-directional energy scenario and represent additional value streams that "stack" in addition to the value generated through the energy market arbitrage.

The Constrain to Zero (CTZ) scenario was contemplated as a pre-emergency 'off market' service to manage periods of low demand and was tested without integration in the bi-directional energy scenario. Nonetheless, the capability to constrain generation to zero was used as part of the aggregator's facility control method under the bi-directional energy scenario.

Overall, key findings from testing the BMO scenario include:

- Continuous real-time operation and monitoring of the facility demonstrated sufficient potential to expect a future real-time energy service in the timing requirements of the Real Time Market. While there were concerns about the speed of responses to a dispatch instruction provided in real time with a target of 5 min. in the future, aggregated DER demonstrated sufficient speed of response, combined with expected future capability to *pre-schedule* events and only re-send instructions when changes occur.
- The continuous monitoring required by the Aggregator to plan, control and monitor the DER for their own purposes as well as to provide customers real-time information of their DER operation showed potential to create and provide a continuous, automated real-time (or near-real time) data feed to the DSO and DMO.
- After initial issues were overcome with how price signals would be used to determine how customer DER would be orchestrated, testing showed successful control of the VPP particularly when price was below -$100/MWh and when the price was positive.
- DOEs were successfully calculated and published, but compliance with them was inconsistent and achieved approximately 50% of the time.
- Aggregator platform capability was limited to responding to pre-dispatch instructions only providing for a period of computation ahead of the delivery of energy. Dispatch instructions were inconsistently met with under-delivery of energy being the most common cause, indicating that aggregator forecasting, and optimisation capability requires further focussed development.

As an example, Scenario 1 (BMO) was demonstrated on 05 Jul 2024, where the VPP response / orchestration (blue line) broadly followed the price signals (black line) and dispatch instructions (red line) e.g., participated in the bi-directional energy market, in a relatively economically efficient way, and in an automated fashion without manual intervention. The graph below demonstrates that when the market price was low, DER assets (battery storage) were charging (both Residential and Large), and when price was high – and therefore customer benefit was highest – the same DERs were discharging to meet in home demand and/or selling power into the grid.

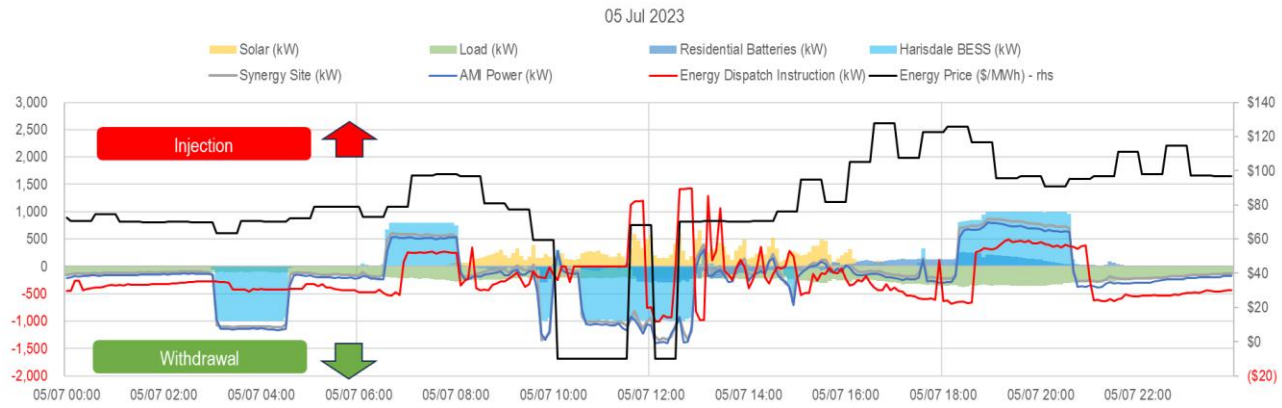


Figure 25: Energy Services – Bi-Directional – Balancing Market Offer example

5.5.2. Network Support Services (NSS)

At present, safe distribution network operating limits are maintained primarily through maintenance and augmentation – such as building more poles and wires – at times requiring significant investment to alleviate constraints that only occur for a few hours across a handful of days in summer each year. It has long been envisaged that aggregated demand management, particularly cooling loads like air conditioning which drives the SWIS summer peak, could be utilised to alleviate local constraints at a cost lower than traditional augmentation. Despite various technical trials demonstrating the potential of air conditioner demand management to reduce demand at peak time (including WA's own Perth Solar City program[36]), some technical, information and capability barriers have persisted to prevent its broader application. However, with the increasing adoption of battery energy storage, including by customers, the potential to aggregate and orchestrate this DER and address network constraints, in combination with demand management as part of a VPP to reduce peak demand, is renewed. As such, Project Symphony set out to pilot how using a contracted network support service (NSS), consisting of aggregated DER as provided by the Parent Aggregator, can defer, or even avoid traditional augmentation.

More specifically, two types of network support services were designed and tested as part of Project Symphony:

- A *firm* service: Which is used in investment timeframes (long-term), with lead-times in the order of months or years, as an alternative option to capital network augmentation. The required mega-watts (MW) & mega-watt hours (MWh) of a firm service tend to be large, with aggregators likely to need long-lead times to recruit the requisite DER capacity, as part of establishing a commercial agreement with the DSO including availability payments and strict penalties for non-provision defined.
- A *flexible* service: Network support services, not covered by a firm service are shorter term (day ahead or same day) or more opportunistic and are designed to cater for unexpected events, or alleviate the reliability impacts of unplanned outages. As part of the commercial agreement, for flexible services there are dispatch payments but no availability payment or penalties for non-provision.

[36] Perth Solar City program: https://www.perthsolarcity.com.au

In testing this scenario, the initial focus was on targeting transformers with the highest *penetration* of solar PV (generally greater than 30% penetration). This was to enable an increase in measurability of VPP orchestration at the distribution transformer. However, in order to best demonstrate ability to provide localised NSS at the transformer level, the approach shifted towards the highest *loaded* distribution transformers (>80% utilisation) to target recruitment for air conditioner and battery storage assets – also referred to as Very Important Transformers (VITs).

Overall, testing highlighted generally positive outcomes, with aggregated DER able to respond to provide NSS. However further improvements are required to achieve appropriate compliance levels.

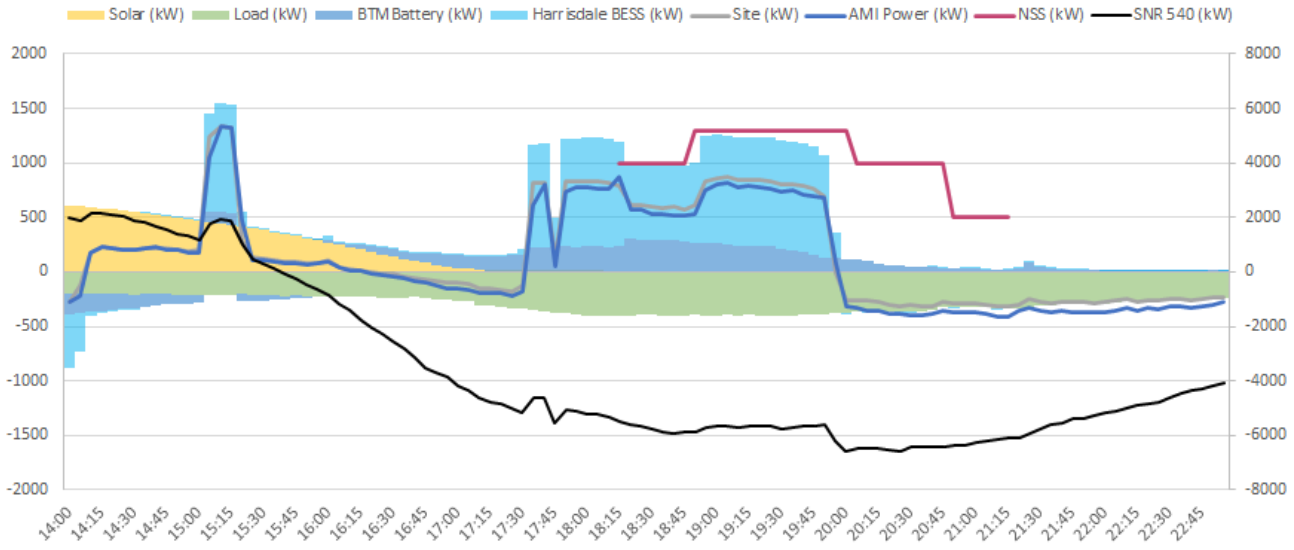


Figure 26: NSS dispatch example – 2 July 2023

As illustrated through the diagram above – on 2 July 2023, when the NSS deployment signal (red line) was active, the Project Symphony VPP provided a response (shaded area), either close to or meeting the requested response. This statement holds true from when the NSS was first deployed at approximately 6.15pm, until approximately 8.00pm. After this point, the VPP response fell with a large gap between the response and the NSS deployment signal, due to other tests which occurred that depleted battery storage. As such, this example clearly demonstrates the ability for a VPP to participate effectively in NSS, but also the requirement for improvement in real life situations.

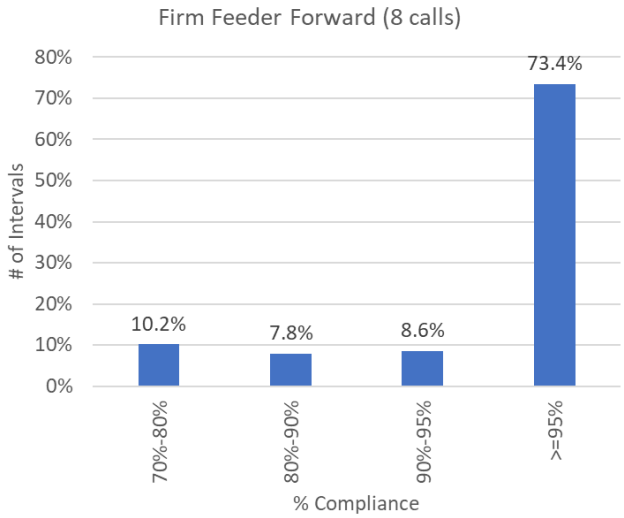


Figure 27: 5-minute interval compliance feeder forward NSS firm

This is further highlighted when reviewing compliance data, that is the proportion of five-minute intervals which were within 95% of the NSS deployment signal instructions, and therefore deemed compliant. From a small sample size of 8 NSS calls, data from testing highlights that non-compliance was experienced in 26.6% of NSS intervals.

Symphony demonstrated the feasibility of VPPs providing network support services. However, with compliance quite regularly not being sufficient to provide confidence in procuring a reliable NSS, further improvements will be required to focus almost exclusively on NSS using multiple DER types at peak times, and to measure availability and reliability of the NSS.

Overall, key findings from testing the NSS scenario include (also see Recommendation 3.2):

- State of charge becomes a critical consideration in effective participation of aggregated DER in NSS. In short, NSS cannot be facilitated through aggregated DER where battery storage assets do not have any charge. Further consideration is required on how to optimise state of charge of battery storage systems to enable participation in ESS-CRR as well, noting opportunity costs.
- Whilst improvement was demonstrated as the pilot progressed, further improvement in NSS scheduling is necessary. Where scheduling activities can be improved, utilisation and impact of NSS will be maximised.
- The need to assess different types of assets for their value (capacity and cost) to network support services, such as air conditioners, which was not tested as part of Project Symphony.

5.5.3. Constrain to Zero (CTZ)

Over recent years, the SWIS 'duck curve' has accentuated, with the belly of the duck curve – or the operational demand low – continuing to decrease year on year, with it approaching unstable operating levels. The primary contributor to low operational demand is generation from DER, and particularly solar PV in the SWIS, during periods of high solar irradiance.

The constrain to zero scenario as designed to test the technical capability for the market operator to manage low operational demand events on the SWIS, by instructing the aggregator to 'constrain to zero'. Simply put, the instruction to constrain to zero is a direction to control end-use customer sites to stop injection of energy from DER into the grid (constrain to zero net) or stop generation of electricity by DER assets (constrain to zero gross).

It is worth noting that this scenario addressed the same system challenges as those targeted by the WA State Government's Emergency Solar Management (ESM) Scheme – introduced in February 2022 –, but contemplates an opt-in, pre-emergency service that can provide an expanded range of equipment and capabilities, and also provide customer with a direct financial benefit – that ESM does not. Testing of this scenario also aimed to understand the value of constrain to zero product to customers.

In constraining export to net zero, the limit is set at the metering connection point – generally a resident's house –, by either limiting the DER asset – normally a solar PV asset – to zero export (still enabling it to generate for customer self-consumption – unlike ESM), or if it still exports, by instructing a battery storage asset at the same connection point to import to the point where the overall export of electricity at the connection point becomes zero, as displayed below:

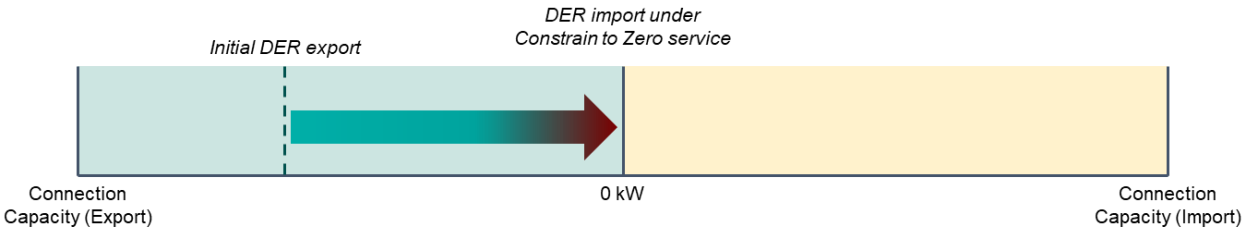


Figure 28: Constrain to net zero at the metering connection point example

Where constraining to net zero keeps DER assets actively operating, constraining export to gross zero refers to switching DER assets off so to achieve zero generation at the source, which is likely to result in energy being imported from the grid. This is depicted in Figure 29.

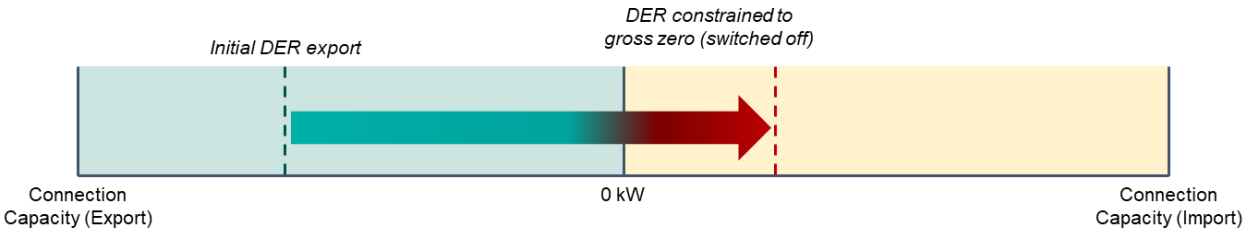


Figure 29: Constrain to gross zero example.

As part of the pilot, Project Symphony sought to demonstrate the use of the project partners' platforms to dispatch an instruction to the Parent Aggregator to constrain energy output from customer rooftop solar and battery storage assets at times of system low demand. As constrain to zero is not currently a defined market service[37] available under market regulations, the pilot sought to use insights gathered from this test scenario to provide recommendations on future regulatory guidelines.

While testing activity, particularly in May 2023, it was demonstrated that the Symphony VPP was able to participate in constraining solar PV to both net and gross zero in generally efficient and effective way. However, results differed depending on whether the instruction was to constrain to gross or net zero.

[37] Can participate as part of NCESS

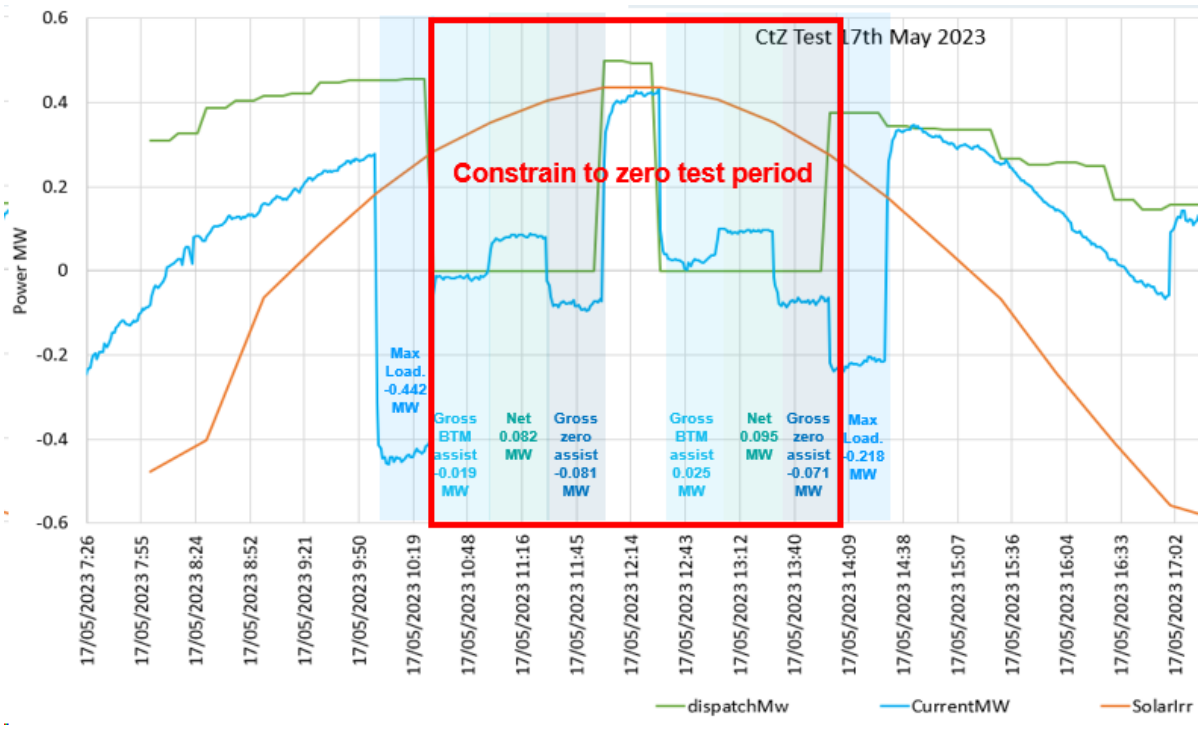


Figure 30: Constrain to zero test example – 17 May 2023

CtZ Gross BTM Assist: Represents instruction to curtail PV generation to cover BTM loads for PV systems only, while allowing the BESS assets to continue to supply the BTM load where such system exist.

CtZ Net: Controls all available assets via the gateway device to achieve a target measure of zero net injection at the connection point.

Gross zero assist: Represents a PV and BESS resource level response via the gateway device in an attempt to achieve load at the connection point through full PV curtailment and zero battery discharge to supply BTM loads.

As evidenced in the test graph above, aggregated DER participation (blue line) in the constrain to zero scenario achieved or beat target instructions (green line) when in the constrain to *gross* zero capability (blue line meeting or below the green line – demonstrating export at or below zero levels). Whereas, in the constrain to *net* zero capability, results fell short of target (blue line remaining above the green line, demonstrating energy export above instructions). The difficulty in achieving targeted net zero capability is largely due to complexity of managing solar PV, battery storage assets and uncontrolled load to achieve a balanced, or net, position.

Overall, key findings from testing the CTZ scenario include:

- Successfully tested the capabilities of the VPP in constraining customer rooftop solar to both net and gross zero with compliance consistently between 86% to 98%.
- Compliance with DOEs also improved for the CTZ tests achieving ~66% compliance.
- Value engineering of the relatively high technical cost to enable participation in the CTZ scenario will be required.
- Should CTZ be enabled via a cost-effective technical solution and become more prominent as a service, the DSO would need to implement monitoring activities to fully understand the impact *frequent* CTZ events may have on network forecasting.
- The demonstration that a VPP could deliver a range of unique capabilities that could be packaged for NCESS procurement.
- The applicability with the minimum demand NCESS contract, to enable the unique range of capabilities to be packaged for NCESS procurement, and provide financial value to the Parent Aggregator, and customer.

5.5.4. Essential System Service (ESS) Contingency Reserve Raise

In simple terms, when frequency deviation of substantial magnitude is identified, the system has been designed to automatically respond to the event, which is then measured, as there is no time for control signals to be sent. Energy storage assets will automatically discharge their load and inject energy into the system, to raise the frequency back into normal operating range. This can all happen in a matter of seconds to minutes.

The Contingency Raise Service keeps generation capacity in reserve to maintain frequency stability following a sudden loss of generation. It is provided by Facilities which hold capability in reserve to rapidly adjust output or consumption in response to significant changes in their local frequency. Level of reserves required to maintain the system secure depends on:

- Size of contingency
- System conditions (demand, load relief, system inertia)
- Facilities' Tau factor

In figure 31, a conceptual chart identifies the relationship between the different durations of services to restore the frequency back into a Normal operating frequency band.

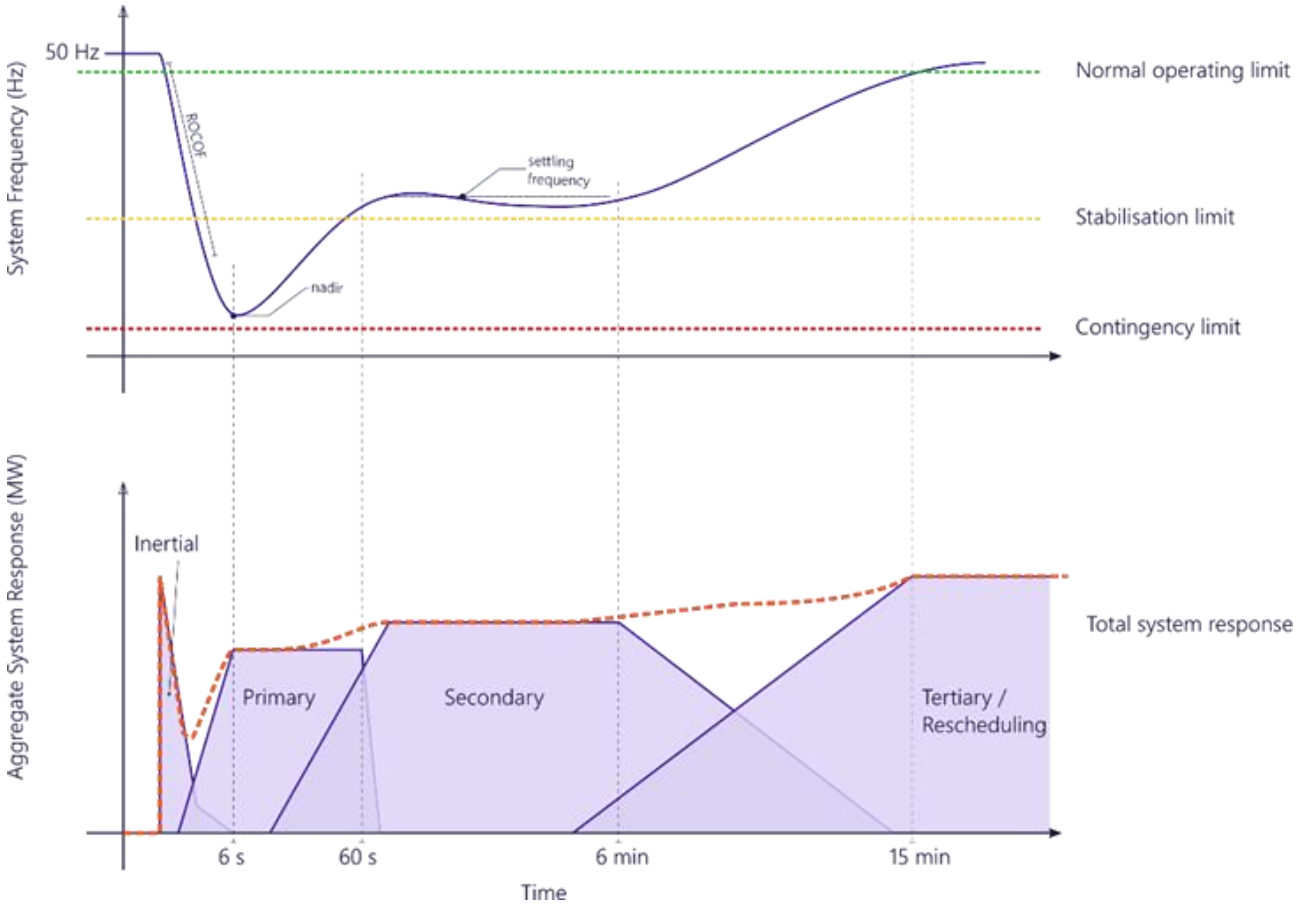


Figure 31: Restoration of frequency using ESS - Contingency Raise service.

The Very Fast inertial (Rate of Change of Frequency - ROCOF) service begins outputting straight away, ramping up to its full output within 1 second.

At six seconds, the Primary service begins delivering. The ROCOF service, having reached its target output, can now ramp back down to its original (energy market) target dispatch.

At 60 seconds, the Secondary service begins delivering. The Fast service can now ramp back down to its energy market target dispatch.

At six minutes, the Tertiary (6-15 minute) service begins delivering. The Secondary service can now ramp back down to its energy market target dispatch, whilst the Tertiary reaches its max output.

The ESS-CRR scenario was identified as one of the four 'must-have' scenarios to test in Project Symphony given it is an established service under existing frameworks, in which more traditional large scale battery assets participate in. As such, Project Symphony aimed to test the ability of aggregated DER assets to also participate. Additionally, similar trials and pilots have been run at a national level which have demonstrated the ability for aggregated DER to effectively play in similar services.

Whilst the converse scenario exists – in the Essential System Services – Contingency Lower –, this scenario was ultimately determined to be one of the two 'nice to have' test scenarios, that ultimately was not tested through the pilot.

Pilot testing ultimately sought to demonstrate the DMO platform's capability to identify the occurrence of a contingency event, and address it including the use of DER. The platform would detect a low frequency event and send a signal to the aggregator platform, instructing it to rapidly increase the electricity fed into the system from identified DER asset(s) to assist with raising and restoring the frequency in the system.

The testing of the ESS-CRR scenario occurred in both simulated situations as created by the project team and in response to 'real-life' examples.

The ability of aggregated DER to participate in ESS-CRR was clearly demonstrated on a number of occasions, including when at 1:14am on 6 July 2023, a real contingency event occurred due to the Cockburn power station tripping, resulting in a loss of approximately 260 MW and frequency falling from a stable level ~50Hz to 49.66Hz. The Symphony VPP responded to the frequency drop. Once the frequency dropped below the 49.975Hz threshold, the VPP responded by injecting the required amount of energy automatically and almost instantaneously to do its part in helping to return network frequency to stable levels. In this scenario, a combination of the Harrisdale and the City of Armadale battery storage provided most of the response.

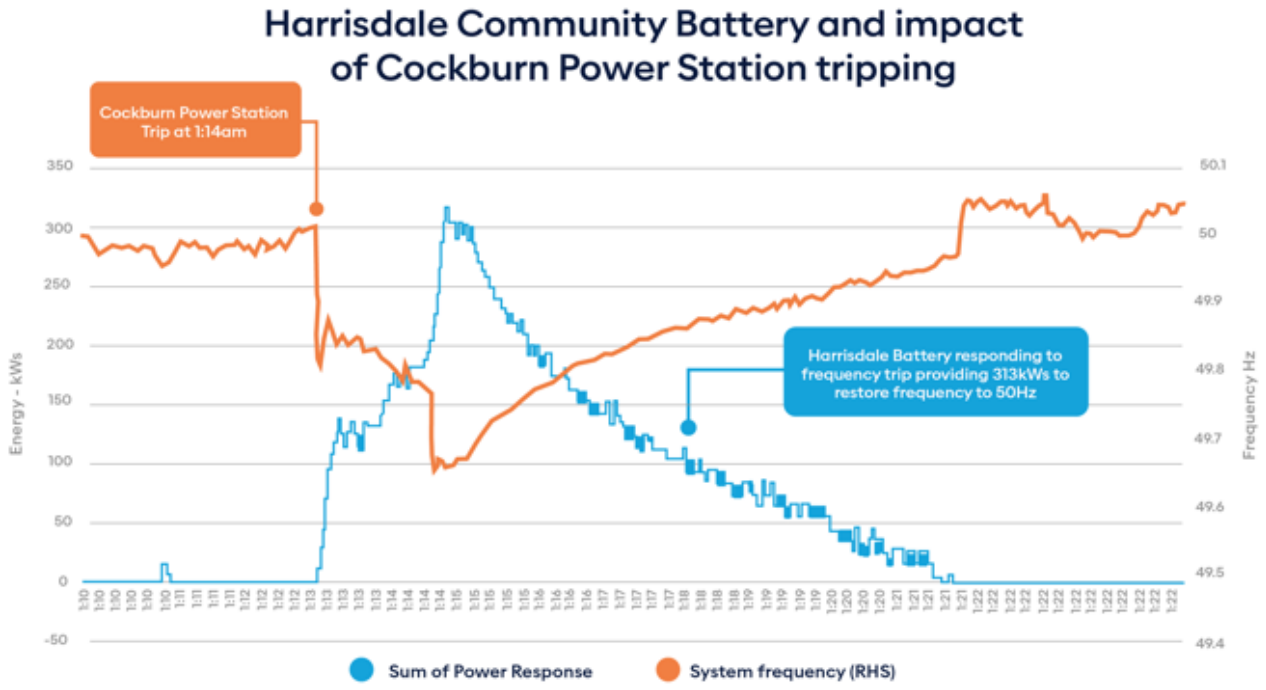


Figure 32: Cockburn Power Station trip ESS-CRR response graph

These promising results were backed up on two weeks later on 20 July 2030 at 1:16pm, where another contingency event occurred, when 4.5kW of residential battery storage assets responded and provided the necessary energy injection to restore frequency to normal operating conditions.

Overall, Symphony demonstrated the ability of aggregated DER to participate in the ESS-CRR value stream by providing contingency raise responses to both simulated and real frequency contingency events from customer-owned and network battery assets.

As a result of the ESS-CRR scenario testing, a number of key findings and lessons were identified:

- State of charge is a critical consideration in effective participation of aggregated DER in ESS-CRR. In short, ESS-CRR cannot be facilitated through aggregated DER where battery storage assets do not have any charge. Further consideration is required on how to optimise state of charge to enable participation in ESS-CRR, noting opportunity costs.
- Given the speed in which contingency events can occur, to facilitate ESS-CRR, high-speed data recorders were confirmed through Symphony as necessary, to accurately report on delivery of energy against existing FCESS standards.
- Further work is required to understand how residential battery storage assets respond to network frequency events, given lack of visibility.

5.6. Technical lessons learnt and recommendations

Recommendation 1.1 – Adopt a single communications protocol for all inverter-based DER (CSIP-AUS) to maximise asset interoperability.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Synergy	January 2025

Symphony scope

Successful orchestration requires DER assets to establish communication with, and respond to, commands sent from the Parent Aggregator platform.

To test orchestration in the Symphony VPP, Synergy as Parent Aggregator recruited a representative mix of DER asset types consisting of solar PV and battery storage, as well as air conditioners and hot water systems. Of the 911 assets recruited, 714 were orchestrated as part of rigorous testing.

Experience and findings

The discrepancy between DER assets recruited and orchestrated as part of the Symphony VPP was largely caused by technical issues associated with lack of reliable communication and interoperability between the Parent Aggregator Platform and the DER assets. The overall impact of this contributed to Symphony achieving technical feasibility as opposed to technical viability, and somewhat diminished the confidence of replicating the results at scale.

A significant amount of existing / legacy customer DER assets (from residential customers and TPAs) had limited seamless or standard interoperability with the Parent Aggregator platform despite it being one of the more advanced solutions in the market. This resulted in several asset types and some disappointed customers unable to participate in Symphony.

Limited interoperability was in large part due to limited availability and/or adoption of interoperability standards by original equipment manufacturers (e.g., air conditioner incompatibility with AS4755 control standard), non-compliance of DER assets with existing standards (such as AS4777, which impact volt-var settings) at point of installation, or the changing of settings within DER over time.

Through Symphony, 32 different rooftop solar PV and battery storage inverter models across 7 manufacturers were recruited. This was done purposefully to obtain as wide a representation as possible of the different inverter makes and models within the SWIS and to test their ability to be communicated with and respond to commands as required to achieve orchestration.

Although inverter-based DER is a relatively mature technology, manufacturer design and production of these assets, particularly in terms of communication and interoperability, has not been considered under an industry standard approach, resulting in inconsistent application and performance.

The impact of this was experienced in Symphony, where inverter-based DER varied significantly in terms of model variants, firmware versions, capacity and location. This resulted in significant challenges when attempting to achieve seamless communication and integration between inverters, gateway devices[38] and the Parent Aggregator's platform. In simple terms, without seamless and reliable communication with the DER inverters, orchestration is unable to be facilitated effectively.

To overcome this challenge, an intermediary 'gateway device' was procured, set up and then installed at each participating customer's premises through which all orchestration commands to the various DER were translated. This also required Original Equipment Manufacturers to augment existing DER assets via a software or firmware patch to the inverter and/or gateway device as required, and in some instances required older inverters to be replaced with newer models.

In some cases, multiple customer site visits were required to troubleshoot communication issues. Instances were recorded where some customers with solar PV assets, particularly air conditioner assets (see Recommendation 4.5), were unable to participate in the pilot due to the prohibitive effort, time and/or cost associated with making their existing assets 'orchestration ready'.

Overall, the lack of a standard communications protocol within DER inverters led to increases in technical cost and effort to enable orchestration, reduced the available pool of DER to recruit from, made product development challenging, and at times negatively impacted the customer experience. Despite the challenges, significant evidence-based lessons were learnt, including the need to address the root cause of insufficient interoperability by establishing a common 'language' for DER orchestration.

The way forward

To enable the seamless integration of inverter-based DER for the purposes of VPP participation, it is recommended that SA HB 218 "*Common Smart Inverter Profile – Australia with Test Procedures*" (CSIP-AUS), which utilises protocols of *AS5385:2030 "Smart Energy Profile Application Protocol",* is adopted for all new inverter-based DER installations in the SWIS. Given past standards have been interpreted and adopted to various levels, it is recommended that adoption of AS5385:2030 is mandated within the SWIS.

The main benefit of CSIP-AUS, for the SWIS, is that it would allow aggregators the ability to communicate with inverter-based DER assets in a consistent and reliable way regardless of the equipment manufacturer type. This includes communications to enable security features and pass on commands from the aggregator to DER inverters in a common format. This then maximises asset interoperability, leading to a simpler, more cost effective and streamlined approach for customer assets to be orchestrated within a VPP.

[38] The intermediate asset which translates data from DER assets into a common format for the aggregator platform

Deep Dive

CSIP-AUS is the Common Smart Inverter Profile – Australia (CSIP-AUS), which was drafted by ARENA's Distributed Energy Integration Program (DEIP) and Standards Australia in 2019. CSIP-AUS has been based off other existing standards, namely the IEEE 2030.5-2018 specification, and the Common Smart Inverter Profile (CSIP) standard first implemented in the USA.

The CSIP-AUS standard provides a minimum set of requirements and implementation guide for communication and security between devices, and DER inverters for dynamic and static commands, whilst providing original equipment manufacturers operational and design flexibility while remaining compliant with the CSIP-AUS protocol.

Australian Standard 5385:2023 aims to help the Australian energy sector to implement CSIP-AUS and easily access the important best practice information that will ultimately support the move to the Smart Grid and energy transformation.

From a national perspective, demonstrable progress is being made in CSIP-AUS and AS5385 development, facilitated through the Distributed Energy Integration Program (DEIP) Interoperability Steering Committee, and implementation across various National Energy Market (NEM) jurisdictions. An example of this progress is evident in the *Flexible Exports for Solar PV* project in progress by the SA Power Networks.

Under this recommendation, CSIP-AUS and AS5385 adoption would not apply retrospectively to inverter-based DER that are already installed, however it may be possible that an 'opt-in' provision is possible for some existing equipment.

Whilst this recommendation is a critical enabler in accessing and unlocking greater benefits from DER orchestration, the adoption of CSIP-AUS or AS5385 will need to take the following into consideration:

- Assess the limitations of CSIP-AUS, and the full extent of the AS5385 protocol and commands, which may lead to the requirement for revision and update as further use cases, including non-inverter based DER, and applications are developed.
- Lead time required to engage and communicate the impacts of CSIP-AUS and AS5385 to original equipment manufacturers (OEMs) prior to the required adoption date. Further, it needs to be recognised that this may have the impact of reducing the number of inverter models available in WA should OEMs not comply or delay compliance[39].
- Consideration of the appropriate mechanisms to mandate adoption of CSIP-AUS and AS5385 in the SWIS.
- The applicability of CSIP-AUS on all customers – including contestable customers, and across a wider range of DER – such as non-inverter based DER.
- The requirement – and costs and benefits – of CSIP-AUS compliant server interfaces to be assessed by the Parent Aggregator and the DSO.

It is noted that there are currently national efforts underway to establish test and certification requirements for equipment to the considered CSIP-AUS compliant and securely registered (PKI).

[39] The risk will need to be assessed as part of industry consultation. At the time of this report the risk is considered low.

Western Power and Synergy have provided EPWA with a plan confirming where CSIP-AUS adoption is appropriate including the outlining of original equipment manufacturer consultation and adoption for the SWIS.

This recommendation closely aligns to DER Roadmap action number three – 'Evaluate appropriate mandatory standards, communications functionality, and protocols for remote management of DER, including electric vehicle equipment, and establish a plan to implement.'

Recommendation 1.2 – Develop the business case for a 'DER Data Hub' to facilitate effective and efficient DER data exchange between the DMO, DSO and Aggregators.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Western Power	December 2025

Symphony scope

Symphony required complete, accurate and timely DER data to enable orchestration, and platform integration processes that support efficient data exchanges between the DMO, DSO and Parent Aggregator.

Complete, accurate and timely DER data is critical as it provides the baseline 'standing' information such as DER asset location, size/capacity, and type (generator and/or load) to enable DER orchestration to occur.

This data is necessary for the DSO in calculating and publishing optimal Dynamic Operating Envelopes and other operational information such as the forecast movement of energy based on DER asset performance as well as facilitating settlement data.

Accurate DER data assists aggregators in targeting and recruiting the right type and concentration of DER to be aggregated as part of providing a Network Support Service that could be used to alleviate a network constraint such as peak demand.

For the DMO, there is benefit in having DER assets with unique identifiers, and their make up within an aggregated facility could be monitored as well as facilitating switching of devices from one facility to another for the purposes of market participation.

To meet the needs of Symphony, accurate DER standing data had to be created as a combination of data collected via the existing DER Register, and then cross referenced with actual participating DER data as provided by Synergy. This DER standing data was established as a 'single source of truth' for Symphony.

Experience and findings

Complete and accurate DER standing data had to be created for the purposes of Symphony as the existing DER Register data was in some cases found to be incomplete in terms of data timeliness and completeness, due to the following:

- The time difference between DER being added, upgraded and or removed – and being updated in the DER Register – did not align with the requirements of the technology platforms for dispatch schedules in the load forecast, and the need to adhere to project testing schedules.
- The requirements of the existing DER Register only captured solar PV and battery storage and does not capture any type of controllable load such as air conditioners or electric vehicles in the future.
- Does not capture which DER is or isn't participating within aggregated facilities.

Whilst the pilot's DER standing data ultimately achieved the requirements for the pilot and enabled each project partner to deliver on their role and responsibilities, there were notable gaps in creating and updating the data, and which ultimately informed the need for complete and accurate DER data as a prerequisite for scaling.

The way forward

Given the challenges faced in Symphony, as well as related work undertaken by AEMO as part of DER visibility in the WEM and as part of the DER Roles and Responsibilities work, it is recommended that a business case is created which considers developing and establishing a DER data hub as the 'single source of truth'. The data hub would be accessible under certain access arrangements by such entities as the DMO, DSO and SWIS aggregators. This includes the Parent Aggregator, TPAs for non-contestable customers, and aggregators for contestable customers. Additionally, it may serve as a common data exchange solution between the relevant parties.

The development of a business case should consider:

- Various technology options, the type / level of data required in the data hub (e.g., standing data only, or standing and operational data),
- Assess the current limitations, learn from and improve the existing DER Register,
- Roles and responsibilities in ownership and custodianship of the data hub,
- Accessibility rights by relevant parties, and
- The appropriate legal framework to enable collection of necessary information from installers etc.

At a minimum, the DER data hub should be established as a common database for storing and accessing standing data for all parties, and an extension and evolution of the existing DER Register (building on the recent improvements released in October 2023), and will require:

- A common interface and architectural alignment between the DMO, DSO and aggregators.
- Accessibility rights that align with the roles and responsibilities for shared data between the DMO, DSO and aggregator/s. Further, consideration should be placed on if, and to what extent, DER installers in the SWIS would have access.
- Technical specifications and certifications, which appropriately consider security, reliability, accuracy, confidentiality and compliance standards.
- Governance and processes to enable data verification and auditability.
- An agreed data exchange / file transfer methodology, patterns and formats, which aligns with the DMO, DSO and Aggregator/s use cases, to update information and reduce the complexity from potentially many types of data integration and transfer methods.

The development of the business case must prioritise key tenets such as privacy, security, data accuracy, reliability, completeness, timeliness, and ease of data interpretation and usability between the DMO, DSO and aggregators.

High quality data will enable the following potential use cases:

- **Aggregator/s** – More efficient or cost-effective customer targeting, and recruitment based on accurate information about the existing DER they own for potential participation in a VPP, and/or enabling optimal incentives to be developed for the take up of new DER based on location as well as the type of services / products required.
- **DSO** – Efficient calculation, estimation and forecasting of more accurate network demand and generation forecasts based on an understanding of the type, capacity, location, and likely performance of DER and their collective impact on demand, particularly at peak time. Accurate DER data information is also required to more optimally calculate available network hosting capacity to inform the publication of dynamic operating envelopes. Additionally, accurate capacity, type and location data of DER, informs the opportunity for Network Support Services to be procured in a certain area to alleviate a network constraint.
- **DMO –** Adequately assess potential system security issues specific to DER penetration in the SWIS via assessing likely swings, peaks, and troughs as well as the impact of cloud cover on overall system security. Large swings in the generation required to meet the system demand – in the event of cloud formations blocking the sun and limiting households from generating their own energy – can result in challenges with system stability if not more proactively managed.

Whilst this recommendation is a critical enabler in accessing and unlocking greater benefits from DER participation, the delivery of this recommendation will need to consider the usability and/or expansion of existing data repositories, the need for parties to have their own additional databases and development and implementation of new processes.

EPWA has acknowledged the challenges in collecting complete and accurate DER data as well as the benefits and are looking in part to enable Synergy and/or Western Power to monitor ongoing DER compliance with DER connection standards, as well as obtain the necessary information from DER installers through the progression of the Electricity Industry (Distributed Energy Resources) Amendment Bill 2023.

This recommendation closely aligns to the completed DER Roadmap action number 15 ‘Deliver a register of static DER data for the SWIS, with processes to support data collection and future DSO functionality.’ A new or revised action should be added to the DER Roadmap to account for this recommendation.

Recommendation 1.3 – Develop specifications around Parent Aggregator service delivery standards to accelerate compliance with service delivery standards in the WEM.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	AEMO	December 2024

Symphony scope

Critical to evaluating the performance of aggregated DER as a facility included the development, implementation, and testing of:

- DOEs by the DSO as the near real time parameters within which DER can safely participate during any given 5-minute interval,
- DIs by the DMO as the required amount of energy to be injected or withdrawn by the facility, in this case aggregated DER facility, during any given 5-minute market interval.

In orchestrating DER, Symphony measured and assessed the ability of the Parent Aggregator to comply with these instructions as an important indicator of technical feasibility and viability.

In Symphony, compliance was measured as a percentage of instances in which the Parent Aggregator was able to comply with the instructions during the orchestration of an aggregated DER facility.

Experience and findings

To measure compliance with dispatch instructions, standards were derived in part from existing WEM requirements and performance specifications as a representation of real market requirements. For Symphony purposes, a general indicator of non-compliance with *dispatch instructions* occurred when energy injection / load requested was greater or less than 5% of target[40] per relevant time interval. These compliance standards were established once the pilot was substantially progressed and a suitable level of base capability demonstrated.

Overall, testing of the balancing market scenario as the base market service was used as the main indicator of compliance. Testing of this scenario showed that compliance was inconsistent and varied greatly with average compliance for both DOEs and dispatch instructions achieving ~50%. Further, Parent Aggregator platform capability was limited to responding to pre-dispatch instructions, only providing for a period of computation ahead of the delivery of energy. Dispatch instructions were inconsistently met with under-delivery of energy being the most common cause, indicating that NMI level aggregator forecasting and optimisation capability requires further focussed development.

Figure 33 below shows whether dispatch performance met dispatch instructions during testing events with some evidence to suggest compliance improved towards the end of the stability period.

[40] In this context, 'target' refers to the optimal injection or withdrawal capacity, as stated by the Parent Aggregator through facility registration.

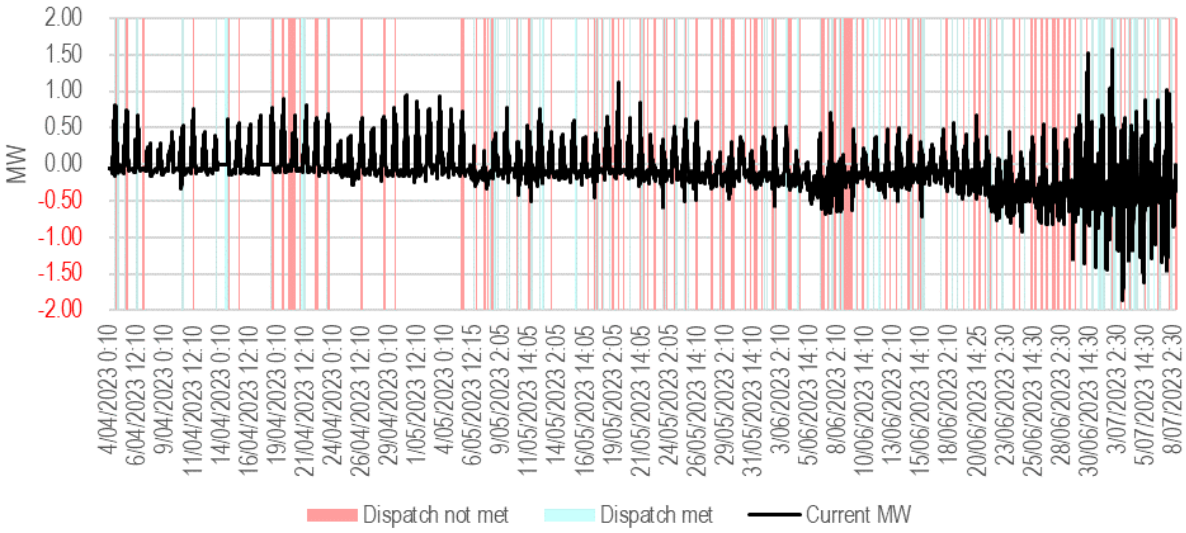


Figure 33: Dispatch performance meeting Dispatch Instructions. Highlighted Dispatch areas identify dispatch events (excluding self-dispatch) and whether events were within tolerance or not

In the real-time energy market, a facility is required to meet its specified dispatch instructions on a consistent basis. If a facility does not meet its requirements through performance monitoring, it would be considered non-compliant and would be excluded from operating in the market. While Symphony demonstrated inconsistent compliance with a range of performance specifications, it has provided a foundation to continue to test and develop capability to improve performance to participate in the WEM in the future.

The way forward

Whilst further testing and improvements in compliance to dispatch instructions and dynamic operating envelopes is required – and therefore to be considered a viable service – it is recommended that an appropriate standard which defines the DER specific compliance thresholds is established. Specifically, these standards need to define necessary performance thresholds for foundational services and provide the flexibility to expand to add new services over time, and also outline how aggregated DER will interact with DMO systems and provide / receive data for operational requirements.

In addition to the compliance thresholds / targets, this standard, or supporting contractual structures, should include a framework to report compliance breaches (which may already exist and just be repurposed), track progress and escalate longstanding breaches with prescribed actions for continued non-compliance.

Without this standard, the Parent Aggregator will be unable to effectively set itself up with the requisite technical capabilities for wide-scale DER orchestration, resulting in a reduced capability to access value streams.

As part of this recommendation, additional consideration should be held on the development of service delivery standards for other aggregators in the SWIS and should be read in conjunction with:

- Recommendation 3.1 Commence work on policy solutions to establish market frameworks that support the participation of DER aggregations in the WEM.
- Recommendation 3.4 Establish clear frameworks to enable TPAs to engage with the Parent Aggregator for non-contestable customers, to reduce barriers to entry and ensure consistent customer experience.

This recommendation somewhat aligns with action 27a 'implement initial changes to WEM Rules to enable development of DMO functionality and DER aggregator participation in the WEM' and 28a 'commence implementation of changes to wholesale market arrangements necessary to enable the participation of DER in the wholesale market via a DER aggregator' in the DER Roadmap. However, clarity may be required on the interaction between the Parent Aggregator as the market facing entity and TPAs.

Recommendation 1.4 – Explore opportunities to establish platform and communication solutions, such as AMI, to lower risk and achieve greater efficiencies.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	Western Power and Synergy	December 2025

Symphony scope

As part of Symphony, substantial time, effort and cost was incurred in establishing the appropriate technical capability to underpin DER orchestration while also helping AEMO, Synergy and Western Power to deliver on their emerging DER-related roles and responsibilities in practice.

AEMO, Synergy and Western Power – in their respective roles as the distribution market operator (DMO), Parent Aggregator, and distribution system operator (DSO) – designed, procured, built independent technology platforms before integrating and testing them as part of a single end to end solution.

Further, to ultimately achieve orchestration, the DER assets were required to register and integrate with the 'front end' of the Parent Aggregator platform. This required the installation of ancillary assets for communication, monitoring and measurement such as gateway devices, power and other site meters, data recorders etc. at most customer sites.

Experience and findings

Through the individual build and then integration of three platforms, end-to-end data flow is established from customer DER to off-market settlement via (AEMO) as shown in Figure 34.

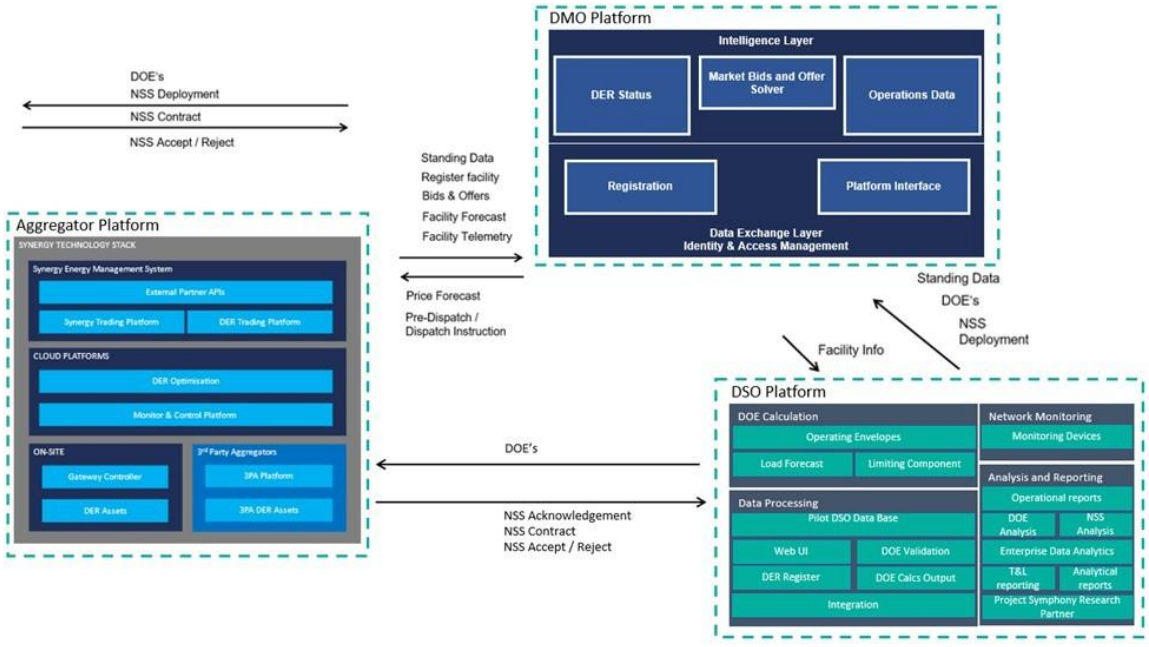


Figure 34: Conceptual platform design and function[41]

While capable of greater scale, the platforms themselves were originally developed with the aim of delivering Symphony as a pilot rather than scaled DER orchestration being the objective.

Figure 35 provides an overview of the platform-to-platform integrations developed to enable end-to-end transactions.

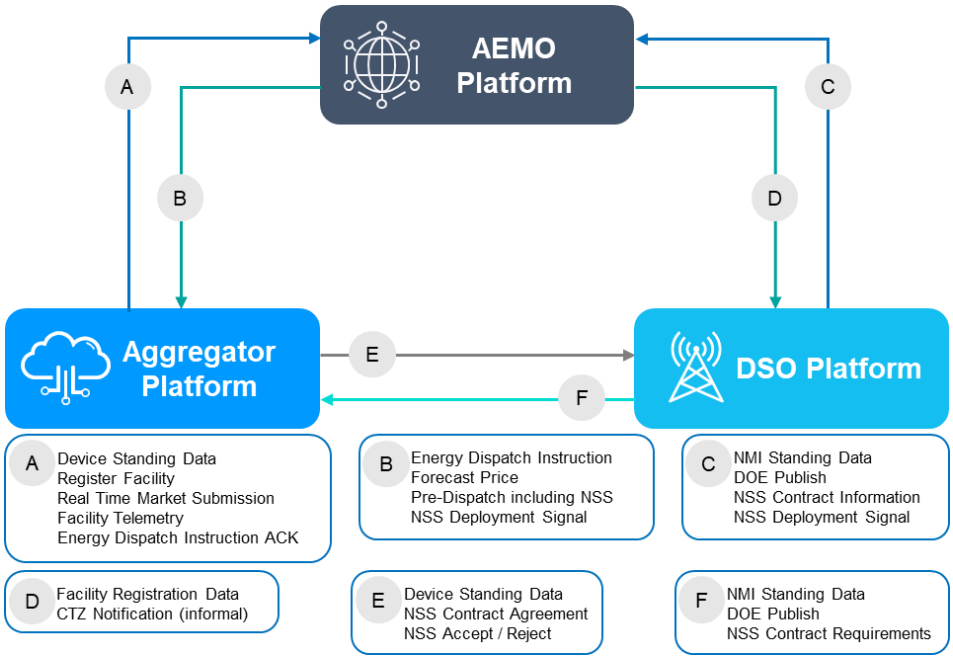


Figure 35: Platform-to-platform integrations[42]

Platform related activities commenced with each project partner largely developing their own functional and non-functional requirements. This was followed by separately timed, uncoordinated procurement processes which contributed to a lack of clarity on strategic objectives, roles and responsibilities and technical requirements as experienced by some vendors[43].

At the time of procurement, solutions were in the early stages of maturing, as most vendor solutions were designed as 'stand-alone' solutions or were designed with the intent of being integrated into a suite of solutions. Seven different vendors across six time zones were engaged to complete the technical elements of Symphony, stemming from core operational platforms to platform and asset integration. Further, while the original intent was to leverage as much 'off-the-shelf' capability, given the leading-edge requirements of Symphony, design and build activities resulted in significant customisation and co-development being required which impacted budgets and the overall schedule. For example, Synergy's Energy Management System (SEMS) / Parent Aggregator platform consisted of both custom-built elements and vendor sourced SaaS hosted commercial off the shelf solutions. Initial misalignment on requirements with vendors – namely that the build missed establishing the capability to support TPAs being incorporated into a VPP facility – resulted in required rebuild and increased complexity in platform build.

[41] Western Power, Synergy, AEMO, & EPWA, 2023, Project Symphony: Combined Platform (as built) Report for DSO, DMO and Aggregator. p. 21: https://arena.gov.au/assets/2023/10/Western-Power-Project-Symphony-Combined-Platform-Report.pdf
[42] AEMO, Project Symphony: API Specification Report
[43] *Project Symphony Lessons Learnt Report 1*: https://arena.gov.au/knowledge-bank/project-symphony-lessons-learnt-report-1/

As the suite of DER orchestration solutions continue to mature in the market, it is expected that consolidation will occur. As experienced during Symphony, two vendors were taken over by other companies while two others either changed strategic direction or exited the Australian market.

As noted prior, in order to achieve communication and interoperability with DER assets as well as monitoring and measurement of performance, separate hardware was installed at each customer site (see Figure 36). Over the life of Symphony, the cost of installing communications hardware – including materials and labour – added $2.5m to the cost of the pilot. Finally, while these devices generally performed well for a pilot, performance will be required to meet or exceed production level performance required of more critical assets – particularly if VPP facilities are to become integral to providing a market or network service.

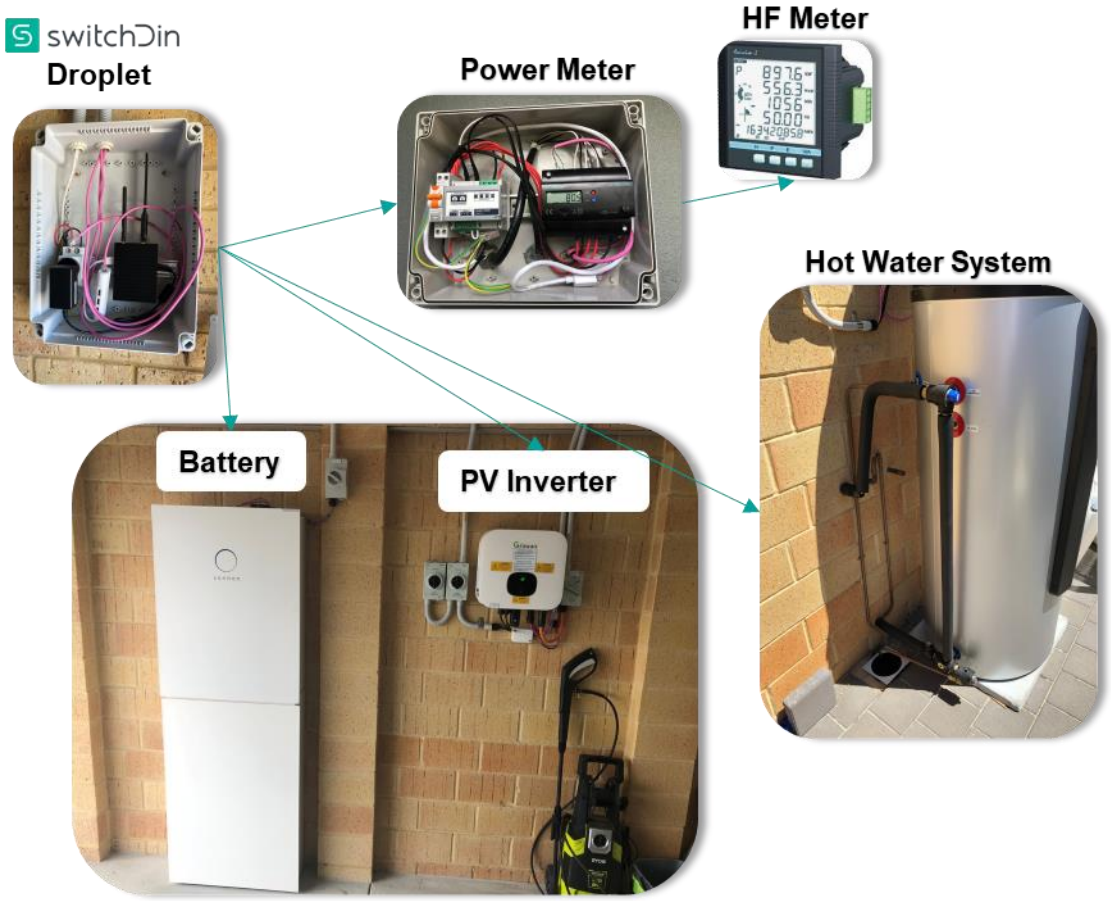


Figure 36: Example customer installation

The way forward

Given the experience, and challenges, of Symphony in building and operating a highly integrated, end to end solution as well as achieving a greater understanding of the communication, monitoring and measurement requirements of DER participation, it is recommended that greater collaboration occurs, particularly between the Parent Aggregator and DSO in the planning for scaled application as follows:

- Conducting value engineering of existing 'platform' and communications solutions.
- Conducting ongoing technology options assessment of 'platforms', including design, technical requirements etc. and joint market briefings in procurement processes as may be required for scale.
- Assess the applicability of some vendor solutions that include a single platform capable of delivering on DSO and Aggregator requirements as used in other jurisdictions.
- DSO and Parent Aggregator assess the relevant experience and lessons from other jurisdictions as platform technology is increasingly deployed and matures.
- DSO and Parent Aggregator to present on respective technology roadmaps as part of the DERRCC.

As a single example of a potential 'stepping-stone' opportunity to achieving greater efficiency, reliability and security in *communications* with DER, consideration should be given to evaluating Western Power's AMI.

Western Power is currently progressing the installation of AMI, which includes both metering assets, and a highly available, reliable and secure mesh communications network, within the SWIS. AMI was installed at each home in the pilot area for measurement of power flows, some validation of services and as input to the calculation of DOES, achieving an average availability of 99.67%.

Importantly, when assessing any option consideration needs to be given to the following:

- Types of meters (dual or multi-element for example).
- Ability to produce data of the right resolution and latency.
- The existing capacity and availability and augmentation costs as required.
- Redundancy and backup options.
- Managing cybersecurity risks.
- Maintaining the ability to deliver on existing use case/s.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action should be added to the DER Roadmap to account for this recommendation.

Recommendation 1.5 – Establish a 'DER Test Lab' accessible by DSO, Aggregators and DMO to prototype and test DER integration products and solutions prior to rollout.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	Western Power	December 2024

Symphony scope

As part of testing the end-to-end capabilities of DER orchestration in the SWIS, new and existing DER needed to be registered and integrated into the Parent Aggregator platform via a gateway device. Installation of a gateway device was required to communicate with rooftop solar inverters, battery inverters and with air conditioner control devices such as DRM cards that also had to be sourced and installed. Further, monitoring and measurement equipment like high-speed data recorders and power meters were also installed in order to validate the performance of some DER assets.

Experience and findings

Whilst considered important, given time constraints, and an expectation of more seamless integration of existing DER assets, testing of technical solutions prior to rollout to Symphony customers was limited.

In August 2021, as part of Phase 1 of customer recruitment activities, early testing was conducted with three employees of the Parent Aggregator and limited to the gateway device, rooftop solar inverter and a single type of battery installation. This phase aimed to trial the requirements for registering a DER asset into the Parent Aggregator platform, as well as understanding the experience and capability of installation contractors and the three customers in a limited and controlled environment.

After Phase 1, three further sequential phases of customer recruitment immediately commenced, during which the following key findings were documented:

- A significant amount of existing / legacy customer DER assets had limited interoperability with the Parent Aggregator platform because of age, size, functionality etc., which resulted in DER assets unable to be seamlessly registered and integrated with the technology platforms.
- This limited interoperability was also in part due to limited and inconsistent adoption of applicable standards for air conditioners by original equipment manufacturers such as *AS4755 – Demand Response Standards.*
- Instances noted of gateway devices – which facilitated the communication between the DER assets and the Parent Aggregator platform performing intermittently.
- Customers remarking on how much equipment installation and retrofitting was required to make the household VPP ready – noting the 'accumulation' of an array of assets, which on occasion required up to 10 tradespersons attending a residency for up to 7-10 hours a day, for multiple days.

The way forward

With customer participation and experience being central to the success of VPPs, it will be important to ensure 'touchpoints' are reduced or optimised where possible, including limiting visits to homes to get associated technical solutions working reliably. To aid in this, it is recommended that a DER test lab is established, first and foremost to enable robust testing of all DER integration elements prior to interacting with customers.

Location, funding (including any 'fee for service' model as required) and accessibility requirements will need to be considered. The lab is envisioned as a physical facility in which various types of testing relating to DER orchestration can be facilitated prior to development of associated products and services. Western Power, as part of its recently opened South Metro Depot, has a dedicated test area for testing of network assets, part of which could be assessed for use as a DER test lab.

Such a 'test lab' could be accessible by the DSO, DMO and Aggregator/s (including the competitive market) as well as Horizon Power which has achieved some significant advances in DER orchestration albeit for power system security and reliability while enabling greater renewable energy hosting capacity.

Testing which would be facilitated through the DER test lab include, but not limited to:

- DER registration and integration testing – Existing brands, models, ages and types of DER as well as new DER brands and models.
- Alternate communication devices and meters.
- Demand response and load control devices.
- Inverter-based DER monitoring and compliance testing – such as ongoing compliance with *AS4777.2 Inverter Requirements* standard.
- Inverter functionality such as inertia and technical capability testing in the event of system restart etc.
- Ability to isolate assets in the event of a cyber-attack.
- Isolate or ring-fence opportunity to test improved compliance with dispatch instructions or DOEs.
- Overall, establishing and testing technologies which reduce the amount of equipment and installation required at customer site.

Practically, the outputs of the test lab could include work instructions, training guides, manuals, research white papers, and other pragmatic deliverables – such as technical requirements and standard amendments / recommendations – resulting from testing activities.

Ultimately, the facility would provide a safe and controlled location to prototype and test DER integration products and solutions prior to rollout, thus minimising impact on customers.

In delivering this recommendation, further consideration should be placed on any additional parties – such as installers and research institutions – which may have access to the facility, and refining the scope and purpose of the test lab, as this will assist in the definition of the physical and non-physical requirements of the facility, such as hardware, software, size, location – new or existing –, and any commercial models.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action should be added to the DER Roadmap to account for this recommendation.

6. Customer

Customer participation at scale is critical to the success of VPPs. Without customer understanding, trust, and the ability to gain greater value from VPPs, participation is likely to be low. As such, Symphony's design placed significant emphasis on customer objectives and their evaluation.

Customer engagement and recruitment activities were led by Synergy in its role as the Parent Aggregator, given their existing role as the monopoly retailer to non-contestable customers. With Symphony evolving customer DER assets from being passive to active participants in the energy system, Synergy was required to understand if traditional retail methods of engagement were readily transferable to the role of Aggregator when recruiting customers to actively participate in VPPs.

The scope of the customer pillar included:

- Designing customer-facing DER products for VPP participation, which include features such as financial incentives for new and existing DER assets, customer contracts and ensuring customers who participated were 'no worse off' overall.
- Developing a commercial product, and related engagement and recruitment, for orchestration of larger scale DER owned by at least one commercial and industrial customer.
- Engaging with and then recruiting ~500 customers and a minimum of 2 TPAs, and ~900 DER into the VPP. This included needing to recruit a representative mix of different generation and load based assets such as rooftop solar, battery energy storage and air conditioners within a specified target area[44].
- Procuring, installing and commissioning ancillary devices on each customer premise as required to enable two-way communication with DER assets.
- Providing ongoing engagement and customer support as required until completion of Symphony.
- Developing and delivering a social research report[45] in partnership with the University of Tasmania. This included evaluation of the engagement and recruitment activities as well as exploring customer preferences and their overall experience of participating in VPPs as part of a longitudinal research study.

The main Work Package delivered in support of the objective was: Work Package 3.3 Social Research Report[46].

[44] Work Package 1.1 Pilot Area Report
[45] Work Package 3.3 Social Research Report
[46] Work Package 3.3 Social Research Report

6.1. Objectives

Symphony's customer objectives were:

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

Pilot the role of the retailer/aggregator in facilitating customers' involvement in providing DER products and services.

6.2. Customer Engagement

The key objective of early engagement and recruitment activities was to raise awareness and onboard an initial group of mostly residential customers and their assets into the Symphony VPP. This included development of materials answering questions such as '*what is Project Symphony?*', '*what benefits are available?*' or '*what costs will be incurred?*', and more technical elements such as '*what is a VPP?*'.

As such, Synergy designed a phased approach to customer recruitment, to progressively learn and adapt to any recruitment challenges early, and prior to rolling out campaigns to progressively larger groups of customers in the target area.

The primary channels in which customer engagement was facilitated was through a combination of direct and broad-reach marketing initiatives as follows:

- Direct marketing: primarily through emails to customers, but also via direct mail, and at times supported by outbound calls.
- Broad-reach marketing: Synergy's website, targeted social media campaigns and community events – such as pop-up stalls in local shopping centre.

Customer recruitment activity was accompanied by criteria which determined customers' eligibility to participate in the pilot. To optimise results and make delivery more practical, the criteria focused on technical needs such as location, geographic solar PV concentration, accessibility to customer (i.e., households who were easily contactable) and expected value / contribution from customer DER assets as defined by the Parent Aggregator.

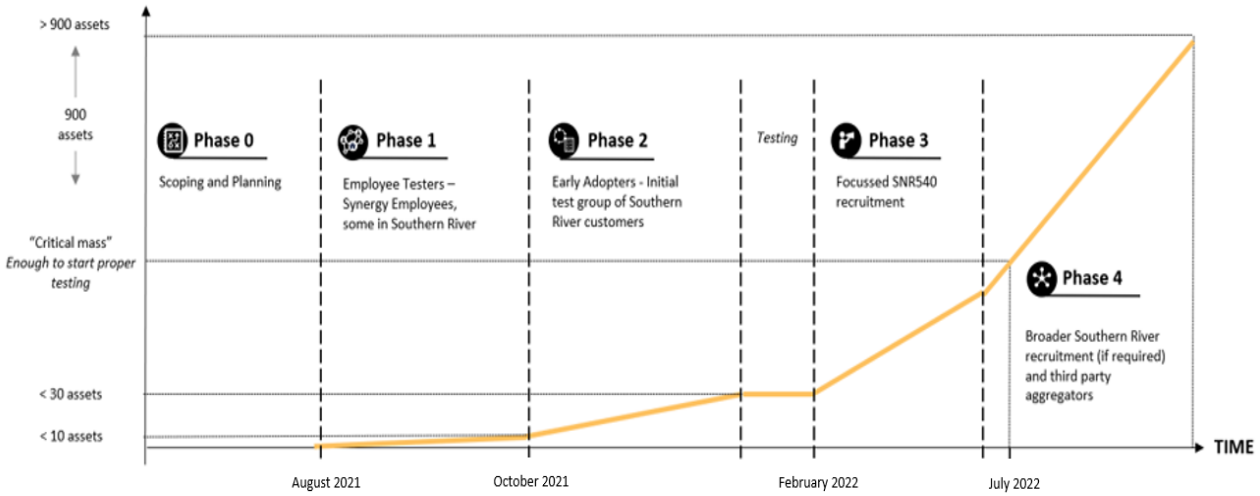


Figure 37: Project Symphony phased customer recruitment approach

Phase 1 of customer recruitment – conducted in August to October 2021 – focused on onboarding three Synergy employees in the pilot area who owned or were open to installing DER assets. The primary objective of this phase was to assess DER technology and contractors, with an emphasis on customer DER asset compatibility.

Phases 2 to 4 – conducted over October 2021 to July 2022 – expanded the recruitment pool iteratively, and while building on the lessons and experience of each prior phase, to the broader pilot area. This included the suburbs of Piara Waters and Harrisdale as the areas supplied by the Southern River zone substation (feeder SNR 540), in order to recruit the bulk of the 500 customers and 900 assets.

Phase 4 also saw recruitment of two TPAs – Rheem and Evergen – Plico which added 173 customers and 221 assets to the Symphony VPP.

Overall, 514 customers and 911 assets were recruited across four main asset types – solar PV, battery storage, air conditioning and hot water systems. The diverse mix and number of assets was purposefully designed to add rigour and hopefully achieve a high confidence level in being able to achieve similar outcomes at scale.

	Total	Solar PV	Air Con	Battery	Hot Water System	TPA
Target	900	300	280	150	30	140
Total recruited	911	292	218	150	30	221
Variance (Target-Total)	11	-8	-62	0	0	81

Table 4: Summary of Project Symphony Customer Asset Recruitment

Following the main recruitment phase and commencing orchestration (Orchestration phase 1), Synergy devised a new ongoing customer engagement plan following customer feedback requesting greater transparency and information shared on a timely basis. This engagement plan aimed at:

- Site re-visits were restricted to occasions when it was strictly necessary. However, some visits were still required and customers were contacted directly by the team and the details explained. The Synergy team found customers to be extremely patient and accommodating in these instances.
- Providing more timely updates on Symphony's overall progress.
- Providing more information on the objectives of Symphony, the benefits and its role in Western Australia's energy future.
- Sharing more timely information on the impacts of orchestration including orchestration insights and learnings.
- Foster ongoing customer connection and engagement opportunities.
- Create awareness of the collaborative nature of the pilot involving Western Australian Government, Western Power, Synergy, and the Australian Energy Market Operator.

Ongoing customer communications were predominantly facilitated through e-mail, including video, and were generally well received by the customers. This included providing dedicated personnel to answer customer questions via telephone.

Customer Demographics Snapshot

There were some dominant characteristics of customers which participated in Symphony, and notable differences when compared to a more general WA population. Demographics have been categorised into household demographics, and primary participant demographics – the single individual who represented the household in research activities and interacted with any pilot marketing and engagement.

Household demographics

- All 513 residential participants in Project Symphony were homeowners, with 79% of these having a mortgage. No renters were involved.
- 68% of participants were tertiary educated, with 70% being young families with dependent children.
- 50% of households had combined income over $150,000 – with the State median being $94,000.
- Pilot participant demographics
- 68% of pilot participants were male, which stands in contrast to the rough 50/50 gender split in Western Australia.
- 2/3 were in their 30s and 40s, with 70% engaged in a full-time occupation.
- Other demographic-related findings include:
- Homes tended to be newer than the state average, at 10 years old. This aligned with the primary pilot suburbs (Piara Waters and Harrisdale) being newer development suburbs, compared to the rest of the Perth metropolitan area.
- Of the participants, 97% of customers considered themselves conscious of their energy use, and majority are interested in reducing their energy consumption.
- Of the participants, most customers indicated that energy use is driven by comfort in the home, rather than cost.

The Outcome

- Pilot participants were likely to be in affluent and highly educated household with a heavy skew to male. Despite this high level of education and also being highly engaged with their energy use, feedback indicated that the language used in customer communications was too technical. Synergy responded to this by re-visiting the engagement approach and using the services of a copywriter for later communications.

6.3. Customer insights

In line with the objective of understanding customer preferences, research was conducted with pilot customers to understand their experience, how they felt about the pilot overall and broader societal implications. The research was also taken at pre-identified milestones, so customer feedback was able to be incorporated into future communication, in line with the test and learn approach of Symphony. This work was undertaken by Synergy in collaboration with the University of Tasmania and will be used to inform the future approach to customer engagement and recruitment for VPP products.

Along with research and lessons from other DER pilots and trials, this research is important to informing the future approaches to customer engagement. This includes the roles and responsibilities of the major actors in the WEM in raising awareness of VPP participation, and in particular testing the effectiveness or otherwise of traditional retail engagement models in achieving customer participation. This is also important given the constraints through which a Government Trading Enterprise retailer such as Synergy often needs to operate such as corporate brand and legal etc.

Given project time constraints, analysis on customer feedback was only conducted on residential customers recruited by Synergy and excluded TPA customers.

Overall, there were four key phases within the customer journey (see Figure 38) – onboarding, installation, orchestration ‘phase 1’ and orchestration ‘phase 2’.

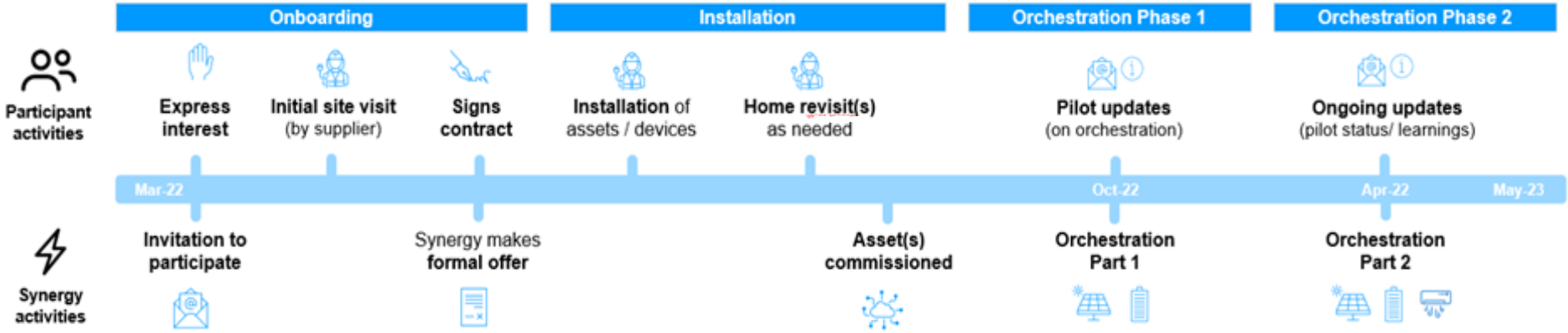


Figure 38: Key phases of the customer' journey

Customer experience fluctuated as Symphony progressed. There was positive sentiment initially, followed by a dip, as participants experienced orchestration for the first time. Sentiment later recovered because of access to more information and greater familiarity with the impacts of DER orchestration. General sentiment during each phase has been detailed further below, followed by the main lessons learnt.

Onboarding (or recruiting): Customers were largely satisfied with the sign-up process. Most notably, the ease of process, clarity of information and the level of communication throughout. Comments also alluded to customers' enthusiasm of being selected and involved in the pilot. Of interest, 71% of customers reported they were attracted to the pilot for environmental reasons. Of the customers who were deemed ineligible to participate, some expressed their confusion and disappointment.

Installation: This phase involved the installation of orchestration equipment at customer's homes; as well as new assets such as battery storage system, electric hot water system and / or air conditioners for those who received asset subsidies. Despite the time and effort involved, customers generally rated the experience positively. Quality of the installation work and professionalism of installers were stand outs for customers. However, for customers who required more installations or for whom installations were more challenging (e.g., physical space constraints), some were concerned with the number of site visits and length of site visits required to make their DER assets 'VPP ready'.

Orchestration phase 1: There was an increase in negative sentiment during the first phase of orchestration. This was driven by feelings of confusion and anxiety from customers expressing a lack of understanding of what was happening and why, concerns about how it might impact their electricity bill, or challenges experienced in getting help on technical issues. Orchestration activities were also notably more frequent and intense during this testing phase. Additionally, there were mismatched expectations about the purpose of orchestration. For some, there was a view that the pilot aimed to increase the use of renewable energy, which conflicted with solar generation being turned off during the day as part of testing the 'Constrain to Zero' scenario. For others who expected the pilot to assist with grid stability, it conflicted with seeing their battery being discharged into the grid at odd times of the night and early morning out of sync with peak demand.

Orchestration phase 2: Negative sentiment eased significantly in the second phase of orchestration. This was due to various reasons such as more customers seeing the financial gains from orchestration, previous bill concerns not eventuating, feeling more informed about the pilot's progress, and greater general understanding of the purpose of orchestration.

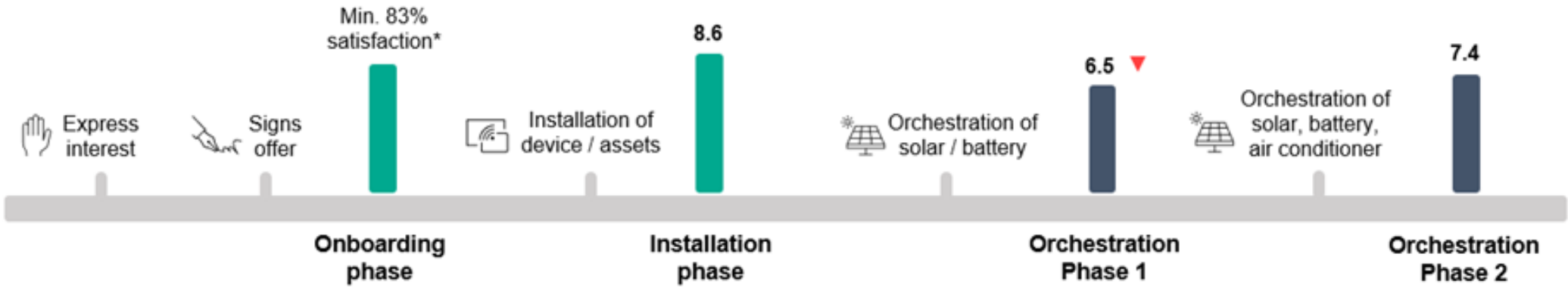


Figure 39: Participant sentiment at key phases of the journey

In-keeping with the objectives of Symphony, other customer insights and learnings have been summarised and separated into key themes of Communication, Orchestration, Technology and Value.

Theme	Key insights and learnings summary
Communications	• The concepts involved in the pilot such as orchestration, VPP and testing scenarios, and jargon such as DER, 'Constrain to zero' and 'wholesale electricity market', are new or unfamiliar, and admittedly complex concepts for customers. This made the task of communicating pilot objectives and activities more challenging. Customers noted a desire for concepts to be simplified and communicated in a way that assumes the average customer would be unfamiliar with these concepts. • For some customers, there were several months between the installation and the first orchestration phase – during which, there were no general updates provided and orchestration then coming as a surprise to customers. Given the time lag and their investment in the pilot to date, customers noted a desire to be kept better informed about the pilot's progress and how their participation has contributed to it. • A high proportion of customers resorted to analysing Synergy online information, or information from their original equipment manufacturer in search of how their asset was being orchestrated and what it meant for them. However often this information was inconsistent or unclear – resulting in an increase in customer confusion on the 'why' of orchestration activities. • The pilot's consequent shift in communication approach to provide more frequent and meaningful updates was well received and noted by participants. This included updates on the pilot's progress, transparent information on areas for improvement and results from testing the 'must-have' scenarios. • The marketing campaign and how the pilot was promoted generally worked well in attracting customers. Apart from the high responses to the expression of interest invitations, there was also clear enthusiasm amongst customers to participate. • Despite the number of steps involved in signing up to the pilot, customers found it an easy process. This is likely because of pre-organised and aligned communication at each step and dedicated customer service personnel responding to queries along the way.

Theme	Key insights and learnings summary
Orchestration	• More than half of customers (53%) say orchestration has changed their energy consumption. Survey comments show that participants changed their energy use behaviour to avoid times when solar was being constrained and / or when batteries were being charged from the grid. • There is desire for further and early notifications to assist with customer's day-to-day planning and to reduce disruption to their routine. This includes clarity on duration of orchestration. • Some customers noted that there was no ability to 'opt out' of an orchestration event during the pilot, even though they had been incentivised or compensated to participate in the event.
Technology	• Clear communication about what is involved with installation was noted as crucial. For example, customers desired an explanation of what is required, where asset(s) were to be installed, how long it would take and anticipated disruptions such as power being turned off. • Some participants reported feeling overwhelmed and/or surprised with the number of items installed – particularly in households with already limited 'free space'. Providing visual illustrations beforehand of what the area will look like once all assets are installed can help manage expectations. • Customers also noted the desire to understand the purpose of each asset that is being installed. Survey comments showed that some participants felt uneasy about the devices in their homes as they are seen as 'foreign objects', with inadequate explanations often provided about what the asset is and its purpose.
Perceived Value	• The most appealing benefits for customers are cost savings and receiving a subsidised asset (notably a home battery). For battery customers, 'savings' was in the form of longer term energy benefits. Whereas non-battery customers realised monetary benefits in terms of the financial incentives and compensation provided – all of which helped reduce their bill amount. • A key benefit customers were seeking, related to contributions to the 'greater good' such as environmental sustainability and the community. Being a pilot, the ability to help progress future energy solutions and contribute to trial learnings were also a strong reason for customers participating. • A key negative for customers – particularly early in the pilot – was the unknown financial impact (including fears of a negative bill impact) of orchestration events, especially when orchestration increased energy consumption and prevented their routine use of solar energy. • For some, there is also an aspect of 'giving up control' of their own assets.

Theme	Key insights and learnings summary
	• The time and effort required to be involved was another aspect of less tangible costs noted by customer. This is in the form of home visits (as part of eligibility assessment), completing relevant paperwork for sign up, being present for installation of assets, quality checks and dealing with any technical issues which may occur throughout. It was especially noticeable for customers who had multiple visits. • There were two sides to the aspect of having new technology, such as home batteries and orchestration equipment, installed in customers' homes. Some felt it was beneficial as it provided access to the latest technology. Others noted a con of having to learn about the new devices and a greater risk of technical issues requiring in-depth troubleshooting by multiple parties. • Lastly, lack of clarity about the value of the pilot also translates to 'cost' as customers expend time and effort in it without any perceived returns. This was mainly amongst non-battery customers, where around a quarter remain unsure about the benefits of participating in the pilot regardless of having received an orchestration payment. This highlights the importance of the timely communication of value particularly if there is a period of time between payment and orchestration, and should be communicated at both a broader level as well as individual level.

Table 5: Project Symphony customer participation sentiment summary

For further details on the customer experience, see:

- Work Package 3.2 Aggregator report[47]
- Work Package 3.3 Social research report

Given the feedback from customers and the results of the Social Research Report conducted by UTAS, the customer-based recommendations are positioned to provide customers:

- With simple, transparent, accurate and timely information on what it means to be part of a VPP, particularly the impact of orchestration (Recommendation 2.1), while
- Utilising the tools and channels *they* prefer (Recommendation 2.2), and
- Establishing a multi-agency approach to raising greater awareness of VPP participation in the broader community (Recommendation 2.3).

[47] Project Symphony Aggregator Report: https://arena.gov.au/knowledge-bank/project-symphony-aggregator-report/

6.4. Customer lessons learnt and recommendations

Recommendation 2.1 – Create simple, transparent, accurate and timely customer facing information on VPP participation for communication throughout the customer journey to improve customer experience, buy-in and retention.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Synergy	Ongoing

Symphony scope

A critical step in Symphony involved communication with, recruitment, and retention of customers who had or were willing to install DER assets to participate in the Symphony VPP. Overall, 514 residential customers, along with their 914 assets, were contracted together with a single commercial customer being the City of Armadale Aquatic Centre.

Led by Synergy in its role as the Parent Aggregator, Project Symphony developed and implemented an approach to recruit, onboard and manage customers. In support of these different activities, customers were provided with a mix of direct and broad reach information. Direct information was mainly communicated via email, direct mail or follow up outbound calling, with broad reach information including video, website landing pages, and a shopping centre 'pop-up' stall.

Experience and findings

Customers who were recruited into the pilot were largely satisfied with the onboarding / recruitment process itself with a satisfaction rating of 8.6 out of 10 for installation activities, and 80% of participants being satisfied with key aspects of the onboarding / recruitment process. Most notably, positive feedback was obtained around the ease of process and the level of communication associated with the onboarding process. Customers also showed an element of enthusiasm and excitement from being part of the pilot.

However, there were also challenges associated with the overall customer experience of being part of a VPP. Key feedback from recruitment activities and customer surveys include:

- Customers did not understand key terms and concepts associated with Symphony. Customers exhibited a nascent understanding of key concepts such as 'DER', 'orchestration', 'VPPs', and almost no understanding of the various testing scenarios. Customers often viewed terms used as too jargonistic, overly technical and confusing.
- Customers feeling insufficiently informed about what 'orchestration' is and what it meant for them, particularly early in the pilot. Customers consistently communicated an overall lack of understanding on what 'DER orchestration' is, what its benefits are, and what it means for them in terms of requirements including financial and time implications.

In conjunction with orchestration activities, a customer sentiment survey was conducted which saw a marked drop off in customer sentiment from 8.6 out of 10 during the installation phase to 6.5 following initial orchestration. Customers noted a lack of awareness of the orchestration activity – such as when or what orchestration activities were occurring, and what DER assets of theirs were being orchestrated and why – and expressed that they did not feel that they had the information required to manage any potential negative impact on their bills. They also felt that there was limited support in resolving issues or getting help.

Following the initial survey results a new ongoing customer engagement plan was devised based on customer feedback requesting greater transparency and information shared on a timely basis. This engagement plan focused on providing general updates, mainly via customer email, on pilot benefits and its role in Western Australia's energy future, progress of pilot milestones, and sharing real-time pilot insights and learnings. Overall, the new engagement plan was better received, and saw customer sentiment rise to 7.4 out of 10 during phase two of asset orchestration from the 6.5 during initial asset orchestration. The way forward:

- It is evident from the findings of Symphony that simple, trusted and timely information is essential to achieving greater customer satisfaction and participation in future VPPs. The challenge rests with ensuring readily available, easy to understand information is presented through tools and channels which customers readily consume and respond to (see Recommendation 2.2).
- This revised approach needs to more clearly and succinctly articulate key concepts and terms around what DER orchestration is, what it means for customers, why it is required including the 'bigger picture' local energy system benefits as well as providing data on how it directly benefits the customer in terms of meeting their financial and environmental objectives – again using plain language and associated best practice communication models.
- When delivering this recommendation, it is recognised that the experience and feedback of VPP customers in the SWIS is not unique and as part of planning future customer engagement approaches, the outcomes of similar VPP projects across Australia should be better considered, to ensure good or better practice customer acquisition is undertaken.

While simple, trusted and timely information on DER orchestration is essential, it should not be implemented in isolation of the other customer-based recommendations being *2.2 Develop end-to-end customer engagement tools to manage and improve the customer experience of VPP participation* and *2.3 Establish a SWIS-wide customer engagement strategy and plan to achieve a consistent and cohesive approach to improve general customer awareness of VPPs*.

While this recommendation is not explicitly aligned with any existing actions in the DER Roadmap, it needs to be considered in relation to Action # 36, 'By July 2020, engage with energy customers and commence an education program to ensure industry, government and the public are sufficiently informed about the need for changes being undertaken as a result of the Roadmap recommendations.'

Recommendation 2.2 – Develop end-to-end customer engagement tools to manage and improve the customer experience of VPP participation.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Synergy	October 2025

Symphony scope

Symphony required customer engagement from recruitment and on-boarding to asset installation, asset orchestration, and billing. To facilitate this end-to-end engagement, Synergy in its role as Parent Aggregator developed a customer acquisition strategy and plan which included the use of a range of engagement materials as well as the tools and channels by which customers would receive the information.

Customers were targeted using a limited mix of direct and broad reach marketing. Direct marketing was mostly through email and supported by follow up outbound calling as required. Broad reach information included website landing pages, and a shopping centre pop-up stall. A common factor with all of these more traditional methods of 'retail' engagement is that they are not usually 'timely' or via the tools customers necessarily prefer, particularly when wanting more 'real time' information on things such as 'orchestration' of their assets.

Experience and findings

Through Symphony, several findings were identified with respect to customers' desire for greater information and key insights into the way in which they prefer to receive information:

- A significant proportion of participating customers wanted more communication on the project and what it was achieving, particularly the impact of orchestration of their assets.
- Customers communicated that they ended up spending time trying to find information themselves through online technical forums, a Facebook group chat set up by a participant, and by reaching out to Synergy and the equipment installers – where information was not readily available.
- Customers highlighted a desire for 'all the data in one spot' with respect to their involvement and participation in VPPs.

Participating customers clearly indicated a desire to remain informed and 'in the know' about how their assets were orchestrated and how their assets were contributing to and generating value from participating in the VPP in near real time. Overall customers noted a lack of awareness of the orchestration activity – such as when or what orchestration activities were occurring, and what DER assets of theirs were being orchestrated – and expressed that they did not feel that they had the information required to manage their energy usage in line with their financial or other goals.

This was evidenced through Work Package 3.3 Social Research Report where it was concluded:

> *´Participants sought clear, graphical information about what was happening with their assets with orchestration, and a broader contextual understanding of what this meant for them and the broader community.*

It was observed that over 60% of customers commonly reported monitoring activity of their battery storage and solar PV assets through mobile applications provided by their DER's original equipment manufacturers. This was closely followed by customers reviewing their Synergy electricity bills (53%) for the same purpose.

However, data from original equipment manufacturer's application often illustrated a contra-view to what the customer was expecting, such as the importing of electricity from the grid during sunny days for the household's usage – when traditionally a sunny day would result in generation and exporting of power into the network. While Symphony sought to understand the value of orchestrating customer assets, as part of testing each of the four scenarios in which their assets could participate, this was not adequately communicated to customers and not via tools or channels some preferred.

The way forward

It is recommended that scalable, end-to-end engagement tools and supporting channels are researched and then established to provide customers the information and support they seek on each step of the VPP participation journey. The tools, such as a customer portal or mobile phone application could include more *timely* information such as:

- When an asset, and which asset, is being orchestrated.
- Why their asset is performing / being orchestrated in a certain way and the quantified benefit to the customer.
- The contribution of their asset/s, and potentially their assets in aggregate with other customer assets are providing or have provided to the energy system or local grid.
- The value customers are and could potentially generate by participating in more/other DER orchestration services.
- Any additional simple, transparent and accurate customer facing information on VPP participation that will be developed as part of recommendation 3.1.

Further consideration and research should be conducted into the preferred ways or channels in which customers like to receive the relevant/simple information. This will need to be done particularly while still achieving cost efficiency, and in the early stages of scaled recruitment, where more intensive or even face to face engagement may be required until VPP participation becomes more normalised or common place.

Recommendation 2.2 will need to closely consider and work in harmony with the other customer recommendations: 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, and 2.3 Establish a SWIS-wide customer engagement strategy and plan to achieve a consistent and cohesive approach to improve general customer awareness of VPPs.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action should be added to the DER Roadmap to account for this recommendation.

Recommendation 2.3 – Establish a SWIS-wide customer engagement strategy and plan to achieve a consistent and cohesive approach to improve general customer awareness of VPPs.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	EPWA	October 2025

Symphony scope

Symphony set a target of recruiting approximately 500 customers and a suitable mix of 900 DER assets including rooftop solar, battery energy storage and major appliances such as air conditioners and hot water systems to be orchestrated as part of a VPP. Symphony piloted the role of the retailer Synergy as the Parent Aggregator in providing DER products and services to facilitate customer involvement. From a customer journey perspective, this required the Parent Aggregator to exclusively design and implement targeted engagement and recruitment campaigns to sign up customers to the Pilot.

Experience and findings

Customer feedback clearly indicated a general unfamiliarity with terms such as 'orchestration' and 'VPPs', or industry insider jargon such as 'DER', and scenarios such as 'constrain to zero'. This extended to fundamentals of the WA energy system such as the workings of the wholesale electricity market, or key concepts as 'system low' or 'low load'. General awareness of 'peak' or 'peak load' appears to be higher and is likely a result of joint public awareness campaigns run by Synergy and Western Power. This resulted in the task of communicating pilot objectives and recruiting participants to the Symphony VPP was therefore challenging.

Customers overall noted a desire for concepts to be simplified and communicated in a way that assumes the average customer would be unfamiliar or not yet aware of the relevant concepts.

Given the scope of Project Symphony was limited to a small part of the SWIS and was primarily focused on residential customers, it is highly likely that large proportions of the SWIS – including contestable customers – are currently unaware or insufficiently educated about DER orchestration and VPPs, how their assets can contribute to the future power system, and the benefits for themselves and the broader network. This is supported by 2022 Synergy research, where 71% of the SWIS population (18+) indicated have never heard of the 'concept of VPP', with 16% having heard of it, 9% knowing 'a little', and only 4% indicating they know 'a fair amount' or 'a lot' about VPPs.

The way forward

Aligned with the other customer recommendations within this report, it is recommended that a multi-agency approach to raising general awareness as to the role and benefit of VPPs is developed via a SWIS-wide customer engagement strategy and plan. This VPP engagement strategy and plan would focus on the general Western Australian public and be developed and implemented in support of the Parent Aggregator's lead role in engaging non-contestable customers on VPP participation. In this way it is envisaged that greater base awareness of the role and value of VPPs would be known to more WA residents prior to being engaged more directly by the Parent Aggregator as part of customer acquisition.

This strategy should focus on increasing general awareness of VPPs, reducing the customer information barriers, and showcasing the role that individuals and their assets can play in solving system and local level energy issues while contributing to the State's energy transition objectives.

Coordinated by EPWA, the engagement strategy and plan would include the roles and responsibilities of each of the major actors in the WEM in the engagement of the WA public on VPP participation.

Recommendation 2.3 will complement the other customer recommendations: 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 and 2.2 Develop end-to-end customer engagement tools to manage and improve the customer experience of VPP participation.

This recommendation closely aligns to and is an extension of DER Roadmap action number 36 'Engage with energy customers and commence an education program to ensure that industry, government and the public are sufficiently informed about the need for changes being undertaken as a result of the Roadmap recommendations.'

7. Value

The value 'pillar' focused on understanding the potential economic and financial value of DER orchestration via VPPs within the SWIS.

Symphony sought to understand the potential value from DER participating in one or more of the four 'must-have' scenarios that were tested. The value assessment also aimed to understand the value created from DERs participating in multiple services or scenarios during any given market interval. In short, which services could be 'stacked' and in which order, or priority, to derive the greatest value.

Several Work Packages were delivered in support of the objective including:

- Work Package 2.1 DER services report[48]
- Work Package 2.3 DER services valuation report[49]
- Work Package 8.3 Project Symphony CBA report

7.1. Objectives

Specific value objectives set out as part of Project Symphony include:

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.

This will also 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 where DER aggregators act as the intermediary to customer DER.

[48] Work Package 2.1 DER services report: https://arena.gov.au/knowledge-bank/project-symphony-der-services-report/
[49] Work Package 2.3 DER services valuation report: https://arena.gov.au/knowledge-bank/project-symphony-der-service-valuation-report/

7.2. Cost Benefit Analyses

At a high-level, VPPs can create economic and financial value by receiving, assessing, and making decisions on various streams of information, such as wholesale and network pricing information. This information indicates if it is economically viable for VPP assets to act in ways that reduce cost in the electricity supply chain and / or provide economic value across the value chain including to customers as DER owners.

Economic cost benefit analysis overview

As captured in Work Package 2.1 DER services report, a study was undertaken to assess the economic impacts of a VPP if its operation were expanded to the entire SWIS, based on assessing *net economic benefits*. Importantly the basis of net economic benefits considers more than just the financial impact – extending into broader societal benefits.

The modelling – which considered 5 different modelling scenarios for residential customer participation over a 15-year period, and only factored residential customer participation in VPPs – resulted in confirmation that across all tested scenarios, economic net benefit of participating in DER orchestration and VPPs is positive, and significantly so – ranging from a present value low of $453m to $967m over the 15-year modelling period.

Whilst the modelling considers several assumptions, the results clearly indicate a real economic opportunity from scaled participation in DER orchestration and VPPs.

Financial cost benefit analysis overview

After all testing was completed, a financial cost benefit analysis was performed to capture a stricter financial impact view of DER orchestration and participation in the SWIS. This work was captured in Work Package 8.3 Project Symphony CBA report. Financial cost benefit analysis is a valuation tool used to quantify the financial costs and benefits delivered by a project. It aims to monetise as many costs and benefits as possible relating to the modelled period, providing a final valuation of the project in financial terms. It also considers factors such as opportunity cost by comparing the net benefits across different modelling scenarios and testing the sensitivity of the results to changes in a range of variables. To do this, a project's expected total benefits are compared to its expected total costs using discounted cashflows (DCF) in each year. This is used to determine the net benefits provided in each year, across a specified timeframe, which are then discounted using an appropriate discount rate to determine the net present value (NPV) of the project.

The analysis leveraged the outcomes directly from the Symphony VPP orchestrating customer DER participating in each of the four Symphony 'must-have' scenarios (refer to section 5.4) and extrapolated the benefits to represent the potential benefit across the SWIS. Additionally, the modelling was carried out under four modelling scenarios – *Pilot, Expected, Growth, Hyper Growth* – and ran over a 10-year period to 2033.

Whilst the analysis is broadly robust, there are some limitations given the scope of the pilot. A summary of the scope, limitations and exclusions applied to the cost benefit analysis have been identified below:

	Included in CBA modelling	Excluded from CBA modelling
CBA inputs		
Asset type	Residential solar PV Residential battery storage	Due to lack of statistically significant data: • EV and EV chargers • Commercial and grid connected battery storage • Air conditioner load control • Hot water load control
Scenarios	The 4 Project Symphony 'must-have' scenarios: • Bi-directional energy – Balancing market • Network support services • Constrain to zero • ESS – Contingency raise Concurrent testing of a combination of the above scenarios – Fully Orchestrating or 'value stacking'	Any other existing or conceptual services out of Project Symphony scope – such as short-term energy market (STEM), reserve capacity mechanism (RCM), FCESS regulation raise / lower, or ESS – Contingency lower
Geography	Pilot area only. Noting that extrapolation has occurred to calculate benefits across the SWIS using the pilot area data.	All other parts of the SWIS
Costs	Cost of establishing and operating the resources needed to support DER orchestration – e.g., cost of establishing the platforms, customer recruitment and customer incentives. Opex incurred by pilot participants associated with the maintenance and operation of the pilot and delivering the VPP at scale over 10 years.	Costs associated with project partner's existing cost base which do not contribute to the pilot. CAPEX associated with asset replacement over the operational period of the model.
CBA outputs		
Benefits calculated	Direct financial benefit and distribution of benefit to key benefactors Deferral of capital network capital expenditure	Impact on improved network reliability Impact on energy affordability Impact on whole of system costs

Table 6: Cost benefit analysis inputs and outputs overview

In assessing the benefits of orchestrating DER in a VPP, the analysis found that there was a positive NPV in the bi-directional balancing market (Scenario 1) and 'Fully Orchestrated' (participating in all Scenarios). However, the other test scenarios (Network Support Services, Constrain To Zero and Essential System Services – contingency raise), when considered in isolation of each other, and *as delivered in Symphony*, did not result in a positive NPV. The negative NPV is attributed to the revenues received from the Parent Aggregator and TPAs being less than the associated cost of providing this service.

The net cashflows in the Fully Orchestrated test scenario, where all 'must-have' scenarios were delivered in concert, for each modelling scenario is provided in the figure below Figure *40*. The four models - *pilot, expected, high growth, hyper growth* – are largely differentiated based on different growth assumptions of DER adoption in the SWIS.

The net cashflows are used to illustrate the benefits of DER orchestration across multiple stakeholders on a year-on-year basis, which are then discounted over the 10-year modelling period to provide a NPV of the total investment. The combined cashflows for the DSO, DMO, aggregators and customers increase in each year for each modelling scenario, delivering a NPV of $450 million over 10 years in the *Expected growth* scenario, and a NPV ranging from $280 million in the *Pilot* scenario to $920 million in the *Hyper Growth* scenario.

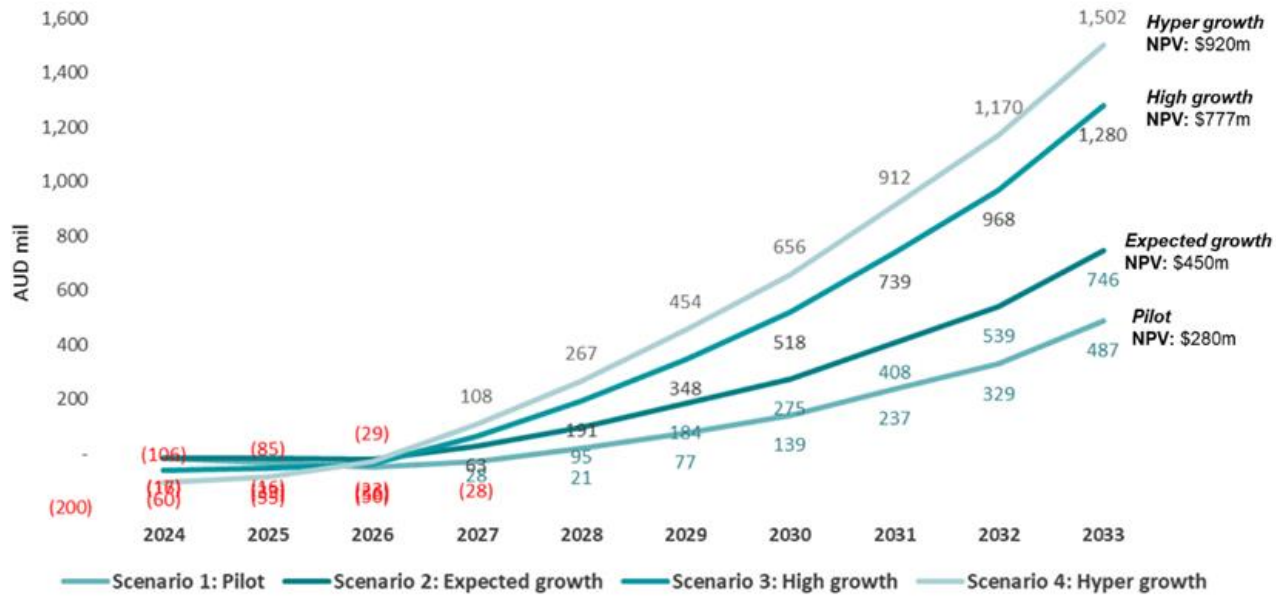


Figure 40: Combined undiscounted yearly cashflows for the Fully Orchestrated scenario

Under the *Expected growth* modelling scenario, customers' electricity bills increased by $76 million from natural price increases, however, over the same 10-year period, customers received $1.14 billion from customer incentive and orchestration payments, which more than adequately compensates for the increase in customer energy costs. It is further noted that the increase to customer energy costs was primarily experienced by customers without a battery, with customers owning a battery achieving a minor decrease in their energy bills because of participating in the VPP.

Even with its limited scope of four 'must-have' scenarios, the small sample of potential applications, and a subset of DER assets, the pilot demonstrated that DER orchestration could provide value across the entire SWIS energy value chain if the appropriate conditions are created and barriers reduced, ranging from cost savings and increased energy efficiency to environmental benefits, grid support and deferral of capital expenditure.

Value modelling findings

The economic and financial cost benefit analyses results broadly demonstrate that real benefit can be generated from DER orchestration in the SWIS via VPPs. More specifically:

- Increased participation of customers and their DER assets in a VPP, and participation in multiple services – 'value stacking' – are critical requirements to enable the benefits of a VPP to be realised, with greater levels of participation in more services resulting in substantially greater value generated.
- Battery storage contributes most of the gross economic benefits for a VPP, given its unique ability to participate in many services, compared to other DER assets.
- Dynamic operating envelopes form a critically important construct within a VPP environment, particularly where DER adoption continues to grow at a substantial rate, and distribution of available network hosting capacity requires continual optimisation.
- Economic and financial modelling has some natural limitations, particularly with respect to modelling inputs, such as types of DER assets included in modelling, the potential services which DER can participate in, and current costs associated with achieving orchestration. Understanding these limitations, the Symphony team recognise the value in conducting further modelling (including analysis of anticipated cost beyond the pilot) to understand a more fulsome and accurate picture of the potential value that VPPs can generate in the SWIS, as well as the distribution of value across key benefactors – such as customer, the Parent Aggregator, other aggregators, the DMO and the DSO.

7.3. Value lessons learnt and recommendations

Recommendation 3.1 – Commence work on policy solutions to establish market frameworks that support the participation of DER aggregations in the WEM.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	EPWA	October 2025

Symphony scope

Ensuring the security and reliability of the power system is AEMO's fundamental role in driving Western Australia to its low-carbon future[50]. Although critical, improving network visibility of DER alone is not enough to balance and manage the challenge and risks of a high-DER power system. Effectively scheduling and managing the dispatch process and coordination between market participation, distribution network, and transmission network, will also require predictability and controllability of DER through aggregation and active participation in system and market services in the WEM.

As a result, Project Symphony tested the capability of aggregated DER to provide market and system services under existing WEM frameworks, with the aim of identifying the regulatory and market development requirements to enable DER aggregations to effectively participate in the market, and efficiently support power system security, reliability and affordability objectives.

[50] https://www.wa.gov.au/service/environment/environment-information-services/western-australian-climate-change-policy

Experience and findings

In summary, the pilot demonstrated a range of capabilities which highlighted the potential for aggregated DER to provide for future system and market needs – and create value –, including but not limited to:

- Delivering locally generated energy to customers.
- Balancing and delivering energy at times of high demand and low load – helping to better manage 'peaks and troughs'.
- Participating in various services at times of high demand and low load – such as Essential System Services – contingency raise, and Network Support Services.

However, a number of unique opportunities and challenges were identified, including:

- The fact that DER aggregations – or facilities – change incrementally and dynamically, necessitating policy flexibility to change size, composition and 'location' of the aggregated DER facility.
- Although aggregated DER can register as a facility under existing Facility Class frameworks, no existing Facility Class – which considers larger and fixed assets such as gas, coal or wind generation – was deemed effective or efficient in accommodating aggregated DER in a way that unlocks the greater value or potential value of that DER. This is because the WEM's existing Facility Classes do not substantially consider the inherent characteristics or operational modes demonstrated within the pilot and therefore, without adjustment, aligning aggregated DER to the existing framework will impose performance and compliance requirements that are challenging for aggregated DER to meet. Whilst alternative and limited registration opportunities may be available (e.g., as a Demand Side Programme), but this would also limit the value streams that are available to the aggregator. Ultimately without specific adjustments of the market arrangements for DER, the value that can be created via the WEM will remain constrained.
- The need for integration and coordination between the DSO and DMO being further highlighted as critical to the provision of services with consistent, achievable obligations, and to enable market / system operation within network limits.
- The need to create a model to encourage and facilitate participation through a fit-for-purpose registration framework, that enables access to services / value streams that are not currently accessible to DER aggregations.
- The need for benefits to be 'balanced' or 'equitable' between all actors to achieve overall net benefit, and not raise barriers to entry to participate in multiple services / value streams.

These findings highlighted the need for WEM registration / market frameworks – specific for DER – to be established, to enable successful utilisation of aggregated DER that meets the operational principles of the power system and creates net benefit for customers. Without these updated registration / market frameworks, considerable costs and obligations are likely to be triggered as DER scales, which would ultimately limit the value which can be generated from orchestrating DER, impact the ability of the aggregated DER facility in providing customer benefit, and deter customers and aggregators from participating in market services.

The way forward

Given that registering aggregated DER under existing frameworks is likely to constrain the scale and opportunities for DER orchestration, it is recommended that work is commenced to consider the cost effectiveness of such an approach and assess the establishment of specific and appropriate registration / market frameworks for aggregated DER. The establishment of these frameworks should be facilitated through review and development of policy solutions.

A new registration / market framework would complement and sit alongside those already in place to support the registration of aggregated DER in the WEM Rules.

These market frameworks will provide the most appropriate and tailored market solution to achieve the greatest level of participation, and therefore the greatest opportunity for value creation from aggregated DER. Additionally, it will remove unrealistic requirements from aggregated DER facilities registering in existing not fit-for-purpose Facility Classes.

More specifically, the aggregated DER market frameworks may exhibit the following features:

- Specific standards that should apply to facilities providing specific services in the market.
- Streamlined process for addition and removal of customers and resources to / from DER aggregations, according to set timeframes.
- Arrangements that allow for aggregated DER to include larger DER equipment, such as batteries, to enable aggregators to deliver optimised outcomes across a broad range of DER equipment.
- Streamlined transition processes that may be triggered by changes to network configuration, potentially requiring changes to zone substation / Transmission Node Identifier (TNI) allocations and aggregation.
- Data sharing arrangements between significant actors in the WEM value chain, addressing visibility, meter data, DOEs and other critical data, setting out the required data accuracy.

Other approaches exist to establishing new market / registration frameworks for DER – such as amendments or incremental changes to the existing market frameworks. However, it is noted that these alternative approaches will ultimately result in greater long-term complexity for all relevant parties in implementation of the required systems and processes, and therefore are not preferred. Alternatively, consideration needs to be given to whether similar value could be obtained from off-market arrangements (such as NSS via NCESS and whether existing mechanisms provide sufficient revenue certainty to incentivise aggregator investment – also see Recommendation 3.2), provided appropriate visibility of energy movements is available and power system security and reliability issues are addressed.

This recommendation forms the market framework arm associated with a two-pronged solution of enabling VPPs and DER orchestration to be an efficient and reliable solution to the SWIS. The technical standard arm is captured in recommendation *1.3 Develop specifications around Parent Aggregator service delivery standards to accelerate compliance with service delivery standards in the WEM.* This recommendation will also need to work alongside recommendation *4.2 Establish policy positions that appropriately incentivise aggregators to participate, and ensure value is passed through to the customer*, by providing the baseline structure to incentivise aggregators to engage with as many customers and services as possible.

This recommendation closely aligns to DER Roadmap action number 27b 'Commence implementation of changes to wholesale market arrangements necessary to enable the participation of DER in the wholesale market via a DER aggregator.'

For further details on the policy requirements, see: Work Package 7 DER Participation Framework Report.

Recommendation 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.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Western Power	December 2025

Symphony scope

As one of four 'must-have' scenarios, the Symphony VPP tested the feasibility of using orchestrated DER to create value through mitigating short-term network power quality and reliability issues, and ultimately its potential to defer or avoid costly network augmentation, through NSS.

NSS is a contracted service provided by a third-party to Western Power as the DSO. The DSO monitors the distribution network and identifies short, medium and long term constraints such as peak electricity demand. Peak demand continues to grow in some localised areas of the distribution network, including in the Symphony pilot area along the distribution 'feeder' known as SNR 540. Peak demand is primarily driven by air conditioners as customers cool their homes, occurring more often in the hot summer months and particularly after several consecutive days of temperatures at or above the mid-30's when power outages are more likely to occur. In areas of sustained or growing peak demand, Western Power has several options for managing peak. This includes adding capacity through the building of more 'poles and wires' infrastructure or through procuring a NSS made up of demand management programs, such as reducing the demand of air conditioning, or discharging of battery energy storage into the network at peak time, both of which were part of the Symphony scope.

Synergy as Parent Aggregator recruited a total of 218 air conditioners, of which 119 were available for orchestration, out of a target of 280 to participate in providing a NSS and successfully incentivised customers to take up 150 battery energy storage systems.

A NSS contract, focusing on the framework that could be used beyond Symphony as well as the method of measuring performance, was developed and executed exclusively between Western Power and Synergy. Considering Symphony was a pilot, the contract was less stringent than will otherwise be required in provision of a NSS to 'keep the lights on'. Further, the NSS as deployed in Symphony was not part of the NCESS framework.

NSS has been included in the NCESS framework, which was introduced in the WEM Rules in February 2022 to address emerging power system needs and locational security and reliability needs. The framework ensures that both AEMO and Western Power have visibility and are consulted on service specifications, the market is tested adequately, and that the dispatch of services procured under the NCESS framework, such as NSS, are reflected in overall market dispatch. As such, Western Power contracts NSS through the NCESS framework.

Experience and findings

NSS was unable to be tested during the summer peak period utilising load control of air conditioning, due in part to delays in delivering the required technical solution/s and the majority of existing air conditioner stock being non-compliant with AS4755 as the voluntary Australian standard for demand response (also see Recommendation 4.5).

As such, Symphony tested both *firm* and *flexible* NSS via the NSS contract[51] between DSO and Parent Aggregator, and predominantly using aggregated battery energy storage.

'Firm' services represent the NSS service which acts as an alternative to capital-intensive distribution network 'poles and wires' augmentation. It is a service which achieves deferral of network augmentation for a minimum 12-month period by consistently and cost effectively reducing peak demand when required by the DSO and is planned several years in advance. On the other hand, 'Flexible' NSS is more opportunistic in nature and can assist in providing support for unexpected, smaller, and short-term events or unplanned outages.

In terms of results, the provision of NSS must be compliant with requirements considering the service is designed to reduce peak and essentially 'keep the lights on' in the designated area. Performance of the service was measured against the NSS contract and the DOE as the parameter within which DER can safely provide the service. It should be noted that the NSS contract developed for the purposes of Symphony was focussed more on the framework for future agreements with test compliance criteria being less stringent than will be required for 'real world' application.

Overall, 8 firm and 9 flexible contracted events were delivered as part of Symphony's testing of the NSS Scenario. Of the 8 firm contracted events, the first 2 would 'fail' compliance but they still delivered at least 70% of the energy in each of the 5min intervals, and all 6 remaining firm events were deemed complaint. Of the 9 flexible contracted events they delivered up to a maximum of 0.458 MW and 0.92 MWh. This was delivered using residential battery storage assets and is a promising result.

Looking to the future there is an emerging value stream for SWIS VPPs to participate in NSS – particularly when other energy services are also delivered (i.e., value stacking). The Symphony cost benefit analysis (Work Package 8.3) conservatively highlighted that cost savings with an NPV of $58 million[52] to 2033 for network investment deferral may be achieved by implementing dynamic operating envelopes and participating in NSS (assuming no direct changes to network tariffs). Further analysis and modelling of the cost savings that can be attributed to NSS should be undertaken, particularly as additional data streams on differentiated costs of augmentation (urban versus rural for example) and therefore deferral value are considered.

The way forward

Despite several high profile, largely technical, pilots and trials focussed on reducing peak demand utilising aggregated *residential* energy efficiency, behaviour change and / or demand side management - technical, commercial, and regulatory barriers persist, with the result that deferment of distribution network augmentation has yet to be achieved in the SWIS. However, with the increased take up of relatively new DER such as residential battery storage assets, along with maturing orchestration capability and demand management technologies, a more concerted effort should be undertaken to deliver a Network Support Service that achieves actual deferral of network augmentation as a discreet DER Roadmap action or project.

[51] Symphony tested a 'stand-alone' NSS contract and was not part of NCESS.
[52] Results are captured under the Fully Orchestrated test scenario, and the Expected growth modelling scenario in the Project Symphony Cost Benefit Analysis (Work Package 8.3).

Further, this should be considered in light of the potential value stream NSS brings to DER orchestration, together with 'global' factors such as the ageing distribution network, persistent peak demand in local areas, increasing climate risks, current supply chain and labour market challenges. As such, it is recommended that Western Power, as DSO, and Synergy, as the Parent Aggregator, continue to invest in and further develop capabilities built through Symphony to deliver a *viable* NSS.

When delivering the NSS as 'business as usual' or "at scale", specific focus should be placed on understanding and confirming the mechanisms available to recover investment in NSS, including incentivisation and coordination mechanisms designed to reduce or overcome barriers and enable NSS. Potential mechanisms for consideration include the Demand Management Innovation Allowance Mechanism (DMIAM) available to Western Power under the Access Arrangement 5 (AA5) period which provides distribution businesses with funding for *research and development in demand management projects that have the potential to reduce long-term network costs*[53]. In addition, these activities will be undertaken within, and with the intent to test and update, the NCESS framework under the WEM rules, to develop appropriate coordination arrangements between the DSO and AEMO for these services. Any recommended changes or opportunities as identified via the DERRCC can be facilitated by the DER Bill and subsequent planned review of the Access regime.

Other considerations as part of this recommendation include:

- Developing compliance standards required to be met by NSS.
- The technical capability required to deliver NSS within the compliance standards and in consideration of market services.
- The policy requirements to enable joint coordination between the DSO and DMO to support NSS in alignment with the market, including potential amendment and evolution of the NCESS framework.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action may be added to the DER Roadmap to account for this recommendation.

[53] ERA, Final decision on proposed revision to the access arrangement for the Western Power Network 2022/23 – 2026-27: https://www.erawa.com.au/AA5

Recommendation 3.3 – Quantify the actual value of DER asset participation for non-contestable customers (>12 months data and without pilot costs) to better inform value streams and the distribution of value between DER owners and the aggregator(s).

Recommendation importance	Lead	Timing
Tier 2 – Enabler	Synergy	July 2024

Symphony scope

A key focus of Symphony was to understand the potential to create sustainable value from DER orchestration as tested through the Symphony VPP.

Over 500 customers and 900 DER assets were recruited to participate in one or more of the four 'must have' scenarios in which DER can participate to earn value.

A detailed financial cost benefit analysis was completed which calculated the net present value (NPV) of all discounted cash flows which is expected to be generated from DER orchestration within the broader SWIS, over the next 10-years, and the distribution of the value between customers and significant actors in the WEM value chain.

Experience and findings

Whilst the Symphony CBA is detailed and generally robust, the modelling naturally has some limitations:

- **Assets –** whilst they represent a substantial portion of all SWIS DER, the cost benefit analysis only considered residential solar PV and residential battery storage in modelling activities due to limitations of data available and data reliability of other participating DER such as air conditioner load control.
- **Limited test period -** testing culminated in a 90-day period of stability testing from April to June 2023 which did not include all seasonal variations in which VPPs can provide different services. It is likely that the availability and behaviour of DER will change across the full year and there will be 'seasons' (shoulder, low, peak etc.) during which greater value can be achieved from DER participation.
- **Services** – an expanded range of services the VPP can participate in, which were not tested as part of Project Symphony, such as the reserve capacity mechanism (RCM), FCESS contingency lower, and potentially regulation raise / lower or as aggregators grow, the short-term energy market (STEM).
- **Pilot incentives/costs –** Over 500 customers were recruited and provided a nominal value or financial incentive to participate. For example, customers were offered a ~50% cash incentive towards the cost of a battery energy storage system or were given ~$150 per DER asset enrolled in the Symphony VPP. Modelling in the CBA assumes the same financial incentives and orchestration payments are provided to customers in the future as part of a scaled application, which is unlikely to be the case. The value of these incentives was largely determined by assessing what it would take to customers to sign up into the pilot, and the perceived value of orchestration and participation. As such, this value was not necessarily representative of the value that could actually be derived and then shared between the Aggregator and the customer.
- **Distribution of value** - overall, the outcomes of the Symphony modelling demonstrate that substantial value can be created and captured through the orchestration of DER and participation in VPPs in the SWIS (NPV of $450m over 10-years in the Expected growth scenario). The Symphony model also showed customers will receive a disproportionate share of value from DER orchestration to the possible detriment of the Parent Aggregator and/or TPAs.

The way forward

Given the natural limitations of the Project Symphony CBA, it is recommended that further modelling is conducted to understand a more accurate view of actual value able to be created from DER asset participation in the SWIS, as well as the distribution of the value between benefactors, such as customers, aggregators, DMO and DSO.

Against each of the identified gaps, additional modelling is recommended via collection of additional data such as:

- **Timeframe of data available** – at least 12-months of relevant operational and performance data to understand a full-cycle's trends. Where possible, collection of a second year's worth of data would be valuable, to enable like-for-like trend analysis across cycles.
- **Assets** – data from a more comprehensive set of DER participating in VPPs – such as electric vehicles, air conditioners, hot water systems, and commercial and community DER assets.
- **Services** – an expanded range of services the VPP can participate in, which were not tested as part of Project Symphony, such as the short-term energy market (STEM), the reserve capacity mechanism (RCM), FCESS regulation raise / lower, and ESS – contingency lower.
- **Pilot participation costs** – more reasonable, expected, and sustainable customer incentive structures, which are reflective of actual VPP customer contracts, access to new markets and exposure to actual pricing.
- **Other costs** – more reasonable and expected costs, reflective of DER orchestration and participation at scale, rather than costs associated with a pilot program.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action may be added to the DER Roadmap to account for this recommendation.

Recommendation 3.4 – Establish clear frameworks to enable TPAs to engage with the Parent Aggregator for non-contestable customers, to reduce barriers to entry and ensure consistent customer experience.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	Synergy	October 2025

Symphony scope

As part of Symphony, in addition to direct recruitment of residential customer DER, the Parent Aggregator was required to supplement the pool of DER assets with recruitment of a minimum of two TPAs and test the ability to technically integrate their respective 'platforms'.

In the context of the SWIS, TPAs are parties that own, or have access to non-contestable customer, DER and can provide the Parent Aggregator – as the financially responsible market participant (FRMP) – with access to an increased pool of DER for orchestration purposes.

The procurement of TPAs occurred through a range of pre-defined processes and steps to assess their ability to participate in the pilot. The Parent Aggregator ultimately, and successfully, procured two TPA partners: Rheem and Evergen (who engaged the services of Plico), providing access to an additional 221 solar PV, battery storage and hot water system assets.

The experience and findings

The selection of TPAs for Project Symphony commenced via an open Expression of Interest (EOI) process, whereby aggregators and broader DER ecosystem participants were invited to provide a response to the EOI. The EOI included a range of high-level technical and process requirements which the respondents were required to demonstrate ability to comply with. This included:

- The number and type of DER that the TPAs could bring into the pilot.
- Their approach to customer DER asset acquisition / onboarding and integration with their systems.
- Their ability to have technology solutions which enable orchestration and engagement with the Parent Aggregator.
- Their approach to engage with and manage customers.
- In total 11 parties submitted an EOI, with respondents coming from across the DER ecosystem, such as: DER installers, existing NEM VPP providers, local emerging ecosystem participants, energy retailers and technology providers. This demonstrates the interest and desire for various types of organisations to be involved as TPAs within the SWIS.

As the process continued, challenges (as could be deemed reasonable or inevitable given the pilot nature of Symphony) emerged with respect to TPAs. Specific examples include:

- Respondents highlighting many and varying models for participation in aggregation and orchestration of DER, as well as in engagement with customer.
- Difficulty in integrating TPA supplied DER into the Parent Aggregator's orchestration platform due to the range of DER assets, and therefore lack of consistent communication and interoperability capabilities (similar to what was experienced in Synergy's direct recruitment of customer DER).

- Significant time spent in negotiating complex commercial contracts between the TPA and the Parent Aggregator which catered for a strict Statement of Work, whilst providing the flexibility to solve unforeseen challenges and changing requirements associated with an innovative pilot.

These challenges ultimately resulted in greater than expected effort required through Project Symphony to integrate TPAs and their assets into the pilot, and substantial slippage (~10 months) in TPA orchestration activities being conducted from initially planned timeframes. Further, actual orchestration testing of TPA provided DER assets was time restricted in terms of when they became available during stability testing, as well as being restricted to ~2 hours per day when available.

The way forward

Given that current legislation and market rules prevent TPAs from directly participating in the WEM utilising non-contestable customer DER without involvement of the Parent Aggregator, it is recommended an end-to-end framework is established to enable TPAs to engage with the Parent Aggregator. This would enable TPAs to participate in SWIS VPPs, and access greater value from their customer's DER assets in a clearer and more predictable or consistent way. Importantly, this framework must focus on reducing the barriers to entry for TPAs.

Amongst other items, this framework should include detailed requirements and processes on:

- Guidelines on how the TPA can engage and recruit customers including overarching key messages.
- Minimum technology / technical requirements to enable streamlined and effective asset integration / orchestration, and platform integration.
- TPA reporting requirements to the Parent Aggregator.
- Any commercial model between the TPA and the Parent Aggregator.

Importantly, this framework must be robust enough to remove ambiguity, and provide greater confidence and certainty of what is required from TPAs, whilst providing the flexibility to enable various types (DER installers, to NEM VPP providers, energy retailers and technology providers etc.) of TPAs to participate. Additionally, the framework must enable fair and equitable consideration of all TPAs by the Parent Aggregator and establish a pathway for how this 'framework' would interact with Synergy's participation in the NCESS framework.

The framework could provide benefit in a number of ways, including establishing a baseline in which TPAs can mature their capabilities to meet requirements, signalling the expected importance and competition among TPAs in the SWIS. Ultimately, this framework is expected to provide access to a greater pool of DER participating as part of VPPs in the SWIS, and provide customers with a more consistent VPP experience.

In establishing this framework, careful consideration needs to be given to the timing and extent of engagement with TPAs.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action may be added to the DER Roadmap to account for this recommendation.

8. Policy and Regulation

Through the DER Roadmap, Project Symphony was to provide foundational insights to policy, regulation, and technical implementation. With Symphony having largely delivered on its objectives across the pillars of technical, customer and value, it was able to identify and inform some of the policy and regulatory changes required to enable DER orchestration as part of VPPs to continue its trajectory to scale.

Unique to Symphony, and a key strength in its oversight and implementation, was the purposeful and unflagging participation of EPWA at both a governance level as Chair of the Project Symphony Steering Committee and as imbedded subject matter experts as part of the broader project delivery team. Further, while the progress, lessons and outcomes of Symphony have and will further inform the required regulatory and policy changes, parallel streams of work led by EPWA have brought greater clarity under the DER Roadmap and Energy Transformation Strategy. These include defining DER orchestration roles and responsibilities in the WEM (see DER Roles and Responsibilities Information Paper[54]) and complimentary changes to the governance of the WA energy sector via the Electricity Industry (Distributed Energy Resources) Amendment Bill 2023[55] which together continue to provide for a well-coordinated and orderly transition to a high DER future in WA.

Project Symphony creates the basis for specific and deliberate regulatory and market reforms to enable the potential value of aggregated DER to be realised both in terms of supporting the efficient operation of the power system and providing benefit to customers.

8.1. Objectives

Specific policy and regulation objectives set out as part of Project Symphony include:

The Project will 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.

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).

[54] Energy Policy WA, Distributed Energy Resources (DER) Roadmap: DER Orchestration Roles and Responsibilities Information Paper: https://www.wa.gov.au/government/publications/distributed-energy-resources-der-roadmap-der-orchestration-roles-and-responsibilities-information-paper

[55] The Electricity Industry (Distributed Energy Resources) Amendment Bill 2023 was passed by the WA Legislative Assembly in October 2023. It is expected to pass the Legislative Council and become law in the first half of 2024.

8.2. Approach and outcomes

Symphony was intentionally delivered across the pillars of Technical, Customer and Value within the existing energy policy and regulatory environment as a means of identifying which parts of existing policy or regulation, such as the Technical Rules,[56] Metering Code[57], Roles and Responsibilities etc., are or may be a barrier to realising the full potential of DER participation in WA. Again, EPWA's role as Chair of the Steering Committee, and within operational delivery, enabled first-hand experience of the progress against objectives and insights into the impact of current and future policy and regulation.

A key example of this is the way in which orchestrated DER needs to perform as a facility under the WEM's current 'Facility Class' registration arrangements outlines in the WEM Rules which are fit for the purpose of large, single generators connected to the network. Evidence from Symphony suggests that the interaction between aggregated DER facilities and the energy market is quite different to that contemplated by the existing WEM Rules and current Facility Class registration arrangements. That is, aggregated DER as a facility does not fit neatly into existing WEM Facility Class arrangements. If left unchanged, it could result in a continued barrier or constraint on DER participation in the WEM.

As noted in Section 2.2, Symphony is a key dependency of a number of other actions in the DER Roadmap, and through the successful delivery of Symphony, those actions can be updated or amended as required. Finally, where any recommendation is new or unique, it should also be added to an amended version of the DER Roadmap, with timing prioritisation, and allocation of their implementation governed by the DERRCC, and further stakeholder consultation led by EPWA.

[56] https://www.westernpower.com.au/resources-education/manuals-guides-standards/technical-rules/
[57] https://www.wa.gov.au/government/publications/electricity-industry-metering-code-2012

8.3. Policy and regulation lessons learnt and recommendations

Recommendation 4.1 – Support VPP visibility for the DMO and DSO, through implementing amendments to the WEM rules.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	EPWA	December 2024

Symphony scope

In the context of the electricity system, Low Voltage (LV) visibility refers to the ability to monitor and understand the state and performance of a power distribution network, through data. LV refers to the lower voltage levels in a power distribution system, typically below 1,000 volts, which is where most DER assets are connected.

Network visibility involves the use of monitoring systems, sensors, and communication technologies, such as AMI, to collect near real-time data on various parameters within the electrical network. This data can include voltage levels, current flows, power factor, and other relevant electrical parameters.

From the perspective of Project Symphony, the consideration and testing of LV network visibility was critical given the importance of more real-time, granular, and accurate data for both the DMO and DSO to deliver on its respective roles and responsibilities.

The experience and findings

As highlighted in the initial DER Roadmap, there was a noticeable lack of network visibility for both the DSO and the DMO. Specifically:

- Whilst, the DSO had a limited view of distribution network power flows and technical performance, there was virtually no visibility on the LV network where most of the DER is connected.
- The DMO had limited information available as the whole of system operator about the number, location, type, and performance of DER installations, as well as visibility on the impact of dispatching a given volume (MW) of participating DER onto the network.

Overall, this lack of visibility was noted as a barrier to investment decisions required to facilitate future DER installations and to the establishment of a DSO that can actively optimise DER on the distribution network. Improved visibility also improves the reliable operation of the power system, and the transparent and efficient operation of the electricity market via the DMO. Further, as well as related work undertaken by AEMO as part of DER visibility framework[58] in the WEM, visibility of the availability and capacity of aggregated energy for participation in on and off market services will become a critical input to maintaining system security and market efficiency.

As part of Project Symphony, visibility challenges manifested through the calculation and testing of dynamic operating envelopes.

[58] AEMO, Virtual Power Plant Visibility Framework: https://aemo.com.au/consultations/current-and-closed-consultations/virtual-power-plant-visibility-framework

As a key mechanism in managing network operational performance, operating envelopes refer to the technical mechanism which defines the safe area of operations between limits (exports and imports) in which an asset, and the overall network, can function without presenting a network security risk. Operating outside of the operating envelope boundaries can lead to power quality issues on the network, and in extreme cases lead to equipment failure and network outage.

Converse to static operating limits, which are the dominant current operating envelope method, dynamic operating envelopes are calculated and published more frequently (daily during Symphony), which results in operational limits that are varied and flexible based upon time, customer load and DER generation. Overall Project Symphony demonstrated the benefit potential of dynamic operating envelopes in a high DER future, by enabling the more efficient and effective allocation of available network hosting capacity to customers without breaching safe operating limits, providing customers an incentive to install larger DER, providing a mechanism to manage DER operation during periods of constrained network capacity, and maintain network security. The below figure illustrates the additional variable export capacity which can be capitalised on by DER managed via dynamic operating envelopes.

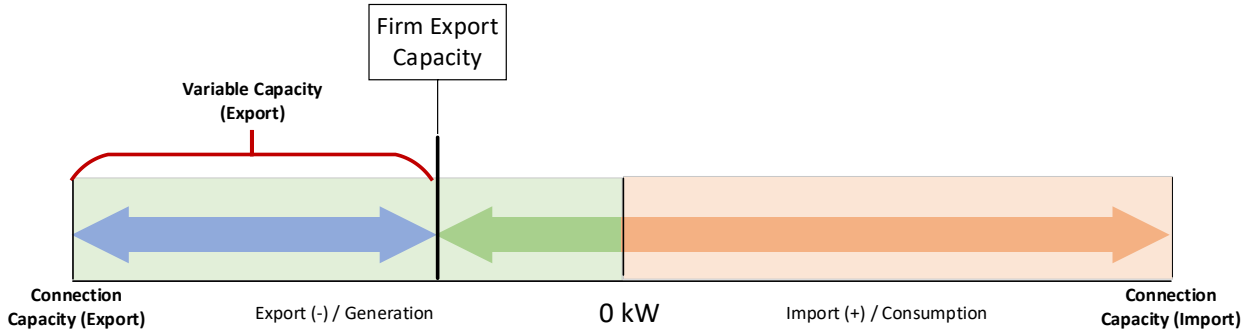


Figure 41: Project Symphony - Dynamic Operating Envelopes

Whilst benefits from dynamic operating envelopes have been demonstrated through Project Symphony, the Pilot also highlighted opportunities for improvement in LV and DER visibility, which are necessary to calculate network capacity and communicate the dynamic operating envelopes effectively and efficiently. More specifically, challenges arose in having the appropriate level of granular, timely and accurate data from LV visibility.

Other areas in which LV network visibility was important for Project Symphony include ability to better forecast network peaks through better understanding energy flows and compliance on the network, measurement of network support services (NSS) called upon by the DSO, service settlement activities, and overall scheduling and dispatch activities.

The way forward

To support greater visibility of DERs via the LV network, and therefore enhance the ability of the DMO and DSO to fulfil their DER orchestration roles and responsibilities and extract more value from DER orchestration, it is recommended that amendments are made to the WEM Rules as well as Western Power's technical rules where appropriate and as required.

More specifically, the recommendation scope should include a review of the coverage of network visibility investments under the regulatory framework under the WEM Rules and extend to the Electricity Networks Access Code 2004.

Additionally, measures should be taken to further update and consider AEMO's VPP Visibility Guidelines[59] for implementation (or similar) into WEM Rules as a cornerstone of ensuring visibility of unregistered DER aggregations. The VPP Visibility Guideline is an interim voluntary step to establish minimum visibility data specifications and processes. However, as a voluntary measure, this cannot provide surety of data quality or completeness at the level that will be required to enable aggregated DER at scale.

Other considerations in supporting greater VPP visibility include:

- **Monitoring equipment:** Deploying the appropriate sensors and monitoring devices at different points in the network to measure electrical parameters, such as Western Power's AMI which is currently in deployment, supplemented with additional monitoring of network equipment (such as distribution transformers) in certain situations where AMI is insufficient.
- **Data collection:** Strengthening the ability to gather data in real-time or at regular intervals from the monitoring devices.
- **Communication systems:** Improving the ability to reliably and security transmit collected data to a central control system using the appropriate communication technologies systems or other data communication protocols.
- **Fault detection and diagnosis:** Enhancing the ability to detect and diagnose faults or abnormalities in the network, allowing for quicker response times in addressing issues.

Increasing visibility of the LV network will be a critical enabler to more real-time, granular and accurate data, which will be captured within the proposed DER data hub. As such, this recommendation forms a critical input into recommendation *1.2 Develop the business case for a 'DER Data Hub' to facilitate effective and efficient data exchange between the DMO, DSO and Aggregators.*

This recommendation closely aligns to and is an extension of DER Roadmap action #14: 'Undertake an assessment of distribution network visibility capability and develop an investment plan for deploying technology to improve that visibility, both static and dynamic, to support DSO and system / market operator requirements' which is the responsibility of Western Power. While rule development overall is being led by EPWA, it is contingent upon such work being completed by Western Power and AEMO.

For further details on 'visibility' as captured in the DER Roadmap and DER Roles and Responsibilities Information Paper, see:

- Distributed Energy Resource Roadmap
- Distributed Energy Resources Roadmap: DER Orchestration Roles and Responsibilities Information Paper

[59] AEMO, VPP Visibility Guideline: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/wa_wem_consultation_documents/2022/proposed-design-for-a-visibility-framework/vpp-visibility-guideline.pdf?la=en

Recommendation 4.2 – Establish policy positions that appropriately incentivise aggregators to participate, and ensure value is passed through to the customer.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	EPWA	December 2024

Symphony scope

Through the customer recruitment process, Project Symphony established criteria to define customers' eligibility to participate in the Pilot.

The criteria were defined by technical needs such as location, geographic solar PV concentration, accessibility to customers (i.e., households who were easily contactable) and expected value / contribution from customers as defined by the Parent Aggregator's business model, to optimise results and make pilot delivery more practical.

The Pilot aimed to recruit 500 customers to participate in Project Symphony.

Experience and findings

While 514 customers ultimately participated in Project Symphony, many other residential customers who were willing to participate were excluded given the limiting criteria – with reasons including customer not being accessible enough, not in the right location and the customer not expected to create sufficient levels of value under the current Parent Aggregator business model.

This exclusion occurred even though many of the ineligible customers had complied with other installation-related requirements, such as right sizing their systems to prioritise self-consumption, rather than generating considerable excess electricity that would flow onto the grid. Some 'ineligible' customers voiced confusion and disappointment about their ineligibility to participate.

Looking ahead to state-wide application and policy setting, in a high DER and VPP-enabled SWIS, the business model would need to maximise customer inclusion/participation as it may not be publicly acceptable to limit or exclude customers from participating. Further, pilot customer surveys indicated views that participating in VPPs should be 'open to as many people as possible' to enable everyone to contribute towards the greater good. It should also be noted that related work to enable DER monitoring and compliance in the SWIS will strongly influence the opportunity and approach to maximising customer participation (also see Recommendation 4.3).

Of note, the cost benefit analysis modelling conducted for Work Package 8.3, demonstrates that higher VPP participation rates – and participation in multiple services, known as value stacking – drive greater value generation from the VPPs overall. Aligned to this finding, the modelling also found that customers are the core financial beneficiaries of scaled VPP (rather than the Parent Aggregator) meaning that there is a viable proposition for broader customer participation.

The way forward

To enable maximum value creation from VPPs in the SWIS, all *non-contestable* customers should have the same opportunity to participate in VPPs and DER orchestration.

While government policy to date has been reasonably focussed on Synergy's DER fleet as the Parent Aggregator as per the DER Orchestration Roles and Responsibilities, for DER aggregation to reach its full potential consideration also needs to be given to the establishment of services with the *contestable* market to ensure VPP participation is maximised.

As such, it is recommended that aggregators in the SWIS are incentivised to augment or create business models which have open and broad criteria for VPP participation that allows equitable opportunity for all non-contestable customers to participate in VPPs, unless clearly ineligible (e.g., customer inverter technically incompatible). For the Parent Aggregator, with the appropriate incentive, over time this recommendation would see a shift from its existing 'retailer' business model to one of an 'aggregator'.

A public perception of equity of access to VPP participation is also important in the SWIS given the position of Synergy as monopoly retailer for, and effective default VPP operator for, households, and its ownership by the State government. Notwithstanding this, whilst Project Symphony tested the business model of the Parent Aggregator, there should be consideration of how this recommendation of promoting access to all who wish to participate could be extended to other TPAs which are or may operate within the SWIS.

Importantly, a more inclusive business model does not promise that all customers will benefit equally from VPP participation, or that all customers will be orchestrated the same amount. It means that all customers will have the opportunity to be incorporated into the VPP, then involved in VPP orchestration based on the customer's consumption behaviour and DER types (e.g., batteries are able to participate in more services than solar PV).

Additionally, these policy positions should promote the delivery of and customer participation in multiple services – or value stacking – which through the Project Symphony CBA was demonstrated to be a critical component in maximising value created from DER orchestration.

Delivering this recommendation will be foundational to enable the transitioning from pilot to broader operationalisation, allowing more non-contestable customers to participate in future SWIS VPPs and in multiple services, unlocking maximum value accretion, and ultimately increasing DER asset's contribution towards the State's decarbonisation objectives.

Although the incentivisation is recommended to be established through appropriate policy provision, further assessment is required which determines the exact form, structure and mechanism of the incentive(s).

It is recognised that substantial effort will be required to execute and manage this recommendation, which involves defining all business model elements, such as the key value streams, likely uptake rate and scale from customers, and implementing a revised operating model.

This recommendation, in particular the development of a new aggregator business model, will be a critical input in the delivery of recommendation *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(s)*, and work alongside recommendation *3.1 Commence work on policy solutions to establish market frameworks that support the participation of DER aggregations in the WEM*, which demonstrates the need for new market frameworks to support DER aggregation and value creation in the SWIS.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action may be added to the DER Roadmap to account for this recommendation.

Recommendation 4.3 - Review and reform end-to-end DER installation, connection, commissioning, and compliance.

Recommendation importance	Lead	Timing
Tier 1 – Critical Enabler	Western Power and Synergy	December 2025

Symphony scope

Symphony was established to test the end-to-end processes and capability associated with DER orchestration in the SWIS, with a focus on small-scale residential DER such as solar PV, battery storage, air conditioners and hot water systems, as well as some larger community batteries.

Critical to scope included the recruitment of customers and their existing DER assets such as rooftop solar PV, as well as the registration, integration, ongoing monitoring, and *compliance* of those DER assets as essential to enabling effective and efficient DER orchestration.

Experience and findings

Through Project Symphony, several complications were encountered with respect to end-to-end DER connection processes. These include:

- ***Inaccurate customer DER information*** – customer DER information collected in advance of Symphony was often inaccurate, with the make and model, and therefore the size, misidentified, leading to compatibility issues with certain DER systems.
- ***Initial installation non-compliance*** – where customers had their assets (like PV) installed prior to the program high levels of non-compliance with customer connection agreements was found. This issue was largely demonstrated through PV inverters being coded to another country's country code (and therefore to another country's volt-var safety mechanisms). Incorrect settings particularly in high-DER areas can result in power quality and reliability issues.
- ***Changing DER asset settings*** – the program experienced DER assets having their settings changed resulting in non-compliance with customer connection agreements. Most noticeability this occurred when DER assets were no longer connected to internet – often occurring due to a change in Wi-Fi passwords.

The downstream implications of these end-to-end process issues included the need for additional site visits to install further ancillary assets or to accurately understand the type of DER asset. Incomplete, inaccurate, insufficient, and untimely data being captured, reduced the Parent Aggregators' ability to orchestrate DER in line with expectations.

Further, opportunities for process improvement were found within the DER application and connection process[60] itself, particularly business to business interactions as well as the technology that underpins the process.

Since 18 December 2021, all new inverters below connected at low voltage must meet the AS 4777.2 standard and be configured to the regional setting of 'Australia B' when installed in the SWIS. AEMO's April

[60] Western Power, Basic Embedded Generator (EG) Connection Technical Requirements: https://www.westernpower.com.au/siteassets/documents/manuals-guides-and-standards/basic-embedded-generation-connection-requirements/basic-embedded-generation-technical-requirements-20240108.pdf

2023 review of Compliance of DER with Technical Settings[61] highlights findings that there are moderately high levels of non-compliance with the AS 4777.2 standard due to installers configuring inverters incorrectly.

Overall, the Project experienced a reduction in efficiency and effectiveness resulting from challenges in end-to-end DER installation, connection, commissioning and compliance activities.

The way forward

Given the challenges identified above, it is recommended that a complete redesign of the end-to-end small-scale DER installation, connection, commissioning, and compliance processes and systems are commenced as a priority.

More specifically, it is recommended that process development is heavily underpinned and invests in substantial technological capability to limit manual workflows and workarounds and increase integration between participating parties.

Investment in required technologies should enable more complete, accurate, and timely data to be collected which is necessary for DER orchestration, whilst also more efficiently managing and monitoring DER asset compliance and improving the overall customer and installer experience when connecting and commissioning DER. Overall, this will result in more effective, cost and time efficient, and value-accretive DER orchestration activities to occur, whilst prioritising customer experience.

Whilst Project Symphony has predominantly focused on small-scale residential DER, development of the recommended process should be established to also be relevant to larger small-scale DER – such as community batteries.

At a minimum delivery of this recommendation will require involvement from the DMO, the Parent Aggregator for non-contestable customers, the DSO and DER installers. Additionally, given the size and scale of this recommendation, early planning on implementation and change management requirements is suggested.

This recommendation will closely interact with recommendation 1.2 *Develop the business case for a 'DER Data Hub'* to facilitate effective and efficient data exchange between the DMO, DSO and Aggregators, by establishing the process that determines what data will be collected and how it be collected.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action should be added to the DER Roadmap to account for this recommendation.

[61] AEMO, Compliance of Distributed Energy Resources with Technical Settings: https://aemo.com.au/-/media/files/initiatives/der/2023/compliance-of-der-with-technical-settings.pdf?la=en

Recommendation 4.4 - Develop incentives to accelerate the take-up of energy storage, bringing forward power system and decarbonisation benefits.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	EPWA	December 2024

Symphony scope

Given the role that battery storage is expected to play in assisting the State towards its energy transition objectives, Project Symphony placed significant emphasis on understanding and quantifying the impact and benefits that residential battery storage could offer in the SWIS, through DER orchestration.

To do this, Project Symphony set a target to recruit 150 residential battery storage assets into the Pilot. As cost is currently a significant barrier to residential storage uptake, incentives were developed and provided to customers via an 'asset subsidy'. The subsidy covered ~50% of total value, equalling between approximately $7,500 – 10,000 depending on the capacity of battery storage.

Experience and findings

In May 2023, the WA Government released the South West Interconnected System Demand Assessment (SWISDA)[62], which modelled the state's main electricity grid and highlights its future reliance on solar and wind energy. These are intermittent energy sources, with at least 13GWh of energy storage required by 2030 to maintain supply reliability in the presence of strong demand growth, especially overnight when rooftop solar is not producing.

Currently, there are around 11,000 batteries installed in the SWIS, compared to 406,000 rooftop solar systems.

Residential battery storage installation is significantly lagging solar PV installation in the SWIS due to the high investment cost of equipment and long payback times. In contrast, the incentive to install solar PV in Western Australia – such as solar panel rebates are strong due to good underlying solar resource, low equipment costs, and ability to increase consumption of self-generated energy. Solar has also been supported by national subsidies under the Renewable Energy Target, and in early years, high energy export payments.

It was noted that the Pilot's asset subsidy, particularly for battery storage assets were 'appreciated by participants' with 76% of participants rating the asset subsidy as a being an influential reason in their decision to participate in the Pilot, and it being noted as the single most significant factor for participation. Subsequent surveys indicated that 88% of participating customers were satisfied with the asset subsidy incentive offered by Project Symphony.

Through achieving the target of recruiting all 150 residential battery storage assets into the Pilot, the Project Symphony Cost Benefit Analysis (Work Package 8.3) showed that battery storage will individually be the most significant contributor to the value that DER orchestration in the SWIS can generate, due to its capability to participate in the greatest number of services and value streams, in comparison to other DER. Modelling within Work Package 2.1 DER Services Report suggests that battery storage will contribute ~70% of the value VPPs can create within the SWIS, with notable potential for shaving or reducing peak demand. This suggests that improving the return on investment for battery storage is essential to unlocking value from VPPs.

[62] Energy Policy WA, SWIS Demand Assessment: https://www.wa.gov.au/government/document-collections/swis-demand-assessment

While large-scale battery storage, such as Synergy's Collie and Kwinana battery storage facilities, will contribute significantly to SWIS battery storage capacity. However, without a steady uptake of residential battery storage, the SWIS will not reach growing storage targets – as highlighted in the SWISDA[63] report – and DER orchestration in the SWIS will not reach its maximum value potential.

The way forward

A key recommendation to enable greater DER orchestration and maximise the benefits generated is to incentivise the take-up of residential battery storage. This can be done through direct subsidies and by improving tariffs associated with customers who are willing to participate in VPPs.

To effectively design a residential battery storage incentive scheme, it is recommended that:

- Incentive amounts are to be determined through further cost benefit and value sharing analysis (Recommendation 3.3)
- Consideration be given to who the incentive applies to – as in for existing, newly purchased and / or replacement battery storage assets.
- Lessons learnt from similar in-train schemes are considered, particularly where the battery incentive is coupled to VPP participation, such as in Victoria (Solar battery loans through the Solar Homes Program) and South Australia (SA Solar Battery Subsidy program).
- Changes required to relevant policy and regulation are reviewed and considered.
- Broader economic and social implications of the incentives are understood and factored into incentive design.

While Symphony did not directly test tariff options, as evidenced in other reports, such as the DER Roadmap, existing tariff arrangements for customers are not optimal for VPP participation.

The flat A1 tariff – which is the default product for WA residential customers – charges one rate throughout the entire day irrespective of peak or non-peak electricity usage. This means that where customers inject or withdraw energy from batteries, the A1 tariff structure results in higher energy use charges that need to be countered by further incentive payments if the customer is to see their overall bill reduce.

It is recommended that as a condition of accepting any battery subsidy, residential customers are placed onto a more cost-reflective tariff, such as a time-of-use tariff. In short, a time-of-use tariff charges different amounts throughout the day, depending on when electricity consumption occurs, with the main benefit of time-of-use tariffs being to align tariff prices with underlying costs and provide incentive to shift discretionary energy usage away from peak periods. In addition to customer benefits, a time-of-use tariff provides a mechanism for a more 'smoothed out' energy demand curve.

Regarding export payments for energy, owners of residential battery storage currently have access to the Distributed Energy Buyback Scheme (DEBS) – which provides customers with a maximum of 10c/kWh when electricity is exported back into the network. Whether this remains appropriate in a higher-DER SWIS, where energy is exported and used to provide network or system support services, requires further investigation.

[63] Energy Policy WA, SWIS Demand Assessment: https://www.wa.gov.au/government/document-collections/swis-demand-assessment

The development and implementation of an incentive structure, with an attached revised tariff structure[64], should encourage uptake of residential battery storage – and due to the ability of storage to participate in many value streams and services – bring forward substantial value creation, and power system and decarbonisation benefits.

The tariff element of this recommendation closely aligns to and is an extension of DER Roadmap action number 17 'Develop tariff pilot programs to explore tariff structures that encourage system-efficient use of and investment in DER and help to share the benefits of DER with all customers. The scope of the pilots should include measures to assist and protect vulnerable customers.'

For more information on the tariff-related DER Roadmap actions see: DER Roadmap[65]

Recommendation 4.5 - Mandate adoption of AS4755 Demand Response Standards by OEMs to enable greater interoperability of air conditioners for load management by aggregators.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	EPWA	December 2024

Symphony scope

Amongst other DER assets, Symphony tested the ability of residential heating, ventilation and air conditioning (HVAC) assets, more commonly known as air conditioners, to be orchestrated as part of being in the Symphony VPP.

This was considered important given the number of air conditioning units in the SWIS, and their contribution to network peaks particularly during summer (also see Recommendation 3.2).

In total, Project Symphony targeted 280 air conditioner systems across both ducted Air Conditioning featuring demand response module (DRM) capability and Split System Reverse Cycle units with smart devices for remote management to participate.

Experience and findings

Specific challenges were faced in orchestrating air conditioner assets, such as underestimating the complexity of implementing available technical solutions, or for those ACs set up to be controlled via infrared control, rather than demand response management (DRM) systems, the infrared transmitter often did not work reliably enough. As a result, air conditioning assets were unable to be tested during the peak summer period and were not available for orchestration testing due to not being on during the cooler months of the 'stability period'.

The decisions made on which air conditioners to recruit, and the technical requirements, was largely based on the Parent Aggregator's understanding of asset eligibility, and technical capability at the time of recruitment. Asset eligibility was formed through discussion with original equipment manufacturers, particularly those who were expected to be compliant with AS4755 as the voluntary Australian Standard for demand response of air conditioner systems. This ultimately resulted in 218 total air conditioner assets being recruited, short of the stated target.

[64] Such a tariff would be opt-in and would not affect the subsidised, regulated tariff.
[65] The Energy Transformation Taskforce, Distributed Energy Resources Roadmap: https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf

As customer site visits were conducted and additional information was collected from original equipment manufacturers around asset capabilities – including the ability to integrate the asset for DER orchestration purposes, some customers had to have their involvement stopped as their assets were not able to be commissioned. On some occasions original equipment manufacturers were not able to determine if air conditioning or inverter models would be compatible, unless physically tested. Ultimately these challenges resulted in only 55% (119) of the recruited 218 air conditioner assets being orchestrated.

One of the critical challenges faced was the fact that not all ducted air conditioners were compatible with DRM as part of AS4755. In fact, approximately only one third of existing air conditioners were found to be compatible. Whilst several scenarios were able to be rectified quickly, more than 10% (29) of the air conditioners recruited which required a DRM card, simply did not have a DRM card slot to enable DRM capability to be retrofitted.

In the context of a VPP, verified DRM capability becomes critical as it allows air conditioners to be seamlessly orchestrated. Whilst AC demand can be managed using other technical solutions they tend to be more invasive, not easily integrated into the Parent Aggregator platform, and more costly to implement.

DRM capability is very useful during network peak demand when ACs can be cycled, enabling the DSO to manage load and network security while customer comfort is not adversely impacted. These findings were demonstrated through Perth Solar City program[66] that was active through 2009 to 2012, and the RACE for 2030 Flexible Demand and Demand Control final report[67] in 2021 and the Broome Smart Sun pilot[68]. Further work is required to fully understand the impact and value that demand management has on the SWIS, as these findings were unable to be fully demonstrated through Project Symphony given the challenges noted above.

Given the relatively young age of customer properties, and therefore air conditioners within the pilot area, it is reasonably expected that the proportion of DRM *incompatible* air conditioners across the SWIS would be the same or higher.

In simplest terms, the conformance of installed air conditioning equipment to *AS4755 – Demand Response Standard*, is limited. As noted prior, the Parent Aggregator found only 35% of customers who applied to participate in Symphony had air conditioners that complied with the relevant Australian standard, AS4755, with original equipment manufacturers often demonstrating limited knowledge of how their products indeed comply with the standard.

Deep dive

Finalised in 2020, *AS4755 Demand Response Standard* establishes the framework in which appliances and manufacturers are all connected and respond to a set of standardised remote signals to enable remote control the asset and its energy usage.

In the most basic form, it requires appliances to have 'demand response modes' that provides an interface to remotely alter power consumption at certain times. This enables external control to shift load to times when demand is low and reduce load when demand is high, potentially reducing cost to end users. AS4755 is currently not a mandatory standard for original equipment manufacturers to adopt in WA.

[66] Perth Solar City program: https://www.perthsolarcity.com.au
[67] RACE for 2030, Flexible Demand and Demand Control: http://www.racefor2030.com.au/wp-content/uploads/2021/10/RACE-B4-OA-Final-report.pdf
[68] Horizon Power, Smart Sun pilot: https://www.horizonpower.com.au/your-community/getting-future-ready/smart-sun-pilot/

All in all, as demonstrated through Project Symphony, misalignment of air conditioner design to AS4755 leads to a reduction and restriction in the number of assets able to participate in VPPs, which limits the VPP's ability to effectively manage network peaks.

The way forward

To achieve scaled provision of peak shaving and emergency demand management services via a VPP, it is recommended there is a common and mandated adoption of assets with DRM capability within the SWIS. Given past standards have been interpreted and adopted to various levels, it is recommended that adoption of AS4755 is mandated within the SWIS via development of the appropriate technical rules or legislative change, with outcomes being carefully monitored to further understand the value and impact potential from mandating AS4755. From July 2023, South Australia mandated the requirement that certain air conditioners must comply with[69].

Under this recommendation AS4755 adoption would not apply retrospectively to air conditioner assets that are already installed.

Whilst AS4755 is relevant to a range of assets such as air conditioners, pool pumps, electric hot water systems, and electric vehicle supply equipment, in the context of this recommendation, it focuses on air conditioners due to the market proliferation of air conditioners and the large impact successful demand management of air conditioners would have on load management in the SWIS.

The mandating of AS4755 would necessitate changes to original equipment manufacturer approaches and asset design / build. This change must be managed and timed appropriately, with significant actors in the WEM value chain recommended to engage with original equipment manufacturers to conduct any co-design / refinement of AS4755 which is necessary.

The primary benefit of AS4755 is that it would require a common set of capabilities in air conditioners across original equipment manufacturers, which enables greater interoperability, and therefore more efficient orchestration. This leads to the ability to manage network highs and lows more effectively, and an increase in overall value generated from orchestration.

Additional considerations are required on specific timing of adoption, potential to collaborate with national counterparts to drive national adoption, the specific mechanism in which AS4755 will be mandated through, and applicability across customer types – non-contestable and contestable. Review of South Australia's experiences and learnings in mandating AS4755, should also be undertaken as part of this recommendation.

This recommendation closely aligns to DER Roadmap action number 3 'Evaluate appropriate mandatory standards, communications functionality, and protocols for remote management of DER, including electric vehicle equipment, and establish a plan to implement.'

[69] South Australian Government, Air conditioner regulation change: https://www.energymining.sa.gov.au/industry/energy-efficiency-and-productivity/air-conditioners-regulation-change

Recommendation 4.6 - Introduce dynamic network connections to enable the flexible connection of DER onto Western Power's network to improve customer choice whilst contributing to decarbonisation.

Recommendation importance	Lead	Timing
Tier 2 – Enabler	Western Power	December 2025

Symphony scope

As part of the Pilot, Symphony aimed to test the ability to manage export limits effectively and flexibly through dynamic network connections, such as dynamic operating envelopes to optimise the use of available hosting capacity. This differs to the current method of utilising static operating envelopes.

Each of these terms have been described further below.

Experience and findings

Operating envelopes refer to the mechanism which defines the safe area of operations between limits (exports and imports) in which an asset, and the overall network, can function. Operating outside of these boundaries can lead to blackouts and other major network events.

Current standard practice utilises static operating envelopes as the norm. Static operating envelopes are operating envelopes whose export and import boundaries / limits remain the same, irrespective of changes in network conditions and time, and equitably provide customers capacity based on existing visibility and technical capabilities. In the context of operating envelopes, export refers to the selling or 'release' of energy into the network from a DER, and import refers to the purchase or 'taking' of energy from the network.

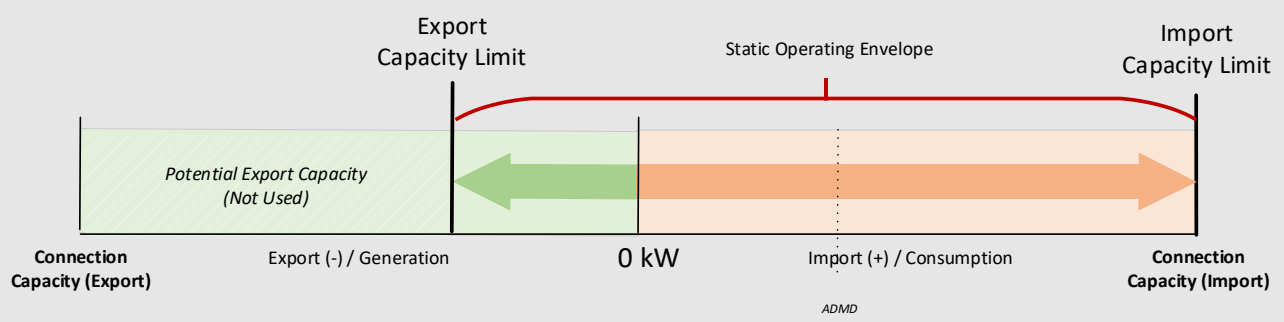


Figure 42: Current state – Static Operating Envelopes

The static limits are governed by the Western Power's Basic Embedded Generation Connection Technical Requirements (the Requirements)[70]. These Requirements details customers' obligations for connection to and interfacing with embedded generation – such as solar PV and can include battery storage assets – with Western Power's distribution network.

[70] Western Power, Basic Embedded Generator Connection Technical Requirements: https://www.westernpower.com.au/siteassets/documents/documents-and-policies/basic-embedded-generation-connection-technical-requirements/basic-eg-generator-technical-requirements-20230411.pdf

With respect to DER – and in particular inverter-based DER such as solar PV and battery storage –, the relevance of the Requirements relates to the allowable limits placed on energy export into the network. Under the Requirements, static export limits are applied, with limits depending on the size and capacity of the asset. More specifically:

- Up to 5 kW where a customer has up to 5 kVA of inverter-based DER capacity and an off-take agreement with an energy retailer.
- Up to 1.5 kW where a customer has more than 5 kVA of inverter-based DER capacity and no off-take agreement with an energy retailer.

In short, unless the customer requires larger solar PV for self-consumption, the existing Requirements and static export limits – as well as lack of suitable tariff structures – place a dis-incentive for customers who want to solar PV assets larger than 5kW, with excess energy being curtailed and no gain obtainable by customers. This argument may also apply for battery storage assets.

Whilst the static and unchanging nature of current operating envelopes makes it easy to manage, the static export limits result in a drawback. Namely in that they can often understate the available hosting capacity of the network at certain times and therefore reduce the amount of benefit that can be captured from maximising the use of hosting capacity, such as financial benefit and contributions to decarbonisation targets as demonstrated through the Symphony Cost Benefit Analysis (Work Package 8.3).

As such a core element of Symphony was to test the development and application of dynamic operating envelopes.

Dynamic operating envelopes are operational limits that can change flexibly depending on time and network constraints. Dynamic operating envelopes therefore provide the technical capability and opportunity to utilise remaining available network capacity without breaching safe operating limits, that static operating envelopes would otherwise be unable to use.

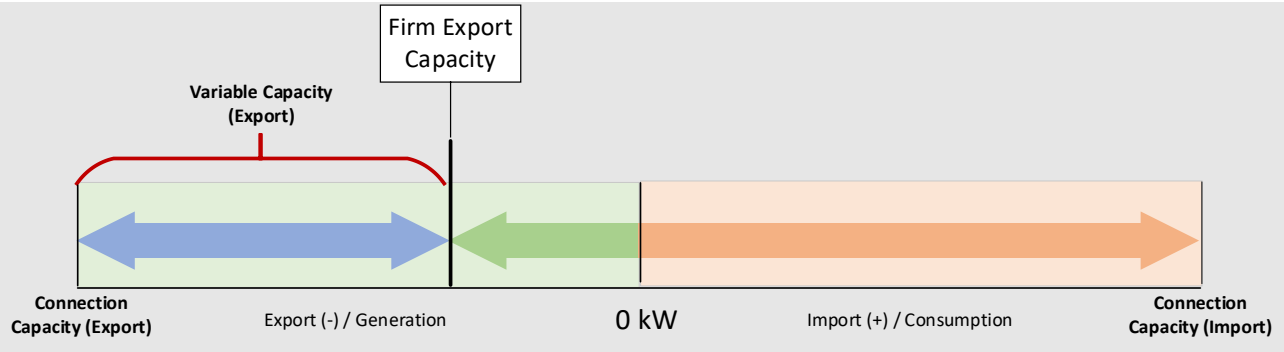


Figure 43: Project Symphony - Dynamic Operating Envelopes

The outcomes of developing and testing DOEs include the following:

- Confirmation that DOEs become more effective, and create more value, the greater the participation of DERs in a VPP.
- Confirmation that in a high DER future where available hosting capacity is reduced, DOEs are a necessary part of a VPP-enabled SWIS. DOEs are necessary to avoid inadvertent over allocation of capacity and breaching technical and operating limits.
- Recognition that to generate the most value from dynamic operating envelopes in the SWIS, corresponding changes to customer contracts and relevant regulatory instruments are necessary.
- Leveraging the capability of DOEs, greater consideration can be given to enabling dynamic connections to the network.

Overall, Symphony highlighted the potential of dynamic operating envelopes as a technical solution within the SWIS, by demonstrating the ability to effectively calculate dynamic operating envelopes and enable flexible management of export limits depending on network needs. In short, dynamic operating envelopes enabled an increase in export limits when the network required additional electricity injected and the price is high (customer is compensated at a higher price) and lowering of export limits when the network load and prices are low.

Symphony displayed dynamic operating envelope's ability to increase DERs' contribution to decarbonisation via establishing increased hosting capacity for 'green' electrons, manage localised constraints to minimise issues in the network, and deliver an increase in tangible monetary value to all stakeholders.

Additionally, the Symphony cost benefit analysis (Work Package 8.3) demonstrated that more value is created through delivery of services via dynamic operating envelopes, the greater the number of DER assets which participate in VPPs.

Whilst dynamic operating envelopes have been demonstrated as technically viable and enable value to be generated, technical restrictions on export limits – via the Embedded Generation Connection Technical Requirements – require update to align with the capabilities that dynamic operating envelopes bring.

Symphony did not directly test the technical capability or regulatory requirements related to dynamically managing imports. However, it is noted that the dynamic network connections tested in Project Symphony can also be leveraged to establish the ability to flexibly manage import limits.

The way forward

Given the above, it is recommended that a four-pronged approach is undertaken to introduce dynamic network connections. This includes:

- Establishment of customer product / contractual arrangements that provides the mechanism to allow aggregators to flexibly manage customer exports when the network dictates.
- Further development and refinement of dynamic operating envelopes, which acts as the technical solution to enable dynamic operating limits to be calculated, communicated, and enforced on export limits when required.
- Updates made to the Embedded Generation Connection Technical Requirements to enable the dynamic export limits, which forms the mechanism to freely utilise dynamic operating envelopes.
- Regulatory instruments developed which are necessary to manage dispute resolution and deal with other regulatory issues which may arise from the calculation and application of dynamic operating envelopes.

In the context of this recommendation, the enabling of the dynamic export limits in the Embedded Generation Connection Technical Requirements does not mean setting a higher static export limit. Rather it refers to allowing flexibility in the export limit depending on the needs of the network at a given time interval, with the maximum export limit set higher than existing limits. To effectively revise the Requirements, further improvements are required in LV visibility capability (recommendation 4.1), policy setting around allocation principles and confidence in the ability of aggregators to comply with dynamic operating envelopes (Recommendation 1.3).

- The introduction and delivery of the dynamic network connections – comprised of customer, technical solutions – will allow customers to safely increase export contribution, which financially benefits customer and provides an incentive for customer to choose to install larger capacity solar PV – and potentially also battery storage – where possible. This in turn maximises the opportunity to export 'green' electrons into the network and the ability for residential generation to contribute to network safety and security.
- Given Project Symphony did not test dynamic management of imports, this recommendation does not extend to dynamic network connections for imports. However, given the potential benefits of import focused dynamic network connections, further consideration is required on the need to test two-way dynamic network connections – both exports and imports.
- Delivery of dynamic network connections becomes a critical enabler to development of Parent Aggregator service delivery standards that is recommended as part of recommendation 1.3 Develop specifications around Parent Aggregator service delivery standards to accelerate compliance with service delivery standards in the WEM. Further, ongoing customer engagement is critical to ensure that customers are aware of their obligations and the implications of dynamic network connections on their usage and bills. As such, this recommendation also closely aligns with recommendation 2.2 Develop end-to-end customer engagement tools to manage and improve the customer experience of VPP participation.

This recommendation does not closely align to any existing actions in the DER Roadmap. A new action should be added to the DER Roadmap to account for this recommendation.

For further details on the existing export limits, see:

- Basic Embedded Generation Connection Technical Requirements[71]

For further details on the value which dynamic network can create, see:

- Work Package 8.3 Cost benefit analysis.

[71] Western Power, Basic Embedded Generator Connection Technical Requirements: https://www.westernpower.com.au/siteassets/documents/documents-and-policies/basic-embedded-generation-connection-technical-requirements/basic-eg-generator-technical-requirements-20230411.pdf

9. Technical and Commercial Readiness

To determine the overall success of the Pilot against its objectives, Symphony used the Technology Readiness Level (TRL) and Commercial Readiness Index (CRI) frameworks to map current and expected future states based on Symphony work packages.

The TRL is a globally accepted benchmark used to measure the development progress of a specific technology and has been adopted by ARENA for use in the renewable energy sectors. However, though the TRL can be used to determine the developmental phase for a new technology, it cannot assess whether the technology is ready for commercial deployment. This is due to the various barriers involved in deployment of a new technology, which ARENA has specifically identified as being true for the renewable energy technology due to large up-front capital costs. As a result, ARENA developed the CRI to be used in conjunction with the TRL, providing a holistic view of a new renewable energy technology's development and readiness for deployment.[72]

The TRL and CRI frameworks were assessed across the stages of the life-cycle framework of DER integration and orchestration (see Figure 44 below) to determine the current technological and commercial readiness for DER orchestration in the SWIS and identify the expected future state capability and readiness following the completion of each work package. TRL is measured on a scale of level 1 – 9, and CRI measured on a scale of 1 – 6 (see Figure 45).

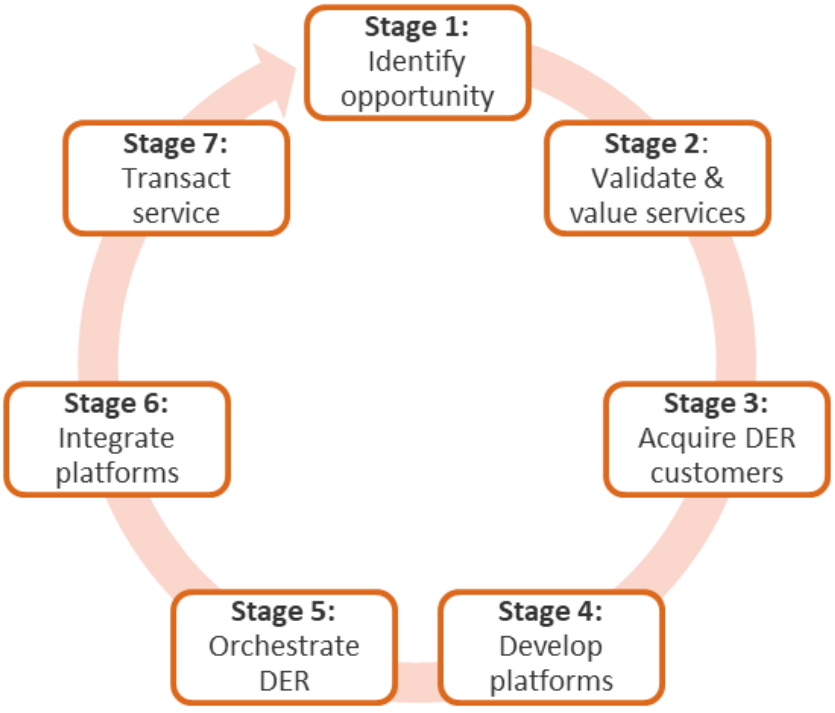


Figure 44: Life-cycle framework of DER integration and orchestration (adapted from Networks Renewed (UTS, 2019), with stages corresponding to Project Symphony work packages.

[72] ARENA, Commercial Readiness Index for Renewable Energy Sectors: https://arena.gov.au/assets/2014/02/Commercial-Readiness-Index.pdf

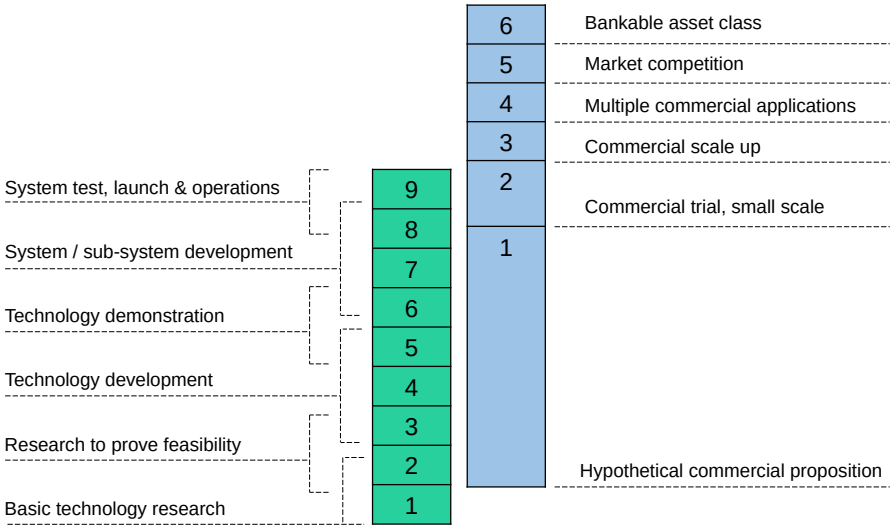


Figure 45: ARENA's technology readiness levels and commercial readiness index

A written and visual summary of TRL and CRI by each life-cycle stage has been summarised below, the full evaluation is available on Work Package 8.2 End of Project Assessment.

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.	**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 for DER orchestration, particularly through the regular publication of the Network Opportunities Map (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.

Stage	Technology maturity	Commercial maturity
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 Project Symphony 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 higgh levels of confidence and inform the scaled application of DER orchestration in WA 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.	**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, air conditioner and/or battery storage assets. The CBA determined that these value offerings are broadly 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.

Stage	Technology maturity	Commercial maturity
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 provide an end-to-end solution, integrated with each organisation's system and processes, that was tested for the four 'must-have' scenarios: energy services – bi-directional energy – balancing market; network support services; constrain to zero; essential system service – contingency raise. 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 'must-have' 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. Some progress was also made towards TRL 8 by delivering real network benefit (NSS) from the orchestration.	**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
6	**TRL 7 was achieved** The DSO, DMO and aggregator Platforms were successfully integrated at the substation level. 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 scale 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 to 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.

Table 7: Summary of TRL and CRI maturity

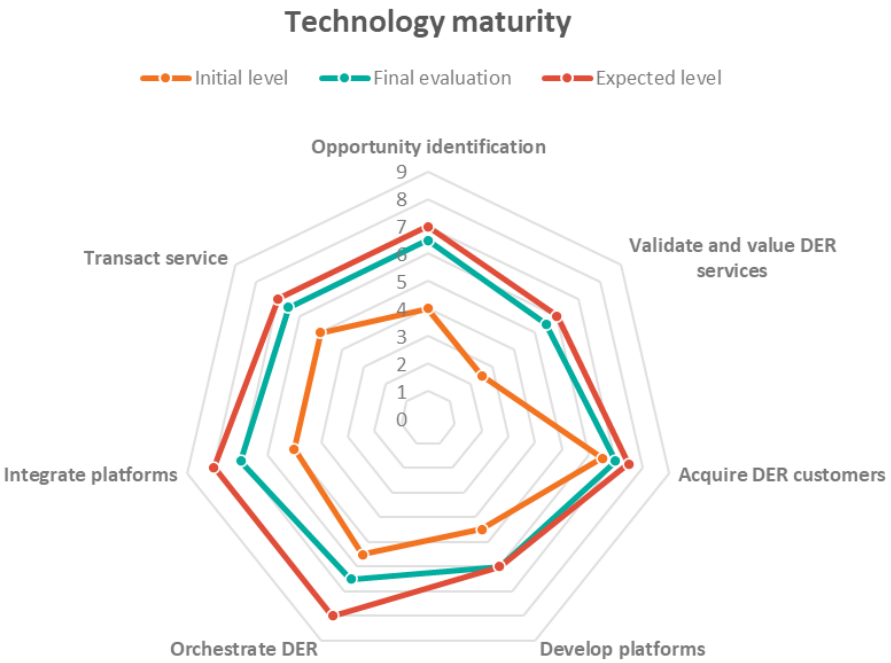


Figure 46: Technology maturity

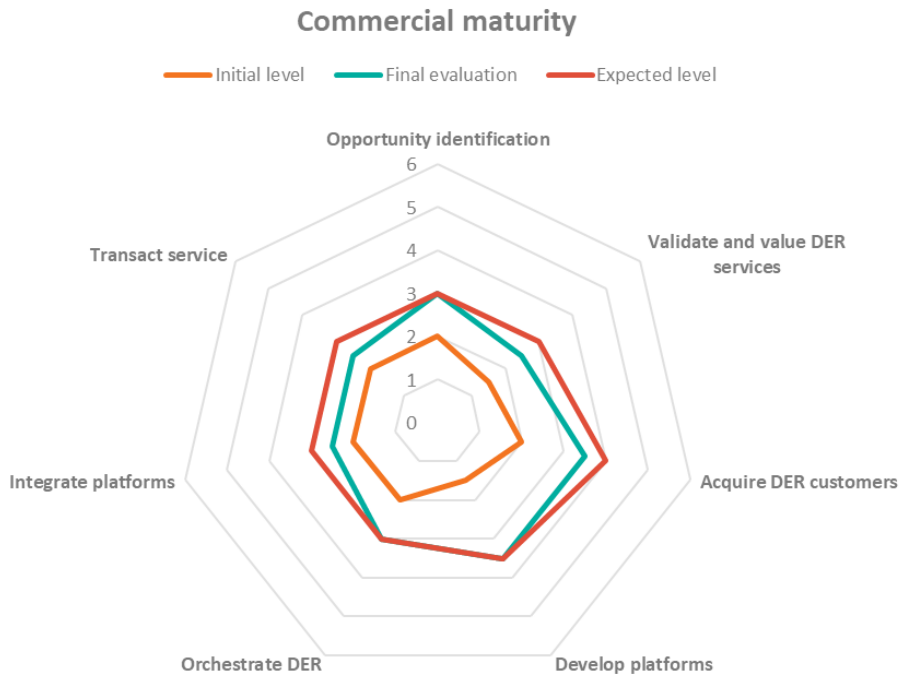


Figure 47: Commercial maturity

Overall, through Project Symphony, both TRL and CRI increased from initial levels, with final levels either meeting targets or falling just short of targets. As such, further work – as highlighted through this report's recommendations – is necessary to achieve technical and commercial readiness targets.

For further details on the commercial and technical readiness assessment, see Work Package 8.2 End of Project Assessment Report.

10. Conclusion

Project Symphony successfully tested the ability of DER to help meet the challenges associated with managing the growing 'peaks and troughs' of electricity demand at both the system and local network level.

With nine key objectives spanning technical, customer, value, and policy and regulation, Symphony advanced not only the technical requirements for DER integration but also gained significant understanding of customer engagement, market dynamics, and the regulatory frameworks required for scaled VPP uptake. The project's achievements in meeting its objectives is summarised below.

Technical

Symphony has significantly advanced the understanding and application of DERs in addressing local, regional and system-wide energy challenges in the SWIS and successfully evaluated the potential of DER to provide network support services, particularly in managing local constraints. For all scenarios, the technical feasibility of DER to provide system and local level services was demonstrated – a major achievement for the project. Despite success in orchestrating numerous DER assets within the Pilot, challenges related to interoperability and communication with the Parent Aggregator platform were identified and will be considered into the future.

Symphony demonstrated that, in time with further development, DER orchestration could be a "trusted" capability, one that becomes reliable, available and cost effective. The Pilot demonstrated the technical feasibility of end-to-end orchestration, encompassing cybersecurity and latency. This brought the project close to delivering a viable product that can be achieved once compliance rates are more consistently met.

Outcomes from the technical studies have informed standards, processes, and frameworks necessary for maintaining system security and reliability. Recommendations include adopting a common communications protocol (CSIP-AUS), developing a DER Data Hub for efficient data exchange, and establishing service delivery standards for Parent Aggregators.

Customer

The customer objectives of the project were to explore residential and commercial customer preferences regarding DER and to pilot the role of the retailer/aggregator in facilitating customers' involvement in providing DER products and services. This objective was supported by a study conducted by the University of Tasmania (longitudinal social sciences study), which provided valuable insights into customer experiences and preferences.

Symphony successfully met customer recruitment targets, with over 500 households participating in the Pilot, and tested the role of retailer/aggregator in facilitating customer involvement in providing DER products and services, scaling up over the stability period. The Aggregator role was found to be relatively complex compared to the traditional energy retailer role, necessitating greater customer involvement.

Recommendations including creating simple, transparent, and timely customer-facing information, developing end-to-end customer engagement tools and establishing a SWIS-wide customer engagement strategy that aims to enhance customer engagement and address challenges over the long term.

While Symphony achieved its objectives, future scalable models must align with customer values and motivations, necessitating ongoing engagement. Additionally, future policy changes may affect the attractiveness of incentives and will need to be considered.

Value

Symphony successfully assessed the functions and services that DER can provide to markets and the extent that aggregated DER can be efficiently used to participate in the WEM and ancillary service markets. Additionally, it aimed to inform the viability of creating and sustaining a market where DER aggregators act as intermediaries to customer DER.

The findings from the Pilot demonstrated that aggregated DER has considerable potential to contribute to both system and market needs. The project conducted an off-market Pilot for all scenarios, replicating market systems, demonstrating how DER can operate as a facility within simulated market conditions by measuring the impact of DER against existing facilities. Ultimately, the Cost Benefit Analysis demonstrated that DER orchestration is viable in WA, particularly where 'value-stacking' can be achieved, but further work is required to determine the appropriate distribution of value between aggregators and customers.

Symphony also assessed the feasibility of customer DER aggregation in the WEM, exploring its potential to sustain a viable market model under current regulations. Several considerations were identified including the need for specific registration and market frameworks better tailored for DER participation, and the more equitable distribution of benefits. Recommendations propose solutions to policy and regulatory frameworks to address these challenges and to optimise DER participation.

Policy and regulation

Symphony has not only highlighted the required policy and regulatory changes to enable DER orchestration within VPPs but has also actively contributed to shaping these changes. Recommendations for regulatory and market reforms, including enhancing market frameworks, improving VPP visibility, and incentivising aggregator participation, are positioned to unlock the full potential of aggregated DER.

The role played by EPWA as the policy arm of government, embedded in the project as subject matter experts and as the policy enabler, has been essential in ensuring Symphony's success. This collaboration has led to several strategic outputs aligned to the Energy Transformation Strategy, including updates to the DER Roadmap, and further defining roles and responsibilities among key energy actors.

By working together, the groundwork has been laid to transition towards a future where DER plays an active role in the energy system, delivering benefits and value to all customers.

11. Next Steps

The insights and recommendations from Project Symphony have been communicated and endorsed by all project partners, including Western Power, Synergy, AEMO, and EPWA. Finalised recommendations have been provided to EPWA to inform the next iteration of the DER Roadmap, wherein they will be translated into actionable steps and programs for key actors to oversee or progress.

12. Glossary

Term	Acronym	Definition
Active DER		DER that can be externally controlled by a third party to provide a response, often coordinated with other DER as part of a Virtual Power Plant (VPP).
Advanced Meter Infrastructure	AMI	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).
Aggregator Platform		The Energy Management System used by the Aggregator to operationally control and monitor DER and sites.
Application Programming Interface	API	An API is a set of functions through which two software systems can communicate without any human intermediation.
AS4755 Demand Response Standard	AS4755	Finalised in 2020, *AS4755 Demand Response Standard* establishes the framework in which appliances and manufacturers are all connected and respond to a set of standardised remote signals to enable remote control the asset and its energy usage. In the most basic form, it requires these appliances to have 'demand response modes' that provides an interface to remotely alter power consumption at certain times. This enables external control to shift load to times when demand is low and reduce load when demand is high, potentially reducing cost to end users. AS4755 is currently not a mandatory standard for original equipment manufacturers to adopt in Western Australia.
Australian Energy Market Operator	AEMO	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).
Available Network Capacity	ANC	The Available Network Capacity is the amount of capacity available to be allocated amongst VPP participants per time interval and communicated as a DOE.
Balancing Market Offer	BMO	Offering (Sell) or bidding (Buy) energy into a bi-directional energy balancing market.

Term	Acronym	Definition
Battery Energy Storage System	BESS	Batteries are an energy storage technology that use chemicals to absorb and release energy on demand. Batteries require additional components that allow the battery to be connected to an electricity network.
Common Smart Inverter Profile – Australia	CSIP-AUS	CSIP-AUS was drafted by ARENA's Distributed Energy Integration Program (DEIP) and Standards Australia in 2019. CSIP-AUS has been based off other existing standards, namely the IEEE 2030.5-2018 specification, and the Common Smart Inverter Profile (CSIP) standard first implemented in the USA. The CSIP-AUS standard provides a minimum set of requirements and implementation guide for communication and security between devices, and DER inverters for dynamic and static commands, whilst providing original equipment manufacturers operational and design flexibility while remaining compliant with the CSIP-AUS protocol. Australian Standard 5385:2023 aims to help the Australian energy sector to implement CSIP-AUS and easily access the important best practice information that will ultimately support the move to the Smart Grid and energy transformation.
Constrain to Zero	CTZ	A test instruction whereby instructions can be sent by AEMO to the Aggregator and executed by the Aggregator to constrain energy output to zero.
Dispatch		Dispatch refers to the instructions from AEMO to generators delivering power to the system. Dispatch instructions are provided in the form of energy, timing, and ramp rate information. AEMO dispatches energy with consideration for the prices offered by facilities, network limitations, and system requirements.
Distributed Energy Resources	DER	DER are smaller–scale devices that can use, generate, or store electricity and form a part of the local distribution system, which serves homes and businesses. DER can include renewable generation, energy storage, electric vehicles (EVs), and technology to manage load at the premises. These resources operate for the purpose of supplying all or a portion of the customer's electric load and may also be capable of supplying power into the system or alternatively providing a load management service for customers.
Distribution Transformer	DSTR	DSTR monitors were used to establish a baseline of active power measurement for comparing aggregate AMI data.
Distribution Market Operation	DMO	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	DNSPs are the organisations that own and control the hardware of the distributed energy network such as power poles,

Term	Acronym	Definition
		wires, transformers, and substations that move electricity around the grid.
Distribution Systems Operator	DSO	A DSO enables access to the network, and securely operates and develops an active distribution system comprising networks, demand, and other flexible DER. Expanding the network planning and asset management function of a DNSP, the DSO enables the optimal use of DER in distribution networks to deliver security, sustainability, and affordability in the support of whole system optimisation (Energy Transformation Taskforce, 2020).
DSO Platform		The solution and Western Power supporting ICT infrastructure and systems employed in the calculation and publishing of the DOE
Duck Curve		The SWIS daily load profile, which represents the energy drawn from the grid by customers, has evolved in recent years to resemble what is known as the 'duck curve', due to its shape. The self-consumption of energy from rooftop solar PV generation is leading to low customer demand from the grid in the middle of the day – the 'belly of the duck'. It is followed by a sharp increase in system demand in the late afternoon as consumers usage increases as they return home and rooftop solar PV generation decreases to zero as the sun sets.
Dynamic Operating Envelopes	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 and may also apply at an upstream distribution network node.
Emergency Solar Management	ESM	Requirements for export capable DER to be instructed to reduce injection or generation during an emergency operating state. ESM was implemented after the commencement of Project Symphony.
ESS Contingency Reserve Raise	ESS-CRR	Market provision of a response to a locally detected frequency deviation that enables a Facility to adjust injection or withdrawal to arrest the decline of SWIS frequency so that it can be raised back to the normal operating range.
Essential System Services	ESS	A range of services designed to maintain or respond to deviations in system frequency.
Financially Responsible Market Participant	FRMP	Financially Responsible Market Participants have the financial responsibility for a connection point in the electricity market. Their obligations include establishing metering installations and ensuring compliance with regulatory requirements.
Frequency Co-optimised Essential System Services	FCESS	Developed in conjunction with the Western Australian Government Energy Transformation Strategy as part of the Delivering the Future Power System work stream, the new Essential System Service Framework outlined the market design to

Term	Acronym	Definition
		ensure support services can be securely and efficiently procured for the future power system. The Frequency Co-optimised Essential System Services (FCESS) sit within this Framework, and comprise the following five services: • Regulation Raise • Regulation Lower • Contingency Reserve Raise • Contingency Reserve Lower • Rate of Change of Frequency (RoCoF) Control Service
Gateway Device		A gateway device provides local control and monitoring of all available customer DER assets on the customer's site.
Injection		Export of energy at the connection point
Key actors		Key actors in the Wholesale Electricity Market (WEM) value chain in the South West Interconnected System (SWIS): Western Power, Synergy, the Australian Energy Market Operator (AEMO) and the WA State Government through Energy Policy WA (EPWA).
National Metering Identifier	NMI	The NMI is a unique 10 or 11 digit number used to identify electricity network connection points in Australia. See Connection Point.
Network Support Services	NSS	A contracted service provided by a generator / retailer / demand side program / 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, part of the WEM construct.
Non-Cooptimised Essential System Services	NCESS	A contracted service, not covered by other ESS categories, provided by a generator / retailer / demand side program / Aggregator to AEMO to help maintain power system security / reliability.
Operating Envelope		An operating envelope is the DER or connection point behaviour that can be accommodated before physical or operational limits of a distribution network are breached. - see also Dynamic Operating Envelope
Parent Aggregator		When multiple Aggregators are in partnership, the Parent Aggregator is the wholesale market facing entity (Synergy) representing the TPA
Rule Participant		Any person registered as a Rule Participant, in accordance with the Wholesale Electricity Market (WEM) Rules, with AEMO.
South West Interconnected System	SWIS	The 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.

Term	Acronym	Definition
Telemetry data		The automated recording and transmission of data from remote sources into and from a central system in support of control, monitoring and analysis.
Third-Party Aggregator	TPA	An Aggregator that is in partnership with a Parent Aggregator
Transmission Node Identifier	TNI	The component on the network which denotes the transmission from the transmission network to a local distribution network at a zone substation. It is anticipated that Facilities involved in the delivery of Network Support Services will be tightly coupled to a local distribution network denoted by a specific Transmission Node Identifier. For example, SNR540 is connected to a specific Transmission Node Identifier located in the Southern River area of Perth.
Virtual Power Plant	VPP	A VPP broadly refers to an aggregation of distributed energy resources (such as decentralised generation, storage and controllable loads) monitored and coordinated to deliver services for customers and power system operations through electricity markets.
Wholesale Energy Market	WEM	The WEM, operated by AEMO, controls the supply and trading of wholesale energy services between Rule Participants on the South West Interconnected System.

APPENDICES

The following appendices have been provided on the following pages:

Appendix A	Project Cost: Actual vs Budget
Appendix B	Where to find more information
Appendix C	Knowledge Sharing Plan
Appendix D	Project Symphony Report Summaries

Appendix A – Project Cost: Actual vs Budget

Based on projected costs, Project Symphony secured $35.44M in project funding. The pilot was partly funded by ARENA ($8.55M), received cash and in-kind contributions from Western Power, Synergy and AEMO and received in-kind contributions from university research partners – the University of Technology Sydney (UTS), the University of Western Australia (UWA) and the University of Tasmania.

Due to resources available to design and implement the platforms, the mitigation of different interpretations of functional process that were discovered during the implementation testing, and consequential updates to project delivery approaches, a total of $3.25M further funding was required.

The breakdown of the project funding is outlined in the table below.

	Original Budget ($)			Total at Completion ($)			Variance ($)
Contributor	**Cash**	**In-kind**	**Sub Total**	**Cash**	**In-kind**	**Total**	
Western Power	8,941,200	1,948,500	10,889,700	7,634,430	5,966,634	13,601,064	-2,711,364
Synergy	12,591,664	657,534	13,249,198	14,834,856	0	14,834,856	-1,585,658
AEMO	7,220,018	2,891,628	10,111,646	5,848,526	3,224,897	9,073,423	1,038,223
University partners	695,164	503,372	1,198,536	694,814	533,884	1,228,698	-30,162
Total ($)	29,448,046	6,001,033	35,449,079	29,012,627	9,725,415	38,738,041	-3,288,962

Table 8: Project Symphony Project Budget

Appendix B – Where to find more information

Links to Project Symphony deliverables are included in the table below. Where a report was not made public, an * is used with the report title. Where a report was not published on ARENA's site at the time this report was submitted, the report title is noted with **.

#	Deliverable	Brief Description	Accountable Party
WP 1.1	Pilot Area Report*	This report will define the selected pilot area for the focus of Project Symphony by using network forecasting and planning data and Western Power's Grid Transformation Engine (GTEng) to develop scenarios for the high DER penetration in the SWIS, where there are existing or emerging network constraints and a possible transition pathway to optimise network investment by leveraging the benefits of DER.	Western Power
WP 2.1	DER Services Report	A report outlining network, retail, and market use cases. The report will identify DER use cases and quantify the value of the various DER services and core barriers and challenges that may prohibit value capture of use case.	Synergy
WP 2.2	Commercial Agreements Summary*	Summary of commercial agreements required for the provision of DER services by electricity customers, 3rd-party DER owners, and 3rd-party aggregators, considering connection requirements and contracts for DER with the Recipient.	Synergy
WP 2.3	DER Service Valuation Report	A report outlining the orchestration processes and modelling that validates energy and financial outcomes across the system including the various components (customer, network, retail, and market). Using techno-economic simulation to determine the actual value of DER services that will be deployed or integrated through the Project.	Synergy
WP 3.1	Customer Acquisition Plan*	A report outlining the planned customer acquisition process, target DER types to be acquired, including the target mix of customers (commercial vs. residential).	Synergy
WP 3.2	Aggregator Report	A report outlining the proposed approach to bringing 3rd party aggregators into the Project. This report will include research on how Synergy can facilitate market participation of secondary DER aggregators and/or third-party DER resources.	Synergy
WP 3.3	Social Science Study Report**	A study summarising the research conducted in partnership with the University of Tasmania aiming to address three key areas: Assessment of what policy support needs to be considered to support the scaling of the Project from a pilot to mass market adoption. Customer sentiment towards a variety of DER asset types and offerings.	University of Tasmania

#	Deliverable	Brief Description	Accountable Party
		The social equity implications of mass market adoption.	
WP 4.1	Distribution Constraints Optimisation Algorithm Report	A report on the network DER Distribution Constraints Optimisation Algorithm (DCOA) tool that includes but is not limited to the function of the tool, how it was developed and the specifications. The network DER DCOA tool will enable the Recipient, as the DSO, to develop the appropriate level of distribution network constraint analysis and support the equitable deployment of DER across the contracted customers.	University of Western Australia
WP 4.2	Provision of DMO Platform Functional and Non-Functional Requirements Report	A report on the set of functional and non-functional requirements for the DMO Platform. These requirements will be used to source the best resource for the development of the market platform (e.g., via tender or internal capability, in line with other DER integration projects). This platform will engage with the DSO and Aggregator platforms, and as this is an off-market pilot, simulate the aggregated DER integration into the WEM. This was provided in a consolidated report - Platform Functional and Non Functional Requirements (WP 4.2, 4.3 & 4.4)	AEMO
WP 4.3	DSO Platform Functional and Non-Functional Requirements Report	A report set of functional and non-functional requirements for the DSO Platform, that will be required to perform the role of the DSO. These specifications will be used to undertake a commercial process to develop a DSO Platform and interface with the DMO and aggregator platforms and the Recipient's enterprise operating technology, as required. This was provided in a consolidated report - Platform Functional and Non Functional Requirements (WP 4.2, 4.3 & 4.4)	Western Power
WP 4.4	Aggregator Platform Functional and Non-Functional Requirements Report	A report set of functional and non-functional requirements summarising the procurement and implementation of Synergy's aggregator platform including functionality approach and cyber security requirements. This was provided in a consolidated report - Platform Functional and Non Functional Requirements (WP 4.2, 4.3 & 4.4)	Synergy
WP 5.1	DSO Platform (as built) Report	The report will document the building of the DSO platform and infrastructure required to communicate with the DMO and aggregator. The report will share key learnings from the build process. This was provided in a consolidated report – Platforms as Built Report (WP 5.1, 5.2 & 5.3)	Western Power

#	Deliverable	Brief Description	Accountable Party
WP 5.2	DMO Platform (as built) Report	A report documenting the development and implementation of the Market platform. This platform is required to test and simulate the capability of the aggregated DER resources to participate in providing for both market and network services. This was provided in a consolidated report – Platforms as Built Report (WP 5.1, 5.2 & 5.3)	AEMO
WP 5.3	Aggregator Platform (as built) Report	A report documenting the implementation of the Aggregator Platform. This platform is required to manage integrations between the Aggregator and the DSO and DMO, while also executing and optimising dispatch instructions from the DMO. The platform will also facilitate participation in DER markets by 3rd-party DER Resource Owners. The report will capture summary key learnings from the platform build process. This was provided in a consolidated report – Platforms as Built Report (WP5.1, 5.2 & 5.3)	Synergy
WP 6.1	Server Hosting Agreement*	Provision of the Server Hosting Agreement which will set out: • Clarity as to what data needs to be shared. • Identification of the relevant party to provide the data set to the market operator and agreement on the level of quality needed. • Other broader considerations that may need to be taken on board such as Cyber security and Privacy.	AEMO
WP 6.2	Data Sharing Agreement Report*	A report summarising the data sharing requirements as identified in WP 6.1, as well as key outcomes of any architecture design workshops between the three parties. The result is to have a simple data sharing agreement for the purposes of the Symphony pilot.	AEMO
WP 6.3	API Specifications Report*	A report outlining the specifications of the relevant Project APIs and other methods of data transfer that would be considered, to integrate all parties with the market platform. This design of the various data integration elements and the method to which the integration will be undertaken will enable future aggregators to understand the potential requirements needed for integration with the key platforms.	AEMO
WP 7.1	Regulation and Rules Report**	A report informing the WA government and AEMO with respect to the future of full DER integration into the WEM. This report will include but is not limited: 1. What key regulations or rules will need to be amended (if any) to enable this future of high volume DER integration. 2. Indicative costings to enable this, and the impact to the market participants from a cost recovery perspective. This was provided in a consolidated report – DER Market Participation Framework (WP 7.1, 7.2, 7.3 & 7.4)	AEMO

#	Deliverable	Brief Description	Accountable Party
WP 7.2	Future Market Participation Requirements Report**	A report to align to and provide learnings to the parallel DER Roadmap and market reform activities. It will develop a high level design and requirements for a future version of Market Platform build that could achieve whole-of-system optimisation to cater for a significantly higher volume of DER integration and take into the account the new market design with constrained access being introduced by Oct 2022. This was provided in a consolidated report – DER Market Participation Framework (WP 7.1, 7.2, 7.3 & 7.4)	AEMO
WP 7.3	DER Market Participation Principles Report**	The report will provide market participants a clear and transparent view and guidelines of how Aggregators can: 1. Register for market and network services. 2. Participate in providing both market and network services. 3. Understand what technical standards and procedures the respective facilities would need to adhere to as part of the registration process and ability to provide the relevant service. 4. Have clarity on the IT system development (such as APIs) to enable their Aggregator platforms to engage with both the DSO and DMO platforms. This was provided in a consolidated report – DER Market Participation Framework (W7.1, 7.2, 7.3 & 7.4)	AEMO
WP 7.4	AEMO Planning and Forecasting Report**	A report summarising what enhancements have been taken to AEMO's planning and forecasting process in light of the lessons learnt from the various Project work packages, as well as offering up insights into what further changes can be made into the future of greater DER integration directly into the WEM. This was provided in a consolidated report – DER Market Participation Framework (WP 7.1, 7.2, 7.3 & 7.4)	AEMO
WP 8.1	Vision and Action Pathway Document	A document that captures the collective vision workshopped with stakeholders in the context of the suite of Australian DER integration projects, including an aligned Monitoring and Evaluation protocol, to be used for the duration of the Project. This document will be used to inform presentations and other forums to be delivered as part of the Knowledge Sharing Plan.	University of Technology Sydney
WP 8.2	Mid-Project and End Project Assessment**	A report evaluating the status of the technology and commercial readiness of the pilot Project and transition into mainstream.	University of Technology Sydney
WP 8.3	Cost Benefit Analysis (CBA) Method Report**	A CBA report, that will provide the methodology and result by which the cost and benefits of the objectives of the Project and scalability to the rest of the WEM. The CBA and learnings from Project Symphony will also provide insights and recommendations for the WEM to transition to the DSO, DMO and Aggregator models being developed within the DER roadmap, if applicable.	Western Power

Table 9: Project Symphony deliverables

Other non-Project Symphony specific relevant reports:

- DER Roadmap
- DER Roadmap one-year progress report
- DER Roadmap two-year progress report
- DER roles and responsibilities information paper
- AEMO WEM Electricity Statement of Opportunities (ESOO)

Appendix C – Knowledge Sharing Plan

Appendix B highlights where the Project Symphony Public Reports can be found. In addition to those reports, the table below outlines Project Symphony's knowledge sharing activities. The text in **teal** provides an outline of the actions completed by the project partners in delivering the Knowledge Sharing Plan.

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
1	N/A	ARENA 15 min Project Survey	Efficient qualitative data gathering. ARENA will request anonymised quarterly portfolio updates.	From Commencement Date to Final Milestone Date (March, June, September, December) Western Power (on behalf of Project Symphony Partners) responded to ARENA Project Surveys - as they were issued by ARENA.	ARENA will provide a link to the survey each quarter.	COMPLETED
2	N/A	Public Project Lessons Learnt Report	To share key lessons from the project and implications for industry.	From completion of Milestone 1 until Final Milestone Date End of April and October each year Lessons Learnt Reports were submitted to ARENA, for publishing, on the following dates: **Milestone 1** – 30 October 2021 **Milestone 2** – 30 June 2022 **Milestone 3** – 12 May 2023 Milestone 4 – 23 February. Milestone 2 Lessons Learnt was shared with the Symphony Information Forum (SIF) # 2 on 11 August 2022. Milestone 3 Lessons Learnt was shared at SIF #3 on 23 November 2022.	Public report to detail the lessons, challenges, solutions, and opportunities for the following topics, as applicable: Project objectives, challenges experienced and how these were overcome Technical, regulatory/legal, financial/ economic, social/ consumer lessons Stakeholder engagement, consultation, outcomes, and impact Lessons from each of the work packages	COMPLETED
3	N/A	Attendance and participation in ARENA-led events (e.g. webinar, workshop, roundtable)	Project exposure and share project lessons and information with other ARENA	From Commencement Date to 3 months following the Project Completion Date Project Partners participated in the following ARENA-led events: 10 June 2022 DEIP Dive Markets Workstream	Evidence of active involvement to be provided (e.g. presentation slides, recordings, written event summary).	COMPLETED

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
			funded projects and key stakeholders.	12 Sept 2023 DEIP Dive Markets Workstream.		
4	N/A	Attendance and participation in industry events	Project exposure and share project lessons and information with industry stakeholders.	From Commencement Date to 3 months following the Project Completion Date Project Symphony Partners have participated in 47 events please see Appendix D for the details of these events.	Evidence of active involvement to be provided (e.g. presentation slides, recordings, written event summary).	COMPLETED
5	N/A	Ad hoc reports, products, and activities	Capture unknown unknowns.	As required Participant in the Project Edge Advisory Group	Format and topic to be agreed at the time of request.	COMPLETED
6	WP8.1	Public Project Webinars / Workshops	Project exposure and interaction with industry. The initial webinar / workshop can include the Vision and Action Pathway workshop.	Milestone 1: Initial webinar / workshop August 2022 (or 6 months after Milestone 2 if varied): Mid-Project webinar / workshop Milestone 4: Final webinar / workshop Project Symphony established the Symphony Information Forum (SIF). The forum is Project Symphony's primary knowledge sharing forum where key industry stakeholders are invited to provide their feedback and observations on the projects deliverables.	Public webinar. Topics to include, at a minimum: Project objectives, challenges experienced and how these were overcome Technical, regulatory/legal, financial/ economic, social/ consumer lessons Stakeholder engagement, consultation, outcomes, and impact Next steps	COMPLETED
7	WP8.1	Public Vision and Action Pathway Report	Publicly share the collective vision workshopped with stakeholders in the context of the suite of Australian DER integration projects.	Milestone 1 The first SIF, in May 2022, was *An Introduction to Symphony*. It shared the collective vision workshopped with stakeholders in the context of the suite of Australian DER integration projects and Work Package 8.1.	Public report to include, at a minimum: Collective vision Action pathway How this Project fits within context of suite of Australian DER integration projects and activities	COMPLETED
8	WP2.1	Public DER Services Report	Publicly share key Project lessons and information from	Milestone 1: Part 1, DER Services	Public report to include, at a minimum:	COMPLETED

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
			Work Package 2 with industry.	SIF # 2 - 11 Aug 2022, DER Services Report & Value Measurement Report & Milestone 2 Lessons Learnt.	Outline network, retail, and market use cases; quantify valuation of DER services and barriers to value capture.	
9	WP2.3	Public DER Valuation Report	Publicly share key Project lessons and information from Work Package 2 with industry.	Milestone 2: Part 2, DER Services Valuation SIF # 2 - 11 Aug 2022, DER Services Report & Value Measurement Report & Milestone 2 Lessons Learnt.	Public report to include, at a minimum: Summarise the findings of Public DER Services Report (if applicable) for context Outline orchestration processes and modelling that validates energy and financial outcomes across use cases.	COMPLETED
10	WP3.2	Public Aggregator Report	Publicly share key Project lessons and information from Work Package 3 with industry.	Milestone 2 SIF # 5 – Customer, 8 August 2023 – covering the Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results.	Public report to include, at a minimum: Research on facilitating market participation of secondary DER aggregators and/or third-party resources.	COMPLETED
11	WP3.3	Public Social Science Study Report	Publicly share the findings of the social science study with industry.	Milestone 4 SIF # 5 – Customer, 8 August 2023 – covering the Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results.	Public report to include, at a minimum: Assessment of what policy support needs to be considered to support the scaling of the Project from a pilot to mass market adoption. Customer sentiment towards a variety of DER asset types and offerings. The social equity implications of mass market adoption.	COMPLETED
12	WP4.1	Public Distribution Constraints Optimisation Algorithm (DCOA) Report	Publicly share key Project lessons and information from Work Package 4 with industry.	Milestone 2 SIF # 3 – Technology Design, 23 Nov 2022 – covering Distribution Constraints Optimisation Algorithm, Functional & Non Functional Requirements and Mid Project Assessment	Public report to include, at a minimum: DCOA tool development, functionality, specifications Value to users (e.g. DSOs) to develop appropriate level of distribution network constraint analysis and support equitable deployment to customers.	COMPLETED

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
13	WP4.2 WP4.3 WP4.4	Public Report on DMO, DSO and Aggregator Functional and Non-Functional Requirements	Publicly share key Project lessons and information from Work Package 4 with industry.	Milestone 2 SIF # 3 – Technology Design, 23 Nov 2022 – covering Distribution Constraints Optimisation Algorithm, Functional & Non Functional Requirements and Mid Project Assessment	Public report to include, at a minimum: Functional and non-functional requirements for the DMO, DSO and Aggregator platforms.	COMPLETED
14	WP5.1 WP5.2 WP5.3	Public Report on DSO, DMO and Aggregator Platforms (as built)	Publicly share key Project lessons and information from Work Package 5 with industry.	Milestone 3 SIF # 4 – Technology as Built, 18 May 2023 – covering the Combined Platforms as Build Report and Milestone 3 Lessons Learnt.	Public report to include, at a minimum: Context and how platforms fit together Key learnings from the development and implementation of the DSO, DMO and Aggregator platforms and integration / communication between the three platforms.	COMPLETED
15	WP7.1	Public Regulation and Rules Report	Publicly share key Project lessons and information from Work Package 7 with industry. Inform stakeholders on future full DER integration into WEM.	Milestone 4 SIF # 6 – Regulation & Policy, 2 November 2023 – covering the Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results.	Public report to include, at a minimum: What key regulations or rules will need to be amended (if any) to enable this future of high volume DER integration; and Indicative costings to enable this, and the impact to the market participants from a cost recovery perspective.	COMPLETED
16	WP7.2 WP7.3	Public Report on DER Market Participation Requirements and Principles	Publicly share key Project lessons and information from Work Package 7 with industry. To provide learnings to the parallel the WA DER Roadmap and market reform activities.	Milestone 4 SIF # 6 – Regulation & Policy, 2 November 2023 – covering the Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results.	Public report to include, at a minimum: High level design and requirements for a future version of DMO Platform build that could achieve whole-of-system optimisation to cater for a significantly higher volume of DER integration. Consideration of the new market design with constrained access being introduced by Oct 2022. How Aggregators can:	COMPLETED

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
					register for and provide market and network services. understand what technical standards and procedures required for the registration process and service provision. have clarity on the IT system development to enable their Aggregator platforms to engage with both the DSO and DMO platforms.	
17	WP7.4	Public Planning and Forecasting Report	Publicly share key learnings from the changes required to AEMO's planning and forecasting requirements as a result of DER integration	Milestone 4 SIF # 6 – Regulation & Policy, 2 November 2023 – covering the Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results.	Public report to include, at a minimum: enhancements to AEMO's planning and forecasting process insights and recommendations to improve DER integration into the WEM.	COMPLETED
18	WP8.3	Public Cost Benefit Analysis (CBA) Report	Publicly share key Project lessons and information from Work Package 8 with industry.	Milestone 4 SIF # 7 – 27 February 2024, Cost Benefit, End of Project Assessment & Final Report	Public report to include, at a minimum: Methodology and result by which the cost and benefits of the objectives of the Project and scalability to the rest of the WEM. Insights and recommendations for the WEM to transition to the DSO, DMO and Aggregator models.	COMPLETED
19	WP8.2	Public End of Project Assessment	Publicly share the status of technology and commercial readiness of the Project with industry.	Milestone 4 SIF # 7 – 27 February 2024, Cost Benefit, End of Project Assessment & Final Report	Public report. Content to include, at a minimum: Evaluation results on the status of the technology and commercial readiness of the Project.	COMPLETED

Item	WP Ref	Deliverable Title	Purpose	When	Content and delivery	Status
20	WP8.4	Public Final Knowledge Sharing Report	Publicly share the final findings and recommendations of the Project to support industry learnings and impacts on industry.	Milestone 4 SIF # 7 – 27 February 2024, Cost Benefit, End of Project Assessment & Final Report	Public report. Content to include, at a minimum: Key results, lessons, insights, and recommendations from throughout the Project, including: DMO, DSO, Aggregator platforms CBA report M&E report Social Science report	COMPLETED

Table 10: Project Symphony Knowledge Sharing Plan

Further to item four in Table 10: Project Symphony Knowledge Sharing Plan, the table below highlights Project Symphony's 54 industry and consumer engagement activities across the duration of the pilot. Project Symphony was presented in 38 industry forums, three consumer engagement forums and at 13 conferences.

Date	Audience/Conference	Activity	Topic
24-Jun-21	EDGE - Distribution Insights Forum	Industry Forum	Symphony 101
17-Nov-21	Boardroom Lunch - Clayton Utz	Industry Forum	Symphony 101 - Boardroom lunch attended by selected industry professionals
01-Sep-21	All-Energy Virtual 2021	Conference	Transforming the grid
22-Nov-21	EECON	Conference	Programs that manage the DER network - Project Symphony
01-Dec-21	AEMO - DER market participation forum	Industry Forum	Symphony overview
13-Dec-21	EDGE - Distribution Insights Forum	Industry Forum	Vision and Impact Pathway
23-Feb-22	EPWA DER Forum	Industry Forum	Symphony Update for the DER Roadmap
15-Mar-22	AEMO - DER market participation forum	Industry Forum	Symphony Update
17-Mar-22	ENLIT Australia	Conference	Symphony overview
07-Apr-22	2nd International Sustainable Energy Conference	Conference	Symphony overview

Date	Audience/Conference	Activity	Topic
19-Apr-22	ANU Battery Storage and Grid Integration Program	Industry Forum	Symphony update
30-Apr-22	Intyalheme Study Tour (Alice Springs)	Industry Forum	Western Power and Synergy hosted the tour which included presentations by all project partners, discussion and knowledge sharing on each project's objectives and progress to date.
May 22	Symphony Information Forum #1	Industry Forum	An Introduction to Symphony
20-May-22	UWA School of Engineering, Guest Lecture	Industry Forum	University of Western Australia School of Engineering, Guest Lecture - The Changing Power System.
23-May-22	PXiSE Distributech Houston Texas	Industry Forum	Symphony and Edge - discussed technologies used to move electricity from the power plant through the transmission and distribution systems to the meter and inside the home.
14-Jun-22	EPWA WAACE Forum	Consumer Engagement	Symphony 101
15-Jun-22	AEMO - DER market participation forum	Industry Forum	Symphony update
20-Jul-22	Australian Clean Energy Summit	Conference	Project Symphony: WA's largest DER Orchestration Pilot - Vision & Impact Pathway
20-Jul-22	Australian Clean Energy Summit	Conference	Project Symphony Overview
26-Jul-22	EDGE - Network Advisory Group	Industry Forum	Dynamic Constraints Optimisation Algorithm
08-Aug-22	Economic Regulatory Authority	Industry Forum	Project Overview
11-Aug-22	Symphony Information Forum #2	Industry Forum	DER Services, Value Measurement Tool, Milestone 2 Lessons Learnt.
18-Aug-22	WA Energy Week	Conference	Symphony overview
01-Sep-22	IEEE - Perth Chapter	Industry Forum	Project Overview
12-Sep-22	ARENA DIEP Dive	Industry Forum	Symphony overview.
13-Sep-22	AEMO - DER market participation forum	Industry Forum	Symphony update

Date	Audience/Conference	Activity	Topic
20-Sep-22	Asset Management Council	Industry Forum	Applying digital Asset Management
27-Oct-22	All Energy Australia (Melbourne)	Conference	Project Symphony: WA's largest DER Orchestration Pilot
04-Nov-22	Climate Council	Industry Forum	Insights in to Project Symphony
23-Nov-22	Symphony Information Forum #3	Industry Forum	Technology Design – Distribution Constraints Optimisation Algorithm, Functional & Non Functional Requirements and Mid Project Assessment
04-Dec-22	IEEE Sustainable Power and Energy Conference (iSPEC)	Conference	WA's largest DER Orchestration Pilot
09-Dec-22	World Renewable Energy Congress	Conference	Project Symphony: WA's largest DER Orchestration Pilot
14-Dec-22	AEMO - DER market participation forum	Industry Forum	Symphony update
16-Feb-23	Young Energy Professionals Event	Industry Forum	Overview of Project Symphony
14-Mar-23	Schneider Electric - Australian Clean Energy Summit	Conference	Overview of Project Symphony
23-Mar-23	ENLIT Australia	Conference	Overview of Project Symphony
05-Apr-23	AEMO - DER market participation forum	Industry Forum	Symphony update
18-May-23	Symphony Information Forum #4	Industry Forum	Technology as Built, 18 May 2023 – covering the Combined Platforms as Build Report and Milestone 3 Lessons Learnt.
09-Jun-23	SEIA Installers Meeting	Industry Forum	Annual SEIA Solar Installers Meeting on Integrating DER - an overview of Project Symphony, the challenges and opportunities and four test scenarios.
14-Jun-23	AEMO - DER Market Participation Forum	Industry Forum	Symphony update
16-Jun-23	NLDC Vietnam / Curtin Trip	Industry Forum	Overview of Project Symphony
05-Jul-23	AEMO - DER Market Participation Forum	Industry Forum	Symphony update
26-Jul-23	DEIP Dive	Industry Forum	Focus of Market Stream on Customer

Date	Audience/Conference	Activity	Topic
8-Aug-23	Symphony Information Forum #5	Industry Forum	Customer –Public Aggregator Report, Social Science Study Report and a preview of Test & Learn Results
22-Aug-23	WA IT Leadership Summit	Industry Forum	How technology is enabling the energy transition
10-Oct-23	Industry Briefing - Test & Learn Briefing	Industry Forum	Overview of Project Symphony Test & Learn Results
18-Oct-23	EESA Net Zero - Autonomous Networks of the Future	Industry Forum	Overview of Project Symphony
02-Nov-23	Symphony Information Forum #6	Industry Forum	Regulation & Policy – covering the Public Aggregator Report, Social Science Report and a preview of Test & Learn Results.
08-Nov-23	ESG Strategy Summit	Consumer Engagement	Overview of Project Symphony & what this could mean for businesses
04-Dec-23	UK Power Networks	Industry Forum	Presentation on Project Symphony and next steps in DSO roadmap
13-Dec-23	AEMO - DER Market Participation Forum	Industry Forum	Symphony update
15-Feb-24	State of Energy Research Conference 2024	Conference	Visibility, meaning and power imbalances in a VPP pilot
20-Feb-24	WA ACE Forum	Consumer Engagement	Present to the WA ACE Forum on PS Social Research Report
27-Feb-24	Symphony Information Forum #7	Industry Forum	Cost Benefit, End of Project Assessment & Final Report

Table 11: Project Symphony Industry Forums & Conferences

Information on Project Symphony was shared with the community via direct customer engagement, Ministerial Media Statements and media. These communication activities were supported by social media from all project partners – Western Power, Synergy, AEMO and Energy Policy WA. The table below outlines the key communication activities in Project Symphony.

Date	Audience/Conference	Activity	Topic
03-Feb-21	General Public	Ministerial Media Statement	Virtual Power Plants to become a reality in WA-first
03-Feb-21	Renew Economy	Earned Media	Western Australia to splash $35m on virtual power plant pilot

Date	Audience/Conference	Activity	Topic
28-Apr-21	General Public	Ministerial Media Statement	Major milestones for Distributed Energy Resources Roadmap
30-Sep-21	Supporting website information	Social Media / Websites	To Synergy and WP landing pages
10-Oct-21	City of Armadale	Customer Engagement	Symphony 101 - Initial presentation to the City of Armadale on the opportunities associated with Project Symphony
01-Dec-21	Media Engagement	Ministerial Media Statement	ARENA Funding Announcement
01-Dec-21	Website	Social Media / Websites	Overview of Symphony
01-Dec-21	Renew Economy	Earned Media	Project Symphony: First big trial to "orchestrate" rooftop solar and battery storage
30-Jan-22	Media Engagement	Minister's on-site media call	
01-Feb-22	Social Media - Customer Engagement	Social Media / Websites	Facebook, Instagram - retail customer focused
17-19/02/2022	Community Engagement Activity	Customer Engagement	Local activity based within Harrisdale with opportunity for residents in the area to attend.
31-Mar-22	Social Media	Social Media / Websites	LinkedIn - industry focused
30-Apr-22	Synergy Customer Engagement	Customer Engagement	Presentations, webinar, eDM
4-May-22	Coordinated social media	Social Media / Websites	Project Symphony MVP Go Live Media statement
05-May-22	ABC The World today	Earned Media	
05-May-22	Renew Economy	Media Article	WA simulates two-way electricity market in milestone for Project Symphony
05-May-22	Energy Magazine	Earned Media	Project Symphony VPP pilot reaches major milestone
06-May-22	ABC New Bulletin	Earned Media	
10-May-22	Coordinated social media	Social Media / Websites	Go-Live' Announcement Stability Period Communications
10-Jun-22	General Public	Ministerial Media Statement	Renewable energy roadmap implementation on track
24-Jun-22	PV Magazine (International)	Earned Media	First notes of a symphony

Date	Audience/Conference	Activity	Topic
16-Jul-22	PV Magazine	Earned Media	Weekend read: First notes of a West Australian symphony
29-Jul-22	Utility Magazine	Earned Media	Project symphony: Western Australia's energy future
01-Aug-22	Utility Magazine	Media Article	Project Symphony hits first major milestone
27-Sep-22	General public	Ministerial Media Statement	Accord struck in Project Symphony's development - Third Party Aggregators
27-Sep-22	Renew Economy	Earned Media	Project Symphony moves step closer to two-way energy market simulation
04-Nov-22	General public	Ministerial Media Statement	Music to energy consumers' ears as Project Symphony premieres
04-Nov-22	Coordinated social media	Social Media / Websites	In support of Media statement
04-Nov-22	Renew Economy	Earned Media	WA "orchestrates" hundreds of home solar and storage assets, as coal shortage continues
11-Nov-22	Energy Storage News	Earned Media	Project Symphony: Western Australia's biggest virtual power plant goes online
14-Nov-22	Energy Sources & Distribution	Earned Media	Project Symphony goes online in Western Australia
31-May-23	Synergy Customer Engagement	Customer Engagement	Awareness article on Balancing Market Offer (BMO)
27-Jun-23	Coordinated social media	Social Media / Websites	Supporting the Ministerial Media Statement on the Community Battery inclusion in the VPP.
27-Jun-23	General public	Ministerial Media Statement	Project Symphony community battery goes live
28-Jun-23	Renew Economy	Earned Media	Community battery adds new note to Project Symphony virtual power plant
30-Jun-23	Synergy Customer Engagement	Customer Engagement	Awareness article on Control to Zero
04-Jul-23	PV Magazine	Earned Media	Community battery to help orchestrate WA's Project Symphony
31-Jul-23	Synergy Customer Engagement	Customer Engagement	Awareness article on Essential System Services
16-Nov-23	WA Govt Climate Action Website	Social Media / Websites	Project Symphony showcased on WA Climate Action website

Table 12: Project Symphony Communication Activities

Appendix D – Project Symphony Report Summaries

Project Symphony
Our energy future

Report Summary - Work Package (WP2.1) DER Services Report

This paper is a summary of the Work Package 2.1 Distributed Energy Resources (DER) Service Report, that presents the outcomes of an economic cost benefit assessment of the operation of an expanded virtual power plant (VPP) in Western Australia's (WA's) South West Interconnected System (SWIS). The report identifies the opportunities that may be unlocked by appropriate operation and interaction of policy, market rules and regulations to capture the full value from DER.

What is the basis of the net benefits assessment?

The study has been undertaken based on the net economic benefits that the operation of the VPP can deliver to the electricity supply system. This basis was chosen because public policy is about maximising benefits to society (i.e., producers and consumers), and this is best achieved using an economic cost-benefit test as opposed to a financial analysis. This provides the project partners with an opportunity to identify the value that can be unlocked by VPPs, including by policy and regulation that ensures that electricity market price signals can reflect their future benefits. It is important to note that the study approach, the model used and the data that was available to the study all have limitations and assumptions. These should be recognised in considering and interpreting the results.

How does a VPP create economic value?

A VPP can receive, assess, and make decisions on various streams of information, such as wholesale and network pricing information, that determine if it is economically viable for VPP assets to act in ways that reduce costs in the electricity supply chain. A VPP can undertake a degree of information processing and decision-making that few customers would be capable of on their own, even if fully cost-reflective price signals did exist in the retail electricity market. This means a VPP offers the potential to optimise any benefits of DER participation/orchestration to end use customers.

Moreover, because VPPs are also located in the distribution network, there is the potential for them to be contracted by the network to help manage local network limitations at a lower cost than a traditional network augmentation solution.

Do retail tariffs need to change to establish a price signal to unlock the potential system values?

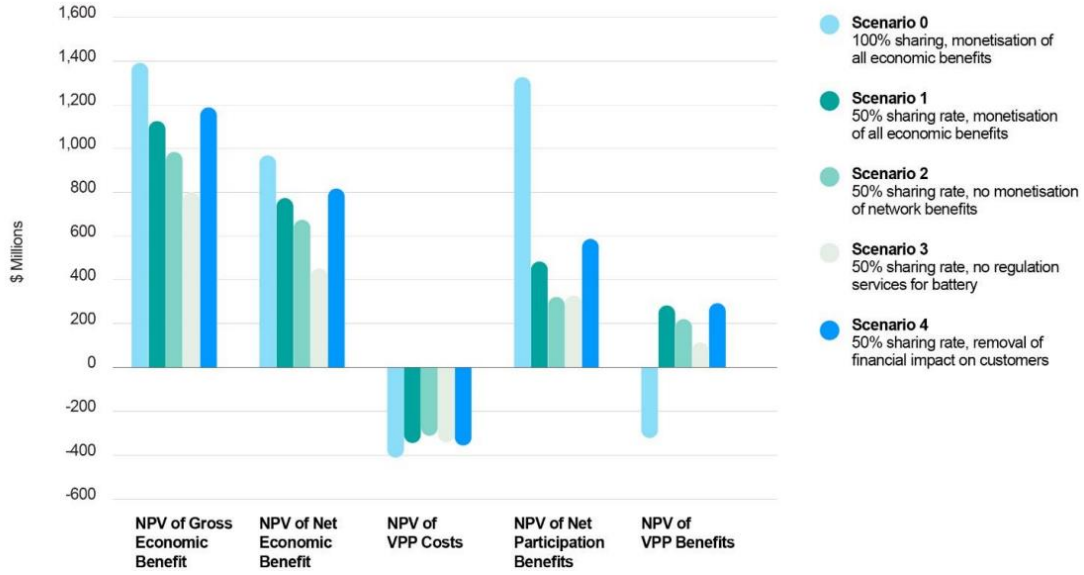
The value of a VPP to respond to price signals is two-fold:

- It is an entity that can access price signals in the electricity market that may not be available to end customers, and
- It can act as an agent for end-use customers, allowing their equipment to be orchestrated providing a return to them without compromising the amenity of their electricity service.

Through a VPP, price signals can be acted upon by a party in the electricity sector that is upstream of the final customer – for example, a retailer or a third party that can use that price signal as the premise upon which to present a business case to small customers.

What were the modelled scenarios?

Five scenarios were developed against which to model the economic value of a VPP in the SWIS. The costs and benefits of each scenario were assessed over a 15-year timeframe and presented in present value terms in 2021 dollars. All scenarios produced positive gross and net 'social' benefits, and all but one scenario produced positive net 'private' benefits for the VPP provider, the contrary scenario assuming all monetised benefits flowed to customers.



How big a contribution comes from batteries?

The modelling indicated that battery storage contributes most of the gross economic benefits for a VPP. Therefore, in terms of targeting customers, battery storage effectively becomes the gateway to enabling the potential economic operation of a VPP.

Were there any other key findings?

- Wholesale market essential system services are the primary contributor to the economic benefits that are generated from a VPP-enabled battery.
- VPPs offer a solution to the significant system security and stability challenges levels posed by unmanaged rooftop solar. VPPs provide a means by which households that have rooftop solar systems but do not have batteries can provide curtailment as a service with economic value to the electricity supply system. Moreover, by shifting load into the middle of the day, VPPs have the potential to reduce both the frequency and amount of curtailment needed.

Recommendations:

1. **Target battery customers: As noted above, the modelling indicates that it is the battery that contributes most gross economic benefits of the VPP.**
2. **Monetise all economic benefits: Simply put, the more benefits that can be monetised the more value the VPP can offer, which in turn will be likely to increase participation.**
3. **Non-cost reflective retail prices, particularly as they relate to the operation of the battery, need to be overcome: Consideration should be given to ensuring that there are price signals in the market that reflect economic costs and thereby counteract the perverse incentive customers currently have to retain energy in their battery during high wholesale price periods.**
4. **VPP technology costs should be as efficient as possible: The costs in the early years of the study timeframe for setting up and operating the VPP make its net economic benefits marginal. Anticipated reductions in these costs will significantly improve the VPP's cost-effectiveness.**
5. **The ability to provide regulation services is essential: The modelling clearly indicates that the ability of batteries to provide regulation – and particularly regulation lower service – is likely to be a significant source of value to the VPP and the electricity supply chain.**

Where can I obtain a copy of the complete report?

The full DER Services Report can be found on the ARENA site - here.

Project Symphony
Our energy future

Report Summary - Work Package (WP2.3) DER Service Valuation Report

This paper is a summary of Work Package (WP) 2.3 DER Service Valuation Report. The report describes a method for estimating the financial flows associated with orchestrating DER during the Project Symphony pilot. The complete work package differs from a cost benefit analysis as it defines value in financial rather than economic terms and over an operational timeframe rather than an investment timeframe.

A financial lens is appropriate, as this will allow the commercial viability of a VPP to be assessed, which is not the primary focus of an economic cost benefit analysis, although the data generated by the complete work package will be used as an input to the financial cost benefit analysis being delivered in Work Package 8.3.

Will Project Symphony participate in the WEM?

Project Symphony will be conducted as an 'off-market' pilot under future market design assumptions, meaning that its DER assets will be dispatched in response to simulated market-clearing outcomes rather than actual market participation.

What are the measurable value streams?

Reported outcomes will be framed as a comparison between the operating cash flows that would occur under DER orchestration and participation in markets, to those that would occur under an assumed non-orchestration base case. The measurable value streams are as follows:

- **Market operating profit difference** - the value obtained by the gentailer from orchestrating a customer's DER across different wholesale markets.
- **Network support service (NSS) payment** – the payment that the network operator makes to the aggregator (in this case Synergy as gentailer) for the provision of a NSS.
- **Customer bill difference** - the change in a customer's retail electricity bill compared to the base case. A positive bill difference corresponds to an increase in bill value for the customer relative to the orchestration case.
- **Retail market-based costs (MBC) difference** - the indicative change in MBC paid by the gentailer's retail business for a customer compared to the base case, a positive difference indicating a higher MBC under the orchestration case than under the non-orchestration case (note that the network bill difference defined below is a component of the MBC difference).
- **Finder's fee** - an amount paid on an operational cash flow basis by the gentailer to an aggregator for providing DER assets to orchestrate (assumes an "aggregator of aggregator" type arrangement).
- **VPP incentive** - the amount of money paid on an operational cash flow basis to the DER owning customer to participate in the VPP.
- **Network bill difference** - the change in the gentailer's network bill compared to the base case. A positive network bill difference corresponds to an increase in bill value for the gentailer in the orchestration case.

What design approach was taken to determine the valuation approach?

At a high level, the approach transforms half-hourly market data inputs to a set of modelling outcomes, by combining observed DER load and generation control data with market simulation and customer baselining estimation techniques, and by applying a set of pre-defined formulae to evaluate and compare the cash flows associated with the pilot.

Figure 1: High-level architectural design of the DER services valuation approach

How did you create a customer base case for service evaluation?

An assessment of the value of orchestrating a DER device as part of the Project Symphony VPP requires an estimation of how that device would have been operated if it were not part of the VPP. To achieve this, a standardised capability built into Enbala's Concerto aggregation platform procured by Synergy will be used to estimate customer loads and battery energy storage utilisation. In addition, Synergy has provided a method for estimating what rooftop solar output would have been if it were not constrained during an orchestration event.

How will energy market values be determined?

For each trading interval, the Australian Energy Market Operator (AEMO) will conduct a market clearing simulation by adjusting the market's balancing merit order and operational demand for the operation of the VPP. AEMO will also provide an essential system service contingency raise price proxy to Synergy based on the peak and off-peak margin values 'availability payment' calculation used to compensate Synergy for the provision of spinning reserve. AEMO's hypothetical market clearing outcomes will then be applied as fixed inputs into licenced PLEXOS software, which will then be used to produce synthetic total generation cost and total emissions for the scenario.

How will the methodology presented in the complete report be used?

In collaboration with the project partners, Synergy will develop a tool for Project Symphony based on the methodology outlined in the complete DER Service Valuation Report, which will seek to value the simulated operating cash flows across the energy system including customer, network, retail and market associated with the integration and participation of the pilot's DER assets.

It is the intent of the partners for this tool to be ready for use in advance of Project Symphony's test and learn phase which will run from October 2022 to March 2023. The outputs from the tool will be leveraged for Work Package 8.3, the Cost-Benefit Analysis Report.

It is important to note that the methodology outlined in this document reflects the partners' current thinking; when the tool is developed it may differ as the thinking advances through development and testing. Any material differences to this documented methodology will be highlighted in Work Package 8.3.

Where can I obtain a copy of the complete report?

The full DER Service Valuation report can be found can be found on the ARENA site - here.

Report Summary - Work Package (WP3.2) Aggregator Report

Project Symphony is an innovative pilot where customer distributed energy resources (DER) like rooftop solar, batteries and selected household appliances are orchestrated as a Virtual Power Plant (VPP) to participate in a future energy market. For the purposes of the Pilot, aggregators are defined as parties that facilitate 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. Within Project Symphony DER aggregation services were provided by both the Parent Aggregator, Synergy, and multiple Third-Party Aggregators (TPAs).

The involvement of TPAs in the pilot was to test the ability to aggregate and orchestrate DER across multiple parties, aggregation models and provide valuable lessons regarding how to foster development of the nascent orchestration and aggregation ecosystem in Western Australia. TPAs were also expected to bring their own customers to the pilot (while integrating with the Parent Aggregator platform developed in Project Symphony), amplifying customer acquisition across a range of DER types.

The subsequent integration of TPAs to the Symphony platforms and testing of this capability has shaped the pilot's recommendations to establish clear frameworks enabling third-party aggregators to engage with the parent aggregator for non-contestable customers, to reduce barriers of entry and ensure consistent customer experience.

Purpose

This report outlines:

1. **the process undertaken to recruit TPAs into Project Symphony; and**
2. **the results from two customer insight surveys on customer sentiment towards DER 'orchestration' and 'aggregation'.**

The report *does not* cover the subsequent TPA integration, testing results or lessons learnt. Information on this can be found in the Lessons Learnt for Milestone 4 or in Work Package 8.4 Final Report.

Third Party Aggregator Engagement

The selection of TPAs for Project Symphony was undertaken via an open Expression of Interest (EOI) process, whereby aggregators and broader DER ecosystem participants were invited to provide a response to the EOI. Following a four-week submission period, responses were assessed against a variety of selection criteria, with shortlisted parties then entering commercial negotiations prior to formal appointment.

Given the pilot objectives, the selection criteria the TPAs needed to satisfy included that they had:

- access to controllable DER within the selected pilot area and more broadly across the South West Interconnected System (SWIS).
- the ability to access or source additional controllable DER within the selected pilot area, and
- technology solutions that met the aggregation and orchestration requirements of the Project within the required project timeframe.

Seventeen parties registered to receive the EOI, and of those eleven submitted responses. The respondents came from across the DER ecosystem: DER installers, existing NEM VPP providers, local emerging participants, energy retailers and technology providers.

Learning from the TPA Engagement Process

Project Symphony is the first VPP pilot undertaken in the SWIS and the first in Western Australia to test customer DER participation in market services. In comparison, there are multiple on-market VPP providers active on the National Energy Market (NEM) and there have been several VPP trials in the NEM.

The legislated split between the non-contestable and contestable retail markets, the different legislative and regulatory arrangements of the Wholesale Energy Market (WEM), Essential System Services and Capacity

market in Western Australia, and the limited ability for aggregators to directly participate in energy markets in Western Australia have all led to an ecosystem that is still emerging. The TPA engagement process highlighted the relative nascency of the aggregator ecosystem in Western Australia.

Customer Insights Survey

Two customer insight surveys into residential *and* business customers sought to gauge sentiment towards DER:

- **'orchestration'** - orchestration of DER meaning an Aggregator (Synergy or a TPA) remotely managing customers' DER devices for the benefit of customers and the grid. This might include remotely managing how much solar energy a home or business' system generates, managing when a battery may charge or discharge, or selecting the time of day that appliances such as air conditioning, hot water systems, or pool pumps are switched on or changing the amount of power that they use.
- **'aggregation'**- is when a party "orchestrates" or manages customers' DER devices and groups them together with other customers to act as a single entity. For example, instead of several home solar systems being orchestrated individually, a group of home solar systems can be "aggregated" so they can all be orchestrated at once to deliver greater benefits. This is sometimes referred to as a "virtual power plant" or "VPP".

The results reflected that these concepts are relatively embryonic within the Western Australian energy consumer mindset. There is a general lack of understanding about what the concepts are, their benefits, and concern about control, cost and risk.

This suggests that industry participants have much work to do to educate energy consumers about the role of DER in the future WA energy system, and the benefits of this emerging model in their energy choices.

Work Package 2.1, the DER Services Report[73], also noted that customer involvement in a VPP was not guaranteed, and that it was important for customers to be offered products and services that were easy to understand and action. The research outlined in this report and the DER Services Report highlight a lack of customer understanding could be a significant barrier to the large-scale uptake of related products and services.

Customers also reflected concerns about the role of TPAs (versus Synergy), including their profit motive, reliability, and degree of regulation. These concerns are understandable, given that this is an emerging model and most of the customer respondents acknowledged little understanding of the concepts. It also demonstrates that unknown third parties may have a considerable hurdle to overcome to establish their profiles in the Western Australian energy market. It should be noted that these results could have differed if known brands were compared against Synergy, which was not covered by the research.

Where can I obtain a copy of the complete report?

The Project Symphony Aggregator Report can be found on the ARENA site – here.

For further information on:

- **TPA integration and testing results**, please refer to the *DER Participation - Pilot Results and Recommendations: Project Symphony Final Report*[74], available on the ARENA site.
- **TPA lesson learnt,** please refer to *Lessons Learnt Report Milestone 04: Project Completion*[75], available on the ARENA site.

[73] https://arena.gov.au/knowledge-bank/project-symphony-der-services-report/
[74] https://arena.gov.au/knowledge-bank/?keywords=Western+Australia+Distributed+Energy+Resources+Orchestration+Pilot.
[75] Ibid.

Project Symphony
Our energy future

Report Summary - Work Packages (WP3.3) Social Research Report

This report describes the social (customer) research findings from the Project Symphony pilot that was conducted by the University of Tasmania (UTAS) with contributions from the Australian National University. It is intended to support the project partners in their understanding of the customer responses to the pilot. The report provides key themes, findings and recommendations.

What was the aim of research?

The research explores four key areas:

1. To understand customer research findings from other Virtual Power Plants (VPP) pilots.

2A. To understand customer sentiment (including perceptions and values) and customer responses to Project Symphony.

2B. To investigate the element of pricing in further detail to understand the implications of pricing and incentives used in Project Symphony.

3. To understand the social equity implications of Project Symphony activity, particularly relating to mass market deployment and adoption.

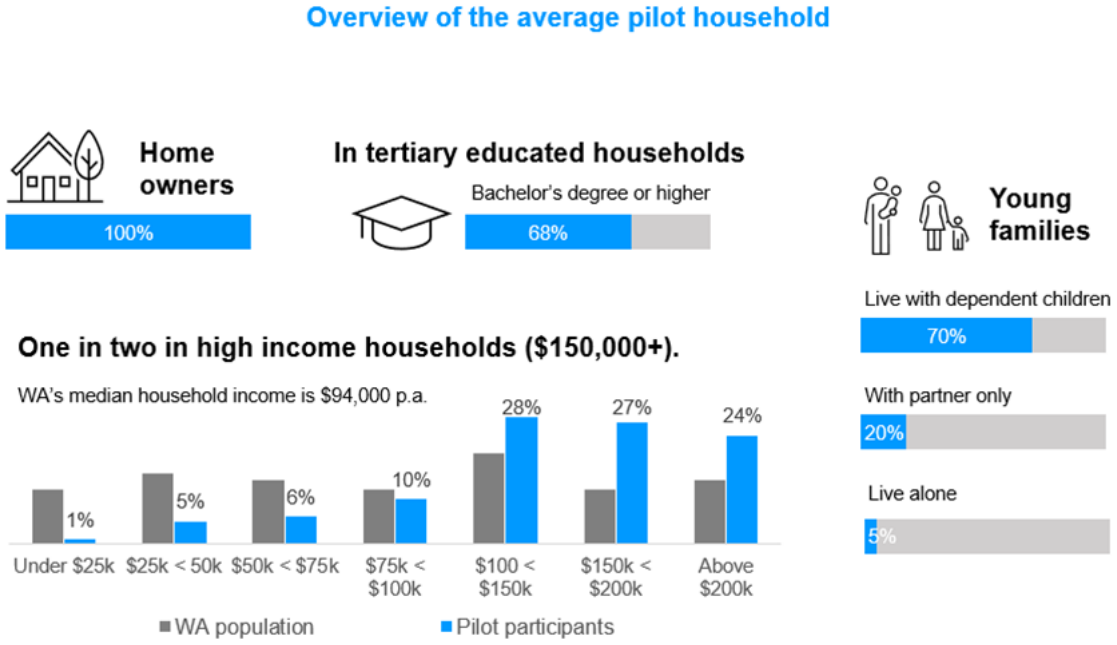
4. To understand government policy implications that emerge during the social research to inform energy policy settings, market design and regulatory reform that will enable optimal deployment and use of VPPs.

What social research approaches were used?

The social research was an applied, multi-method, longitudinal study investigating social phenomenon with participants involved in this pilot. The focus was on household participants that agreed to be part of the pilot, and then also agreed to be part of the social research (via an invitation). The research used data collected over repeat contact with participants (longitudinal data), from interviews, surveys and focus groups. It uses a 'before and after' activity assessment approach.

What was the participant profile?

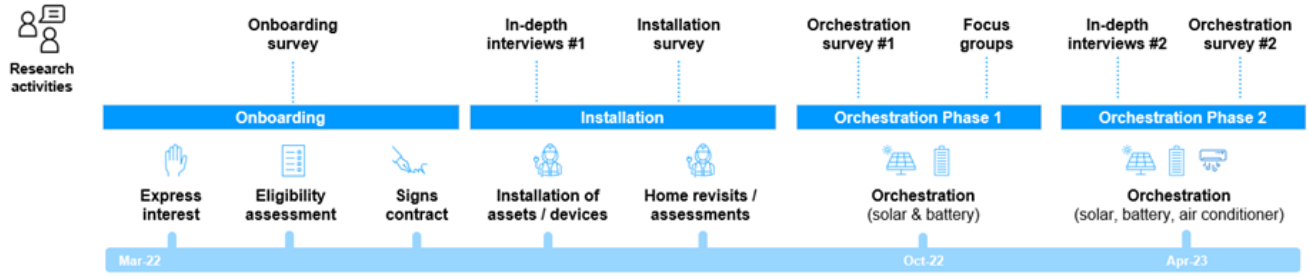
Image below depicts the average pilot participant, based on those who completed survey(s) as part of the social research.



In partnership with:

What did the participant journey look like?

There were four key phases within the participant journey – onboarding, installation, orchestration phase 1 and orchestration phase 2.



What were the key themes and findings emerging from the research?

Communications & Engagement

1. **A majority of participants were unaware of exactly what they were signing up for and returned to their contracts and others in the pilot to find answers as the pilot progressed. Findings suggest that specific information and clear parameters should be provided in contracts, and in any marketing for future pilots or programs.**
2. **Participants sought clear, graphical information about what was happening with their assets with orchestration; and context on what this meant for them and the broader community. The report suggests that participants are kept informed through regular updates and apps with easy-to-understand statistics.**
3. **Terms like 'orchestration' had very little meaning for participants. The use of technical terms that lack explicit meaning, which customers can relate to is common within the energy industry. These findings suggest a much broader issue within the energy industry about the use of insider terms, that then make it out unfiltered to the customer.**
4. **A clearer value statement at the outset of the project detailing what participants were part of would have assisted in setting expectations for participants. Participants questioned the value of participating, as they were not given clear information about what to expect or what the pilot was actually trying to achieve.**

Orchestration

1. **Orchestration was an unknown for participants. Therefore, there was no understanding of the effects of orchestration on their assets, or household energy use. These findings suggest that the social licence to orchestrate participants assets was tenuous, despite participants signing a contract saying that Synergy will use their assets for the purpose of orchestration.**
2. **The research found that many participants expressed concern about the 'constrain to zero' scenarios which restricts the export of rooftop solar energy to the electricity grid. This was particularly so when participants had to purchase / import electricity from the grid. They were less concerned when the scenario enabled their household demand to be met from solar generation.**
3. **Participants discussed desire for notifications of when orchestration events would occur. Given the level of flexibility that would be required to operate customer assets in this way, such opportunities need to consider customer acceptance and how to engage customers in such products.**
4. **The value of the project for battery participants was hindered by orchestration when there was an expectation at the outset of bill reductions. Other measures of value such as battery back-up were**

based on a conventional understanding of the individual benefits of having a battery to store excess solar generation for use in the evening (energy arbitrage).

Technology and Systems

1. Overall installations of assets / devices in participants' homes were positive and improved over time, but there were issues. Quality assurance visits by the retailer are a very positive part of the installation process. They also serve as an intervention, ensuring high quality installations and to check householder understanding of the safety aspects of systems. Positive installation practices captured are listed in the report.
2. Retrofitting of devices and assets (such as gateway devices and home battery systems), and the physical space limitations are important to understand. Certain housing will be more suitable for retrofitting larger assets, such as batteries. Understanding the features that support or inhibit these installations will be useful for planning future programs, and how it may hinder people from being involved.
3. Installations became more complicated with each asset connected and there is a lot of technology being installed, taking up significant space in highly utilised garages and service spaces. Households need more up-front explanations of what is being installed in their homes.
4. There were safety features, such as bollards and heat sensors added into participants garages due to the retrofit of batteries. These safety features are new to domestic spaces and needs further consideration in future programs.
5. Battery expectations can be proactively managed and further communication around how batteries are used in programs would help to ease concern around battery use by the system or the network. Participants value the battery for the personal control it provides over energy use and energy arbitrage. The way a battery is useful for these participants clashes with the use of a battery for a pilot such as Project Symphony.
6. Monitoring and feedback from the perspective of the participant and at the house site was useful to understand. Participants monitor their technology if they think it is, or have been told it is, a useful practice. Programs likely need householders to monitor and maintain their systems over time, thus the risk of unmonitored systems may also grow over time.
7. Participants with access to new apps, particularly those who had also installed a battery, increased their monitoring via apps and Synergy's online portal (My Account). Increased checks and learning about energy can be assumed when programs like this occur. Future programs should also note the range of information participants use to check on and understand technology installed in their homes.
8. Participants were keen to have data between apps align and this could be a sticking point for householders in future programs. Managing the confusion of this could become time consuming for a program and is therefore a risk worth exploring.

Value for Participants

1. A broader definition of value is suggested. One that includes consideration of participant expectations (such as battery back-up, bill reductions), their motivations for participating (such as environmental, costs savings, community benefits) and effort required to be involved in the project.
2. For future VPP projects, there is a responsibility for the Aggregator and the Distribution System Operator (DSO) to ensure that customer assets are optimised for their benefit, or an appropriate tariff is provided. The frequency and duration of orchestrating assets intensely in the first phase of orchestration, may have led to a perceived or (actual) loss of value for battery participants.

3. **Concerns about the first phase of orchestration, issues with installation and the general time and effort required to participate led to unclear value propositions for participants. This was particularly the case for battery participants who make up the majority of this social research.**

Where can I obtain a copy of the complete report?

The Project Symphony Social Research Report can be found on the ARENA site.

Project Symphony
Our energy future

Report Summary - Work Package (WP4.1) Distribution Constraints Optimisation Algorithm Report.

This paper is a summary of the Work Package 4.1 Distribution Constraints Optimisation Algorithm Report, produced to provide information on the network Distribution Constraints Optimisation Algorithm (DCOA) tool.

The DCOA tool will enable the Distributed System Operator (DSO) to develop the appropriate level of distribution network constraint analysis and support the equitable deployment of Distributed Energy Resource (DER) in an off-market pilot to simulate aggregated DER integration into the Wholesale Electricity Market (WEM).

What is a Static Operating Envelope (SOE)?

Under current network connection rules, the net rate of electricity imports and export at the customer connection point is limited within a Static Operating Envelope (SOE). The application of SOEs presently serve to maintain safe network operation during periods of low demand by limiting the total installed PV generation capacity to avoid network issues caused by increasing penetration of DERs, particularly residential solar PV.

A SOE is not time varying and has the effect of limiting renewable energy generation at times when it may pose less risk to the network and will limit the potential for customers to install new or expanded PV systems.

What is a Dynamic Operating Envelope (DOE)?

A DOE is a principled and time varying allocation of the available network capacity to actively participating connection points (such as those within a VPP) on a segment of an electricity distribution network. A DOE provides upper and lower bounds on the import or export power in each time interval for each connection point.

At a high level, the DOE involves a 4-step process as shown in the diagram below.

The DOE process involves the forecasts of the load and generation at each NMI (Step 1), for both VPP participants and others, for each market interval. It uses this forecast input to continually run Medium Voltage (MV) and Low Voltage (LV) load-flow analysis (Step 2) to identify constraining network element(s) and network capacity limits, generating DOEs based on these results pre-defined allocation principles (Step 3) before publishing the DOE for every NMI for multiple market intervals to the Aggregator (Step 4).

What are the benefits of a DOE?

The DOEs will be published to the Aggregator for each customer connection point identified by a National Metering Identifier (NMI). The Aggregator will then orchestrate the dispatch of DER assets at NMIs participating in a VPP (participating or active NMIs) within DOE import and export limits.

This means that while the network is protected with energy flows being maintained within capacity limits, aggregators can maximise the amount of energy that can provide market services.

The Dynamic Limits DER Feasibility Study, October 2021 quantifies the benefits of using dynamic DER export limits on rural and remote networks and demonstrates its ability to increase network utilisation.

The results of the study illustrated that DER utilisation increased, ranging from 120% to 400% higher than that expected by applying static operating envelopes and other traditional connection management methods. It also showed this increase in utilisation was achieved with minimal energy curtailment.

What is the Equal Allocation Method (EAM)?

Project Symphony will make use of a software tool known as "The Dynamic Operating Envelope Calculator," or DOE Calculator, developed by the Evolve project team of Australian National University (ANU) and Zepben.

The Evolve solution has up to three different Equal Allocation Methods (EAM) of spare hosting capacity. The EAM involves a mechanism through which all participating NMIs get an equal allocation of spare hosting capacity based on an upstream network constraint.

What is the Distribution Constraints Optimisation Algorithm (DCOA)?

The work undertaken jointly by Western Power and UWA's Power and Clean Energy (PACE) proposes four alternative allocation methods to the approach used by the Evolve solution to support an equitable allocation of spare capacity. However, it is important that methods appropriately account for the physical and operational parameters of the network, which ideally include both voltage limits at customer connection points and thermal constraints of various network elements.

Whilst the Symphony project is piloting only constraining active power, the method should be extensible to efficiently and equitably manage both, constraining and expanding of active and reactive power. The effectiveness of the methodology can be assessed according to its capability to accurately forecast network capacity and its performance against the allocation objectives.

How will you compare allocation methods?

Each method for allocating capacity (SOE, EAM and DCOA) will be assessed against their achievement of the following objectives:

- Allocation efficiency
- Allocation equity
- Financial Impact (to customers and other stakeholders)
- Environmental Impact
- Network security
- Reliability
- Scalability

Will the DoEs established for Symphony be scalable across the SWIS?

The allocation method will have the ability to deploy progressively into different segments of a distribution network and across the SWIS, supporting expansion in scale and scope.

Are there limitations to the report?

It is important to note that the study approach, the model used and the data that was available to the study all have limitations and assumptions. These should be recognised in considering and interpreting the results.

Where can I obtain a copy of the complete report?

The full Distribution Constraints Optimisation Algorithm Report can be found on the ARENA site - here.

Project Symphony
Our energy future

Report Summary - Work Package (WP4.2) Functional and non-Functional requirements report for DSO, DMO and Aggregator Platforms

This paper is a summary of Work Package 4.2 Functional and non-Functional requirements report for DSO, DMO and Aggregator. Produced as part of Project Symphony, it presents the functional and non-functional requirements and high-level solution design for a DSO Platform, DMO Platform and Aggregator Platform operating under a version of the OpEN Hybrid Model.

What is the role of the DSO?

A Distribution System Operator (DSO) enables access to and securely operates and develops an active distribution system comprising networks, demand, and other flexible DER. Expanding the network planning and asset management function of a Distribution Network Service Provider (DNSP), the DSO enables the optimal use of DER within distribution networks to deliver security, sustainability, and affordability in the support of whole system optimisation. As the existing Network Operator in the SWIS, Western Power will assume the role of DSO. In taking on this role, Western Power will be responsible for developing a DSO Platform which will include capabilities to identify the maximum renewable energy hosting capacity of a distribution system.

What were the key specifications for the DSO Platform?

The DSO Platform will be delivered by procuring several functionally discrete solutions, including a Dynamic Operating Envelope (DOE) calculation solution and integrating them with components sourced from existing Western Power systems.

The platform will support Western Power in the role of DSO in context of the Project Symphony pilot, including supporting functional evolution in response to learnings gained as part of the Project's test and learn strategy.

Function	Description
Distribution system monitoring and planning	Network monitoring and the assimilation of wider data (e.g. weather patterns) to inform long-term forecasts, including network constraints, for the creation of long-term investment plans. The pilot DSO Platform will store and utilise weather, solar irradiation, metering and network monitoring data collected from the pilot area distribution network.
Distribution constraints development	Development of forecast network constraints into long-term static operating envelopes for network customers and, through engagement with DER, the determination of long-term requirements for network services.
Forecasting systems	The pilot DSO Platform will use available data to develop detailed short-term forecasts, including identifying network constraints. Operating envelopes will be dynamically calculated to respect these constraints. The operating envelopes will be used by the Aggregator to determine facility capacity and inform their interactions with the market.
DER optimisation at the distribution network level	Optimise operating envelopes in engagement with the markets to ensure DER bids and offers can feed into market dispatch optimisations while taking account of distribution network constraints. DSO will dynamically calculate, allocate and publish operating envelopes for the Aggregator to use in DER optimisation. The DSO will monitor compliance with published operating envelopes.

Function	Description
Distribution network services	Procurement and use of distribution network services, such as power quality/voltage control, which can be provided by DER, either through bi-lateral contracts or through a market optimisation. The DSO and Aggregator will enter bi-lateral agreement(s) for NSS. NSS agreements will cover periods when forecast demand on the distribution network is expected to exceed planning criteria. The costs/benefits of NSS (compared with network augmentation) will be assessed by the Project.
Data and settlement (network services)	Financial settlement of network support and control ancillary services at distribution and transmission level. The DSO and Aggregator will agree a process for validating and settling NSS provided under bi-lateral agreement(s).
DER register	Establish, maintain and publish or share DER register data to be used by all parties. The pilot DSO Platform will use available information on registered DER to determine NMI capacity, which will support the forecasting of network hosting capacity and dynamic operating envelope allocation.
Connecting DER	The pilot DSO Platform network monitoring, modelling and forecast capabilities will provide information that will inform technical requirements for managing DER and service connections, as well as data to monitor adherence with operating envelopes and relevant contractual agreements.
Network and system security with DER	The Project will test pilot DSO Platform outputs to ensure their application in downstream processes does not impact network safety in the pilot area. The Project will employ strategies to ensure network safety is maintained for the duration of the pilot, including in the event of market or network failure. The Project will also test and investigate services, such as NSS, that may support distribution networks in cases of incident or adverse event, such as events that require outages and/or network modifications.

What is the role of the DMO?

Distribution Market Operator (DMO) is a Market Operator that is equipped to operate a power system that includes aggregations of small-scale devices which can be dispatched at appropriate scale. As the sole operator of the WEM (Wholesale Energy Market), the Australian Energy Market Operator (AEMO) will expand its role as the System and Market Operator and perform the role of DMO. As the DMO, AEMO is responsible for providing a Market Platform (DMO Platform) that will facilitate Aggregator access to wholesale energy markets and essential system services.

What were the key specifications for the DMO Platform?

The specification development stage focused on identifying the on and off-market scenarios that would inform the development of the Market Platform business requirements, functionality, and integrations.

AEMO undertook a requirements determination exercise of the processes and system behaviours required to support the operations and assessment of an energy market incorporating DER. These requirements based on the four 'must have' scenarios were then grouped into the six categories as defined in the following table:

Function	Description
Facility Registration	To receive and store NMI and aggregated DER facility level registration information from the Aggregator.
Process Facility and Constraint Data	Must receive, then process and store, the following data from the Aggregator and DSO: • Constraint information. • NSS Contracts Commitments. • Aggregated facility capacity. • DER facility status.
Manage Bids & Offers	Energy Balancing Market: Test ability of the aggregated DER facility to submit bids/offers for energy and be dispatched by the Market Platform to deliver that energy. Essential System Services: Contingency Raise (e.g. Spinning Reserve & Load Rejection), Test ability of the aggregated DER facility to offer contingency raise services to the market.
Manage Dispatch Instructions / Control Signals	• Must send and manage a series of dispatch instructions to the Aggregator for the provision of energy services. • Must send and manage a series of control signals to the Aggregator for the provision of Contingency Raise and Contingency Lower services. • Must receive and process a deployment signal from the DSO platform for NSS. Must send and manage the dispatch of instructions for NSS to the Aggregator. • Must send and manage an instruction to an Aggregator to constrain their energy generation output to zero. • Must collect and store data related to dispatch instructions and control signals to facilitate post-test assessment by Market and System operations analysts. • Must receive, process and visualise telemetry data (facility) related to the dispatch instructions/control signals to allow the control room operator to manage and monitor the Aggregator's response to a dispatch instructions or signals.
Reporting and Performance Assessment	• System Operations to assess the aggregated DER facility's ability to deliver the level of energy requested. Market Operations analyst to assess the value that aggregated DER facility can provide. • Must allow analysts to retrieve and extract the test related data in a format that can be imported into an analysis platform. • An analyst to perform an assessment of the performance of the system.
User Modified Test Variables	Must allow at time prior or during a test event, the ability to: • Construct and input a dispatch schedule. • Construct and input a control signal. • Modify the testing parameters including dispatch time interval, gate closure cut off time and price ceiling/floor and price/quantity tranches. • Simulate frequency increase or frequency decrease scenario. • Simulate a constrain to zero scenario.

What is the role of the aggregator?

An Aggregator facilitates the grouping of DER devices to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the DSO. As the existing retailer for most small use customers, Synergy will assume the role of market facing Parent Aggregator for the Project. As the Parent Aggregator, Synergy is responsible for DER valuation, customer acquisition and procuring a minimum one to two Third Party Aggregators. Synergy will lead the customer interactions to achieve a suitable mix and concentration of at least 900 DER assets and procure, design, build, integrate and test an Aggregator Platform that will be used to orchestrate DER assets to participate in the energy market. Building an understanding of DER customer sentiment in relation to more active participation in markets is also key for the Aggregator.

What were the key specifications for the Aggregator Platform?

Function	Description
External partner integration	An integration layer providing communication between the DMO, DSO and the other layers of the Aggregator Platform. Allows for ingestion of operating envelopes that will be used by the Aggregator to determine facility capacity and inform interactions with the market.
Trading platform	Synergy Trading platform, DER Trading Platform. Integration of the existing Synergy portfolio trading platform and the new DER trading platform that supports the development and lifecycle of bids and offers.
Ingestion of DoEs and DER optimisation	The optimisation layer responsible for determining 'what' and 'how much' each of the assets within the VPP will contribute to providing the energy or network service. Provides the VPP energy forecasts as a virtual facility and provides dis-aggregation of a dispatch instruction into the discrete setpoints for each of the DER assets.
Aggregator DER bid and dispatch	Aggregators engage with contracted DER resources to develop portfolios of customers and services and engage with Network Operators and markets to submit bids and offers.
Retailer DER bid/offer and dispatch	Retailers engage with contracted DER resources to develop portfolios of customers and services and engage with Network Operators and markets to submit bids and offers.
Provision of distribution network services	The Aggregator will enter bi-lateral agreement(s) for NSS and provide NSS services. NSS agreements will cover periods when forecast demand on the distribution network is expected to exceed planning criteria.
Data Settlement (network services)	Financial settlement of network support and control ancillary services at distribution and transmission level. The DSO and Aggregator will agree a process for validating and settling NSS provided under bi-lateral agreement(s).

Are there limitations to the report?

It is important to note that the study approach, the model used and the data that was available to the study all have limitations and assumptions. These should be recognised in considering and interpreting the results.

Where can I obtain a copy of the complete report?

The full report on platform functional and non-functional requirements can be found on the ARENA site - here.

Project Symphony
Our energy future

Report Summary - Work Packages (WP5.1, 5.2 & 5.3) Combined Platform (as built) Report for DSO, DMO and Aggregator

This paper is a summary of Work Package 5.1, 5.2 & 5.3 Combined Platform (as built) Report for DSO, DMO and Aggregator. Produced as part of Project Symphony, the report describes the development of the 'as built' Aggregator, Distribution Market Operator (DMO) and Distribution System Operator (DSO) platforms that were built and used in the Project Symphony Pilot to understand and observe the functions and capabilities required from the key roles defined in the Open Energy Networks (OpEN) Hybrid Model. The platforms were built to support the end-to-end execution of the four scenarios:

1. Energy Services – Bi-directional Energy – Balancing Market Offer (BMO),
2. Network Support Services (NSS),
3. Constrain to Zero (CTZ) *Net* and *Gross*, and
4. Essential System Service (ESS) – Contingency Reserve Raise.

What were the specifications for the DSO platform?

The DSO platform was built to provide the following functions:

forecasting network loads and calculating the maximum renewable energy hosting capacity of the Pilot area local distribution network.

communicating calculated limits to the Aggregator through the allocation of Dynamic Operating Envelopes.

identifying when and where network loads are predicted to exceed network limits, facilitating the orchestration of DER assets to provide targeted Network Support Services.

monitoring the impact of DER orchestration on the distribution network to ensure operations remain within safe operating limits.

What approach was used to deliver the DSO platform?

- **Options Analysis** to determine the best approach for delivering the DSO Platform to support the pilot. The options were evaluated against several criteria including: Project Requirements, Pilot Test and Learn Strategy, Functional alignment, and Longevity.
- **Procurement** - after considering the available options, it was decided to procure multiple functionally discrete solutions, including a Pilot Dynamic Operating Envelope (DOE) calculation solution and integrate them with modules sourced from existing Western Power systems.
- **Delivery** - an agile approach was adopted for the delivery of the technical capabilities which enabled the progressive delivery of the four core must-have scenarios. It also allowed the DSO solution to evolve as new learnings and requirements emerged from implementation drops and the evolving industry/market context.

New modules were sourced, built and/or implemented by Project Symphony. It was understood from the outset that some of the modules used to build the Pilot DSO Platform may not be fit-for-purpose in the long-term.[76]

[76] Platform Functional and Non-Functional Requirements, Western Power, pg. 35 states "the solution described in this document may not be the best solution for delivering a DSO Platform long-term. A revised set of assessment criteria will be developed as part of project learnings to inform any future evaluation of technology to support the wider delivery of DSO functions."

What was achieved?

A DSO platform with modules procured as part of Project Symphony and leveraged from Western Power's existing portfolio. Notable achievements include the implementation of advanced DOE concepts, such as Default and Short Notice operating envelopes to address multiple failure modes and scenarios; monitoring of DOE and NSS compliance; and technological advancements, such as Battery Energy Storage System (BESS) dual control, high-speed data recorders (HSDRs) to measure high speed droop events and benchmarking of the Wholesale Energy Market (WEM) compliance HSDR's against cheaper alternatives.

What were the specifications for the DMO platform?

The DMO platform was built to test and demonstrate capability of DER Aggregators to participate in the simulated market. The functions required of the DMO platform included:

Integrate with the DSO and Aggregator platforms to deliver the end-to-end solution,

Orchestrating market outcomes and provision of energy, network support and ancillary services.

Assessing the compliance of aggregated DER assets to provide these services as instructed through monitoring of aggregated DER assets within Virtual Power Plants (VPPs).

What approach was used to deliver the DMO platform?

- **Solution design** - AEMO shared the DMO platform development for Project Symphony with Project EDGE. Leveraging AEMO's existing capability allowed the implementation to focus on expanded hypotheses and test outcomes.
- **Procurement** - AEMO sourced individual platform components to meet its identified business requirements and platform specifications. Two vendors were identified to jointly deliver the solution.
- **Delivery** - an incremental/agile approach was adopted for the delivery of the required technical capabilities for the allocated budget and project timelines. This approach enabled the progressive delivery of the four core must-have scenarios. The DMO solution evolved as new learnings and requirements emerged from implementation drops and the evolving industry/market context.

What was achieved?

The core DMO platform consisted of two layers', an intelligence layer consisting of market bids and offers solver, the data repository, and a user interface to provide insight via monitoring the aggregator responses to instructions and market conditions, and the interfaces and message processor (Data exchange layer) between the Project Symphony platforms.

The platform was separated from the existing market and system applications supporting the WEM, so there were no unintentional impacts on the WEM wholesale market.

Notable achievements included adoption of an innovative data exchange layer selected specifically for DER aggregations that demonstrated concepts such as Distributed Ledger Technology (DLT), Self-Sovereign Identity (SSI) and Decentralized identifiers (DID). The DMO platform build also facilitated the Aggregator to value stack services enabling its customers to optimise value by participating in a multiple market and off-market services.

What were the specifications for the Aggregator platform?

The Aggregator platform was built to perform DER valuation, customer acquisition and integrate two Third Party Aggregators. The functions required of the Aggregator platform included:

Asset registration and configuration management.

Execution of dispatch instructions from the DMO and optimisation of DER assets to meet VPP energy objectives.

Real-time monitoring and control of DER assets to support the project scenarios.

What approach was used to deliver the Aggregator platform?

- **Solution design –** The platform design incorporated custom-built elements and vendor sourced SaaS solutions. The custom built elements of the solution were developed using Platform as a Service (PaaS) services, allowing the Aggregator to invest in system capabilities.
- **Delivery -** The Aggregator platform was developed using Agile-based practices. This approach aligned with the explorative nature of Project Symphony, allowing incremental delivery of capabilities, responding to feedback from test cycles, and incorporating new requirements.

The solution was built on stand-alone implementations of solution components to minimise risk to the stability or operational behaviour of existing enterprise systems. The custom solution components developed for Project Symphony were hosted within the Aggregator's cloud tenancy to benefit from existing enterprise-wide network and cyber-security controls capabilities.

What was achieved?

The Aggregator platform is comprised of:

DER Monitor & Control Platform – providing management and control of Gateway Controller devices,

VPP & DER Optimisation Platform – providing composition modelling for VPPs, defining operational objectives and generating events to control DER assets to meet operational objectives.

Synergy Energy Management System (SEMS) – providing the requirements not met by the other platforms e.g. Consume & publish messages from/to the DER Data Exchange, provide contextual awareness for routing messages to internal systems or Third Party Aggregators, a User Interface for Operators and Traders to manage data and submit and review market transactions, aggregation of multiple VPPs to AEMO registered Facility level.

The platform leverages the Aggregator's API gateway, Gateway Controller devices and the DMO's DER Data Exchange Layer and integrates with TPA systems.

What were the lessons learnt?

The lessons learnt documented in the full report outlines the barriers, benefits and lessons specific to the complexity such as adopting emerging and new technologies not available 'off the shelf', from multiple vendors, and a lack of industry standards. Project challenges were also faced with policy and market reform evolving in parallel in the WEM from the time of Project inception to platform delivery which resulted in changes to scenario design to align with updated policy and reform.

Several lessons were documented in the delivery of the three platform solutions. The technical complexity of the Project, the large number of stakeholders and extended project term meant it was challenging aligning delivery approaches, document and data management processes, and deploying common testing tools and systems across the three organisations.

Despite these common challenges encountered, the 'as built' solutions were built and delivered as specified with many learnings to inform future integration in the WEM and SWIS as well as within organisational IT infrastructure, systems, standards, and processes.

Where can I obtain a copy of the complete report?

The Project Symphony Combined Platform (as built) Report can be found on the ARENA site – here.

Report Summary - Work Packages (WP8.2) End of Project Assessment

Project Symphony piloted a model for Western Australia's energy future, a model that tested the ability of distributed energy resources (DER) - being residential customer, and business owned assets in actively participating in the energy system. The objective of this participation is to help meet the persistent challenges associated with efficiently managing the 'peaks and troughs' of electricity demand in the SWIS. The End of Project Assessment has used the ***mutually exclusive and collectively exhaustive life-cycle framework, that leverages ARENA's "technology readiness levels" (TRLs) and "commercial readiness index" (CRI) to assess the maturity gains of the Pilot.***

Purpose

The purpose of this report is to outline the final project evaluation of Project Symphony. It assesses each of Project Symphony's work packages against the stages of a rubric for both technology and commercial maturity that was outlined in Work Package 8.1: Vision and Impact Pathway using:

- a life-cycle framework of Distributed Energy Resources (DER) integration (in Figure 48) 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) in Figure 49.

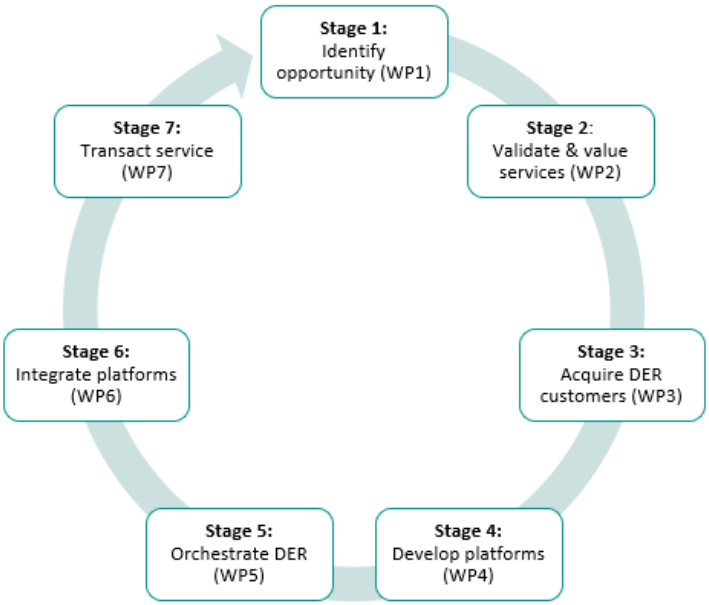


Figure 48: Life-cycle framework of DER integration with corresponding Work Packages (WP)

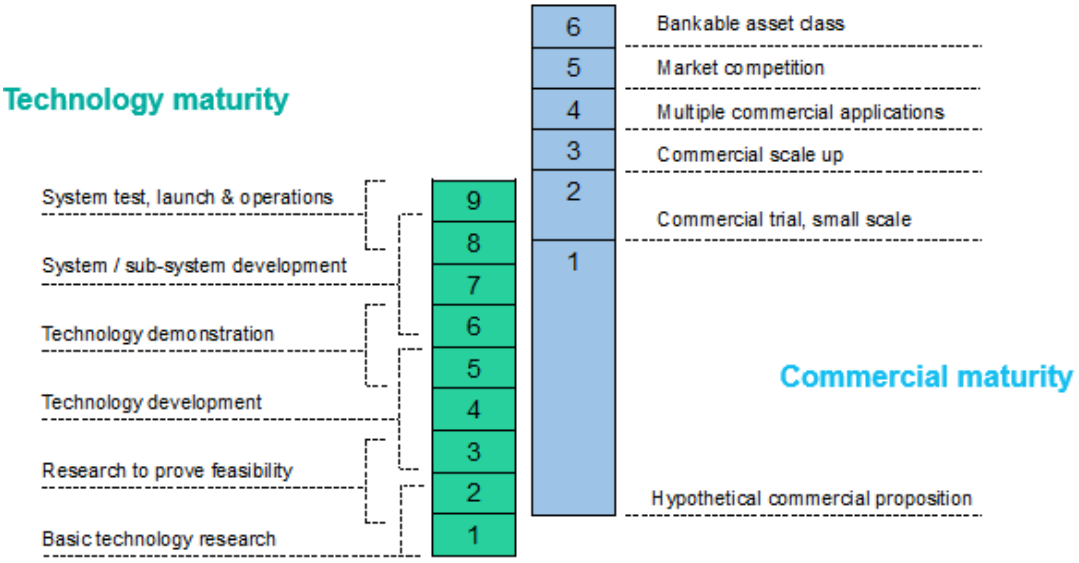


Figure 49: ARENA's technology readiness levels and commercial readiness index

Methodology

The final assessment was completed in five steps:

1. Gathering and screening interim/final reports for work packages 1-8 to undertake a preliminary evaluation.
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.
3. Review by the Core Project Team (Western Power, Synergy, AEMO) and Energy Policy WA (EPWA) to provide an opportunity for feedback.
4. Presentation to industry members and technical experts to gather further supporting information that may help provide further context for the evaluation.
5. Final review by the Project Steering Committee.

Final Project Assessment

The assessment outlines the progress that Project Symphony has made towards technology and commercial maturity of DER orchestration and is summarised in Figure 50. 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.

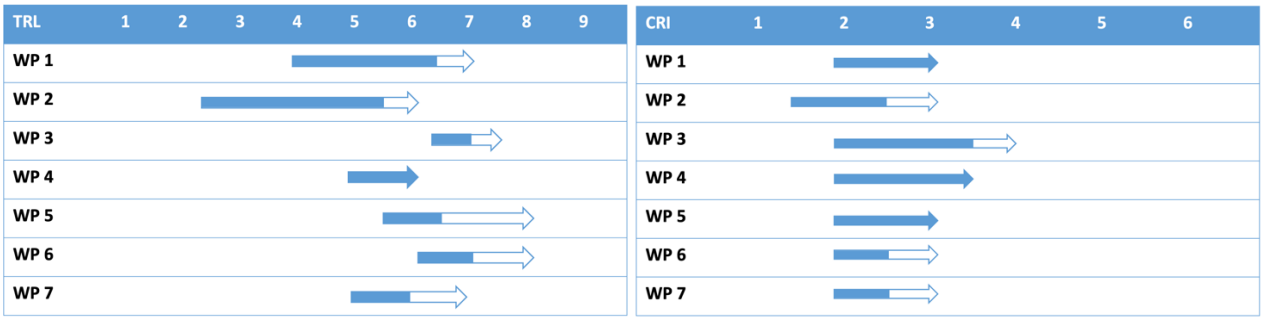


Figure 50. Summary of Project Symphony's progress towards technology and commercial maturity

Key technology maturity insights include:

- **Stage 1** Significant progress was made by Western Power and Synergy in establishing their respective technical DSO and Aggregator capabilities.
- **Stage 2** Prototype valuations were tested through a comprehensive Cost Benefit Analysis (CBA) of DER orchestration however TRL6 was not fully achieved given the valuations were not tested to the customer level.
- **Stage 3** The Pilot delivered a statistically relevant number of customers and assets to inform the scaled application of DER orchestration in WA.
- **Stage 4** 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.
- **Stage 5** Project Symphony successfully conducted a 90 Day Clean Run at the zone substation level. TRL 6 was achieved as the Pilot was able to deliver multiple network and market services.
- **Stage 6** The DSO, DMO and Aggregator Platforms were successfully integrated.

- **Stage 7** Transactions were demonstrated at zone substation level including the fundamentals of forecasting, measuring, scheduling and settlement. As aggregated DER acts in a fundamentally different way to the existing Facility Classes in the WEM, further work has been identified.

Key commercial maturity insights include:

- **Stage 1** The objective was achieved and further improvement opportunities have been identified e.g. sharing of data and moving from a static DER Register to a DER Participation Framework.
- **Stage 2** 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.
- **Stage 3** The Pilot recruited customers to deliver both network and market services that could be 'value-stacked'. Given there is not a standard product available, applied in multiple jurisdictions that has tiered options and a clear risk profile, it was not possible to fully achieve CRI 4.
- **Stage 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.
- **Stage 5** All project partners indicated that scale-up to the required standard to deliver a strategic market solution was technically possible.
- **Stage 6** 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.
- **Stage 7** 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".

Assessment Against Project Objectives

The report also considers whether Project Symphony met its objectives. The detailed assessment can be found in the report and a high level summary, at category level, is outlined in the table below.

Project Objective Category	End of Project Assessment
Technical	Close to achieved, with a basis to understand how to fully meet this objective
New Energy Market	Achieved
Customer Experience	Achieved
Roles and Responsibilities	Achieved
Policy and Regulation	Achieved

Where can I obtain a copy of the complete report?

The Project Symphony End of Project Assessment Report can be found on the ARENA site.

Report Summary - Work Packages (WP7) DER Participation Framework

This paper is a summary of Work Package 7 DER Participation Framework. The Work Package provided recommendations for policy and rule changes to encourage and facilitate participation of aggregated Distributed Energy Resources (DER) in the Wholesale Electricity Market (WEM).

Project Symphony contemplates DER as intrinsic energy infrastructure that can be leveraged and enabled by the active management of DER in aggregate. The pilot tested the conversion of DER capabilities into value streams, that could be accessed via the wholesale market in the future.

The Western Australian Government's DER Roadmap77 policy vision is to leverage Project Symphony to enable DER to become actively manageable, visible to the market, network and power system, and aggregated to enable the provision of services and gain access to value streams above the existing ability to offset purchases from the grid.

DER aggregations are expected to start small and scale over time, as opportunities arise. Work Package 7 lays out a pathway that enables a progressive rollout by promoting visibility in the first instance whilst defining a pathway into the WEM. The proposed pathway seeks to avoid unintended consequences and impacts on existing participants, thereby opening up opportunities for consumers and limiting impact to the market whilst aligning with the updated78 State Electricity Objective (SEO).

As set out in the DER Roadmap, the commencement of DER Aggregator participation is to be supported by amendments to legislation, the WEM Rules and resulting systems that incorporate the Distribution Market Operator (DMO) and Distribution System Operator (DSO) roles in the WEM.

What were the pilots' observations?

The Project Symphony market platform and test scenarios enabled Aggregators to participate in a simulated real-time energy market, with testing designed to reflect services provided under the WEM's current Facility Class registration arrangements.

Project Symphony successfully demonstrated capability and limitations of orchestration, and this Report's recommendations are based on the broad evidence gathered during the development, implementation and testing undertaken in the pilot. This evidence shows that the interaction of aggregated DER with the energy market is fundamentally different to that contemplated by the existing WEM arrangements.

Importantly, Project Symphony found that 'facilities' comprising aggregated customer-owned DER, with or without stand-alone DER (such as a distribution-connected battery), could provide additional value through modes of operation based on capabilities that cut across those contemplated for multiple Facility Classes in the WEM's existing registration framework, rather than aligning neatly with a single Facility Class.

A lack of specific accommodations in the WEM Rules for the registration and participation of aggregated DER would require Aggregators to register in the current Facility Classes, with the imposition of associated obligations once scale thresholds are reached. Hence, retaining existing frameworks for aggregated DER facilities is likely to significantly constrain scale and opportunities for DER orchestration, with changes needed to gain access to the full value of DER.

These observations demonstrate that access to the WEM is therefore not limited by technical capability, rather it is limited by existing obligations that place barriers to participation that are largely founded in a misalignment between the underlying technical capabilities of aggregated DER, customer preferences, and the existing market framework. Such limitations may be overcome by an Aggregator through very conservative DER

[77] https://www.wa.gov.au/system/files/2020-04/DER_Roadmap.pdf
[78] Legislative amendments scheduled to go through Western Australian parliament late 2023 / early 2024.

operations that will limit value to the Aggregator and system, or by aligning market obligations with DER capability to enable aggregations to scale and derive value to both the Aggregator (therefore customers) and the system.

Establishing a DER Participation Framework

The core recommendation of this Report is to establish a DER Participation Framework that encourages and facilitates WEM registration of DER aggregations through the development of a new, tailored Facility Class that specifically accommodates the technical capabilities of these Facilities.

Registration in the WEM will provide access to value streams that are not available to unregistered DER, enabling DER aggregations to achieve significant scale in the years following commencement. Registration of Aggregators will enable the realisation of net benefit for DER owners and support the orchestration of DER at scale in return for improvements in visibility, predictability and controllability of aggregated DER for the DMO and DSO.

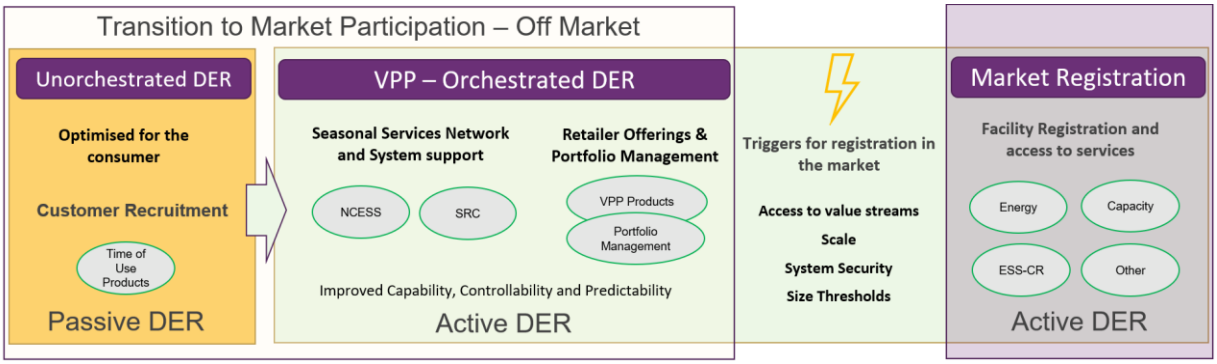


Figure 51. Transitional value streams for VPP's

Encouraging registration at DSO/DMO commencement will also prevent punitive measures being forced upon DER owners and Aggregators that achieve scale outside of WEM constructs, potentially requiring expensive retrofitting of equipment and technology to comply with AEMO standards should system security thresholds be breached.

The core recommendation meets both the SEO and WEM Rule Objective 1.2.1(c), as it:

- Improves market efficiency by encouraging the provision of services and participation in markets by aggregated DER;
- Supports the security and reliability of the power system through measures that improve the visibility, controllability, predictability and scalability of aggregated DER;
- Avoids unnecessary participation costs for aggregated DER and Aggregators through the design of a specific Facility Class with fit-for-purpose technical requirements for market participation that reflect DER capabilities and the value that aggregated DER can provide to the system and market;
- Avoids cost and minimises disruption to existing Rule Participants and the services they provide; and
- Reduces barriers to timely and efficient investment in lower-emission technologies by minimising the complexity of market participation for aggregated DER.

The Report's recommendations align with the long-term interests of consumers in relation to the quality, safety and reliability of supply of electricity, through alignment with key principles, and the price of electricity through improved market efficiency. By progressing this Report's recommendations, the WEM will be on a course of active participation of DER Aggregators, and therefore customers – delivering a two-way WEM energy market at significant scale over coming years.

Where can I obtain a copy of the complete report?

The Project Symphony Combined Platform (as built) Report can be found on the ARENA site.

Report Summary - Work Package (WP8.1) Vision and Impact Pathway

Project Symphony (in parallel with Project EDGE in the National Electricity Market) is unique as it is the first end-to-end pilot of a new energy market, using new and existing assets, rather than an independent and/or incremental trial of specific elements of the technology solution. The vision and impact pathway is designed to aid in the monitoring and evaluation of each work package delivered throughout Project Symphony. It is based on a mutually exclusive and collectively exhaustive life-cycle framework that leverages the Australian Renewable Energy Agency's (ARENA) "technology readiness levels" (TRLs) and "commercial readiness index" (CRI).

The pilot actively incorporated lessons that have been learnt through previous Distributed Energy Resources (DER) related trials to leverage the most up-to-date knowledge and test the best ideas that have been presented. These lessons have been directly mapped to each work package in a way that informs the current state (TRL and CRI) along with the stages needed to reach greater technology and commercial readiness. Project Symphony encompasses the end-to-end transactions that represent the life cycle of DER integration and orchestration.

Purpose

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

Vision

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

Impact Pathway

To achieve the Project's purpose the four partners, Western Power, Synergy, AEMO and Energy Policy WA, outlined seven work packages. These work packages align to the life cycle of DER integration and orchestration as outlined in Figure 52.

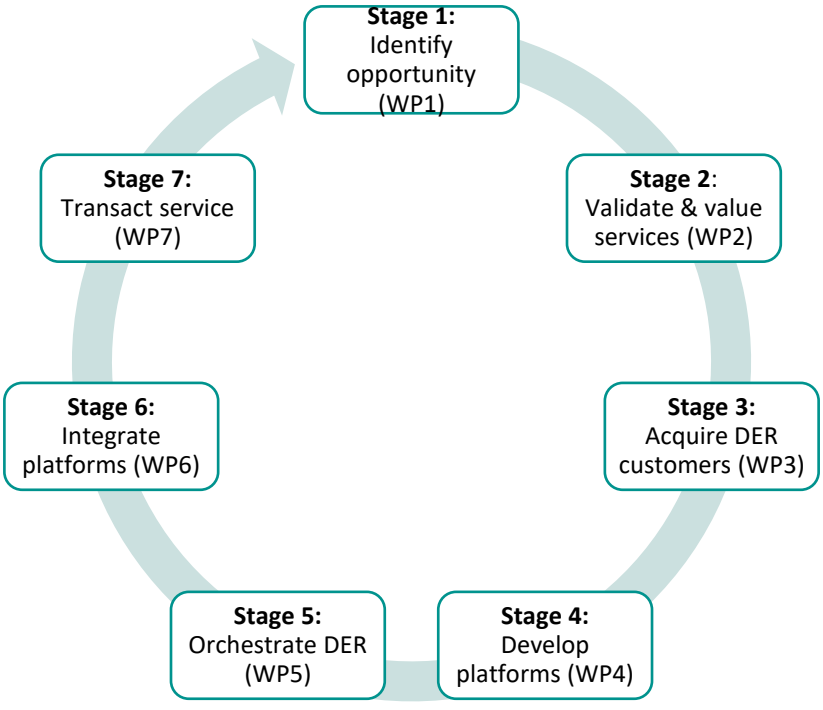


Figure 52:Life-cycle framework of DER integration and orchestration (adapted from Networks Renewed (UTS, 2019)), with corresponding Project Symphony Work Packages (WP)

The report outlines the assessment of each work package against the ARENA's maturity matrices for Technology Readiness Levels (TRL 1-9) and the Commercial Readiness Index (CRI 1-6) as outlined in Figure 53.

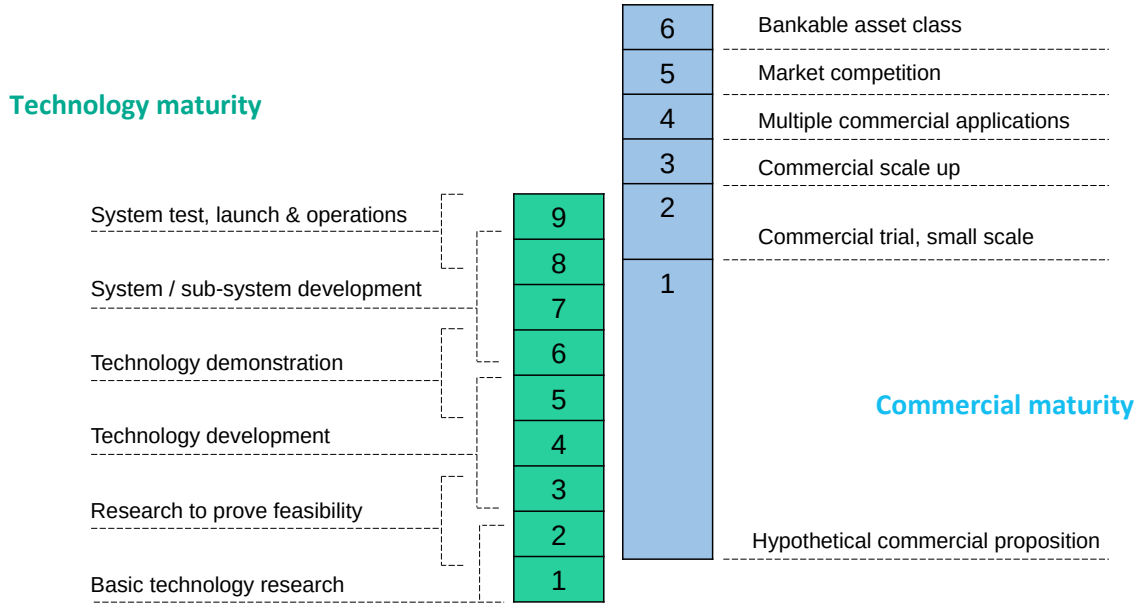


Figure 53:ARENA's technology readiness levels and commercial readiness index

The report includes an assessment of the 'current state' – before Project Symphony and a projection of 'future state' – once the work packages and project are completed. This assessment can be found in Figure 54.

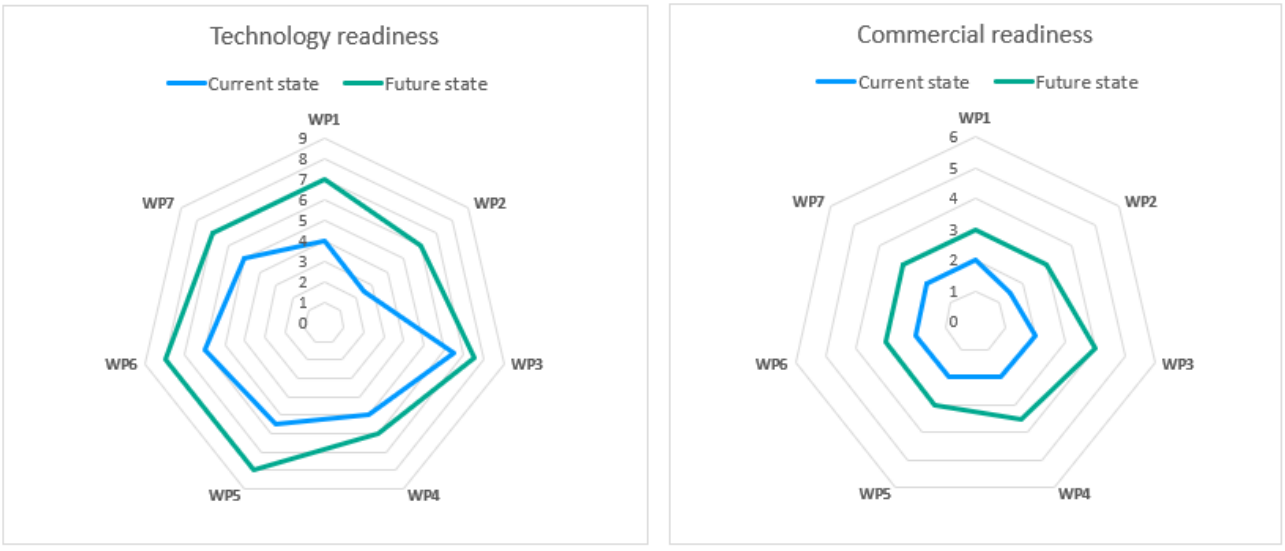


Figure 54: Project Symphony - Current and Future State Assessment

This analysis suggests that Project Symphony would:

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

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

Approach

This framework was used to guide the mid-term (Work Package 8.2 Mid-Project Assessment) and final project evaluation (Work Package 8.4 Project Close Out Report), to determine whether Project Symphony met its stated objectives and progress to the technology readiness and commercial readiness goals.

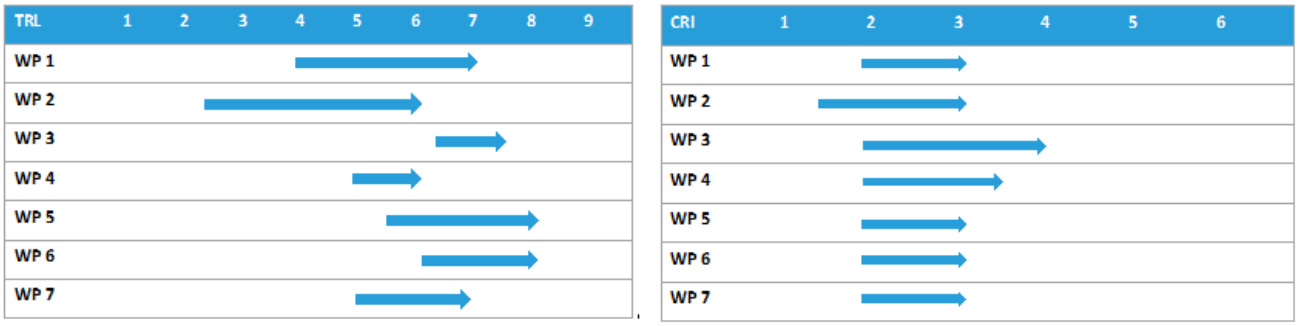


Figure 55: Impact Pathway for Project Symphony

Where can I obtain a copy of the complete report?

The Project Symphony Vision and Impact Pathway can be found on the ARENA site – here.

Report Summary - Work Packages (WP8.3) Cost Benefit Analysis Report

Extrapolating the results from Project Symphony (the Pilot), this Cost Benefit Analysis (CBA) report has been prepared to quantify the costs and benefits across the SWIS over a 10-year period for residential customers, Western Power (as the Distribution System Operator (DSO)), Synergy (as the Parent Aggregator), AEMO (as the Distribution Market Operator (DMO)) and Third-Party Aggregators (TPAs).

Scope

The Cost Benefit Analysis (CBA) for Project Symphony includes four broad objectives:

1. **To quantitatively assess the costs and benefits of each participant in the Pilot in relation to the four test scenarios.**
2. **To identify whether any barriers exist that prevent equitable distribution of value across the Pilot stakeholders: AEMO, Western Power, Synergy, TPAs, and Customers. The CBA also outlines recommendations to remove these barriers, ensuring an optimised and equitable value distribution.**
3. **To scale the findings of the Pilot to the entirety of the SWIS, providing a quantitative analysis of these scaled costs and benefits within a three-to-ten-year period, and show how this value may be distributed.**
4. **Provide high-level recommendations for achieving the scale and value of future Distributed Energy Resources (DER) orchestration via a Virtual Power Plant (VPP) within the Wholesale Energy Market (WEM). This includes insight relating to the conditions under which the benefits of a VPP to orchestrate DER outweigh the costs, where optimal value from DER can be realised, and any recommendations to explore other potential benefits of DER orchestration that were not included in the scope of the CBA or Pilot.**

Assumptions & Limitations

The CBA is focused on the quantitative analysis of the four test scenarios considered within the Pilot and an area of the SWIS that had a high penetration of DER that could be recruited to participate within the Pilot. As such, it does not provide a valuation of DER orchestration from a whole of system perspective.

Project Symphony orchestrated residential customer DER assets including Distributed Photo Voltaic (DPV) systems, Behind The Meter (BTM) batteries, air conditioner systems, and electric hot water systems; one commercial property's DPV system and BTM battery. Whilst Western Power's grid connected community battery and the commercial DPV and battery were included in the latter stages of the Pilot's stability period, these assets, together with hot water systems and air-conditioner systems were not included in the CBA modelling due to the lack of statistically significant data. In absence of these data points, some additional case studies have been provided as a qualitative commentary on potential benefits and applications that were unable to be quantified in financial terms.

The quantitative analysis of the CBA focuses on the two DER types: DPV rooftop solar and BTM battery storage.

The CBA incorporates wider market considerations, such as current tariffs and system costs (e.g., minimum demand services and load following ancillary services), to determine a scaled value of the costs and benefits. It also compares those costs and benefits associated with each test scenario to that of a base case with the absence of DER orchestration.

The wholesale market prices for services used in the CBA are based on historical prices. As such, Project Symphony provides a simulated market and the prices used are not forecasted wholesale prices of the market. Forecasted wholesale prices may differ from those used, impacting the results of the CBA. To minimise the risk this presents to the CBA, the sensitivity analysis considers changes to price assumptions and provides a NPV range rather than a single value.

Results

Four modelling scenarios were considered in the CBA to reflect the variability of future conditions, and a range of net present values (NPVs) to deliver the VPP at scale across the SWIS. These modelling scenarios are *Pilot, Expected growth, High growth* and *Hyper growth*. In addition to the four test scenarios, the CBA considers a Fully Orchestrated test scenario, combining the four test scenarios from the Pilot into a single test scenario and taking advantage of value stacking capabilities.

The Fully Orchestrated test scenario, where all test scenarios are delivered in concert, shows a positive NPV, suggesting significant upside for all participants if Project Symphony's solution is scaled with multiple value streams. The combined cashflows for the DSO, DMO, aggregators and customers increase in each year for each modelling scenario, delivering a NPV of $450 million over 10 years in the *Expected growth* scenario, and a NPV ranging from $280 million to $920 million in the other modelling scenarios. Though a positive NPV under the Fully Orchestrated test scenario was achieved, the distribution of value across each of the stakeholders requires further consideration.

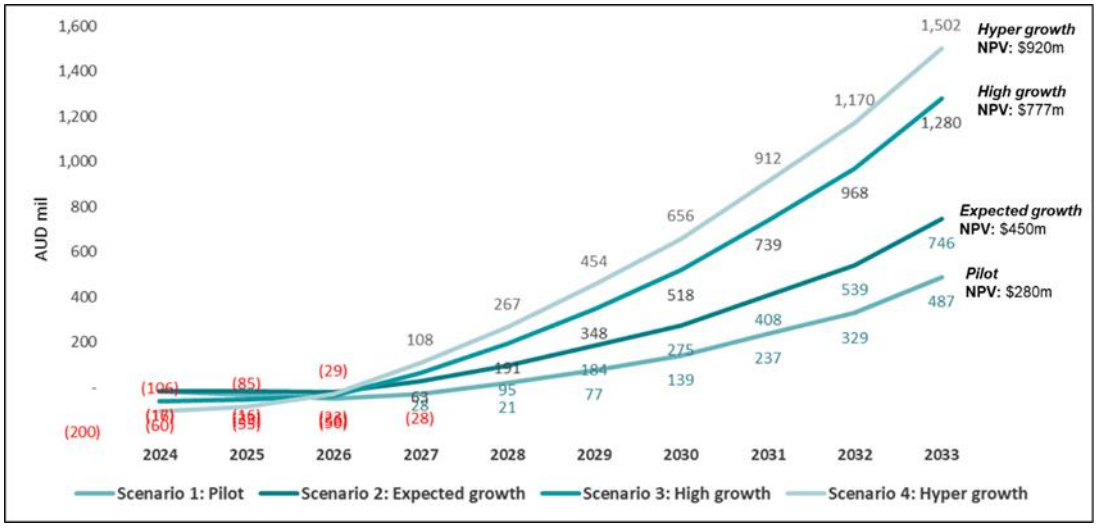


Figure 56: Combined undiscounted yearly cashflows for the Fully Orchestrated scenario

The CBA results broadly demonstrate that:

- A net positive value across all participants can only be achieved when value stacking network and market services. This was only possible under the conditions of the Fully Orchestrated DER scenario.
- The distribution of value across participants is responsive to the costs associated with developing and maintaining DER orchestration and aggregator capabilities, however, significant upside potential can be realised as technology costs reduce, business capabilities mature, and customer engagement approaches become more commercially focused.
- The more customer DER assets are recruited into a VPP, the greater the value generated and the higher the opportunity to share benefits across participants.
- Orchestrating DER through aggregation via a VPP substantially reduces system costs and helps alleviate local network constraints, allowing a reduction in costs to be passed through to market participants and, potentially, end-use customers.
- Further work is required to develop the commerciality of a VPP to equitably pass through the financial benefits of DER orchestration across participants and actors within a VPP, whilst not at the detriment of customers in the SWIS that do not own DER or elect not to participate in a VPP.
- The payment for providing NSS and CTZ requires further work to ensure it is priced to provide sufficient incentive for aggregators to invest in providing the service, whilst maintaining an acceptable distribution of benefits.

- Battery storage within a VPP can access multiple revenue streams from the market and non-market services, in contrast to other DER assets. Further value could be derived in VPPs by prioritising the recruitment of battery storage.

Opportunity

The Pilot demonstrated that DER orchestration can deliver a positive NPV when the four test scenarios are co-optimised. Sensitivity analysis of the CBA results indicates that there are further opportunities to optimise value for project participants when delivering the VPP at scale, such as:

- Developing a customer participation and engagement model that provides a compelling value proposition for customers and targets the recruitment of DER assets in the VPP in consideration of the market, system needs and localised network constraints.
- Transitioning to DER specific tariffs and connection agreements.
- Achieving economies of scope and scale to reduce the capital and operating costs associated with DER orchestration and developing the required business capabilities to operationalise a VPP at scale.
- Maximising the types and capacity of DER assets that can provide orchestration services (e.g., larger battery capacities and vehicle-to-grid EV capabilities).
- Maximising the types of energy services and markets that orchestrated DER can access.

Recommendations

The CBA report includes a series of recommendations for further investigation. These recommendations have fed into the Project Symphony's final recommendations and are categorised as:

1. **Optimising commercial arrangements to distribute value equitably (3 recommendations).**
2. **Alternative incentives to increase customer participation in VPPs (6 recommendations).**
3. **Transition to flexible connection contracts and enhanced use of DOEs (3 recommendations).**
4. **Reducing capital and operating costs (5 recommendations).**
5. **Accessing the value of DER in other energy services and markets (1 recommendation).**
6. **Maximising the types of DER assets that provide orchestration services (9 recommendations).**
7. **Analysing the impact of a VPP from a whole-of-system perspective (3 recommendations).**
8. **Establishing a competitive TPA market (3 recommendations).**

Where can I obtain a copy of the complete report?

Project Symphony Cost Benefit Analysis can be found on the ARENA site.