Project Symphony

Our energy future

Combined Platform (as built) Report for DSO, DMO and Aggregator

Work Packages 5.1, 5.2 & 5.3

5 May 2023

In partnership with:

western power synergy AEMO GOVERNMENT OF WESTERN AUSTRALIA Energy Policy WA

Project Symphony

Our energy future

Purpose

This report has been prepared jointly by Synergy, the Australian Energy Market Operator (AEMO) and Western Power (collectively the Project participants) for the Australian Renewable Energy Agency (ARENA) to document the build of the Distribution System Operator (DSO), Distribution Market Operator (DMO), and Aggregator platforms, and the infrastructure required for them to communicate. The report assesses the build against the original platform requirements identified in the Project Symphony Platform Functional and Non-functional Requirements Report and shares key learnings from the build process. This will help to inform how organisations can scale technically for a South-West Interconnected System (SWIS)-wide enablement of Distributed Energy Resources (DER) orchestration to provide network and market services.

ARENA Disclaimer

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Acknowledgement

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Project Symphony

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1 Executive Summary

This document describes the development of the 'as built' Aggregator, Distribution Market Operator (DMO) and Distribution System Operator (DSO) platforms that are being utilised 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 platform architectures designed to integrate Distributed Energy Resources (DER) were based on assessments of existing platform solutions and business requirements relevant to each role and to the project scope and objectives. As part of developing the specifications, four 'must have' on-market and off-market services or scenarios were selected by the project participants. These scenarios enable facilities made up of aggregated DER to participate in the following services:

1. **Energy Services - Bi-Directional - Balancing Market Offer (BMO):** Offering (Sell) or bidding (Buy) energy into the balancing market, issuing, receiving & responding to dispatch instructions and settlement to determine the most economically efficient dispatch of generation to meet system electricity demand at a given time.
2. **Network Support Services:** a contracted service provided by a DER aggregator to help manage network constraints such as distribution level peak demand or reverse power flow and/or voltage issues as identified by the Distribution System Operator (DSO).
3. **Constrain to Zero:** AEMO dispatches an instruction to the Aggregator to constrain energy output from DER to zero export **(net)** or zero output **(gross)**. This could be offered as a market service or incorporated into normal dispatch arrangements if customers are remunerated appropriately.
4. **Essential System Services (ESS) Contingency Reserve Raise:** Market provision of a response to a locally detected frequency deviation to help restore frequency to an acceptable level in case of a contingency event (such as the loss of a large generator or load).

The functional and non-functional platform requirements were developed to deliver the capability to integrate the Aggregator, DMO and DSO platforms in delivering the end-to-end solution. They were also established to enhance the learnings from Project Symphony by including additional interfaces, integrations and reporting and assessment capability between the platforms.

This report provides a detailed description of the platforms developed to deliver the core set of DER functionality specific to the roles of the DSO, DMO and Aggregator as defined in the Hybrid Model and integration of these platforms into organisational systems and processes. It highlights the nascency of available platforms and highlights the importance in developing interoperability and equipment standards to maximise the assets opted into the facility and to simplify asset control.

As Project Symphony enters the scenario testing phase, observations, analysis, and learnings will lead to a greater understanding of, and recommendations for, future market design, integration

methods, data sharing requirements and operation of DER and orchestration of Virtual Power Plants (VPP's).

2 Introduction

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.

The WA community is installing rooftop solar at unprecedented rates. With one in three households in the SWIS already having a rooftop solar PV system, and over 3,000 households adding a new system each month, customers with DER are already enjoying the benefits of lower electricity bills while contributing to de-carbonising the power system.

However, the high penetration of DER can pose a significant risk to power system stability, for example at times of low system demand.

In response, the WA Government released the DER Roadmap of which Project Symphony is a key DER Roadmap Action.

Action	Element	Owner	Description	Priority
22	DER Orchestration	Synergy, EPWA Western Power	By July 2020, commence a comprehensive VPP technology pilot to demonstrate the end to end technical capability of DER in the SWIS…and transition to market participation testing.	High
23	DER Orchestration	Synergy AEMO	Complete a comprehensive VPP market participation pilot that tests the incorporation of aggregated DER into energy markets, including market dispatch and settlement arrangements from the market operator to individual customer.	High

Project Symphony is being delivered by Western Power in collaboration with Synergy, the Australian Energy Market Operator (AEMO) and Energy Policy WA (EPWA). The Project aims to understand how the opportunities and challenges of increasing Distributed Energy Resources (DER) can be managed through orchestration of Virtual Power Plant's (VPP's) by Piloting a version of the "Open Energy Networks" (OpEN) Hybrid Model[1], suitable for the SWIS, which defines roles and responsibilities for transitioning to a two-way- power grid, allowing better integration of customer DER.

[1] Interim Report: Required Capabilities and Recommended Actions, AEMO and Energy Networks Australia, July 2019, pgs. 21-22. *Last accessed 15/12/2021.*

The Hybrid Model outlines three key roles that Project Symphony participants will be required to fulfill:

- Distribution System Operator (Western Power).
- Aggregator (Synergy).
- Distribution Market Operator (AEMO).

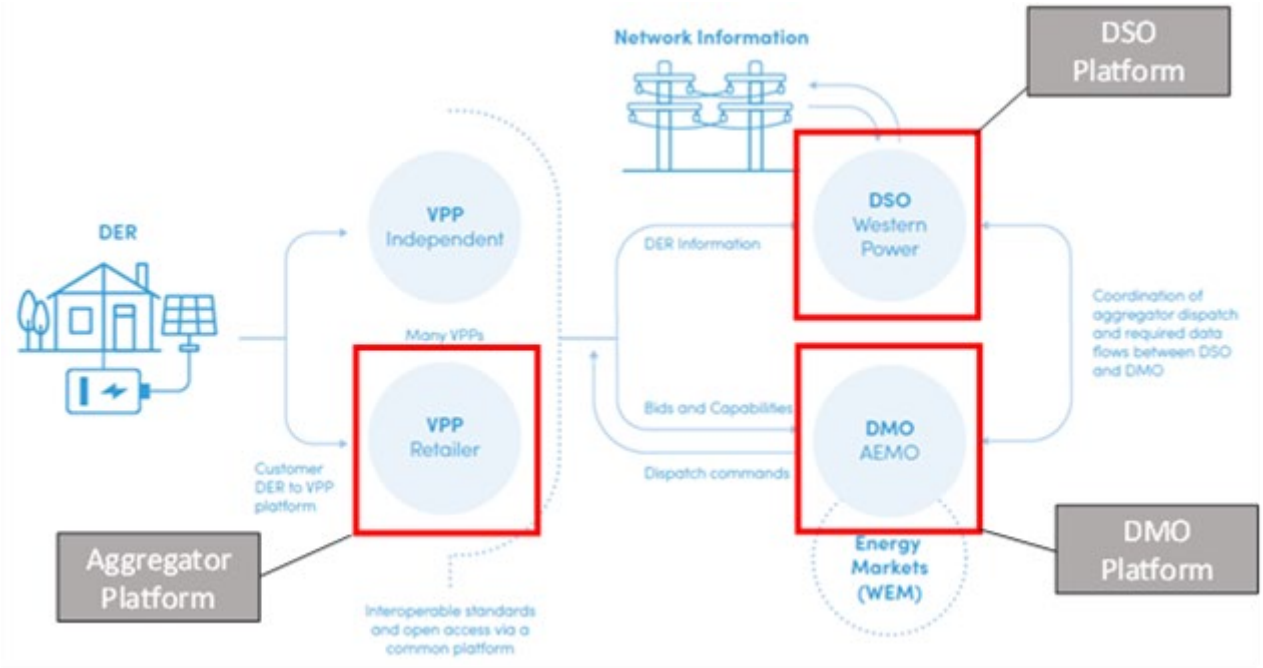

Figure 1: Key roles in the context of the Hybrid Model[2]

Each party was required to build and test separate platforms that, when integrated, created a cohesive system for managing DER resources from end-to-end in support of a safe, reliable, and cost-effective electricity system. In building and piloting these platforms, the participants developed an understanding of the capabilities and technical complexity involved in managing a system to support a working Hybrid Model, collecting learnings that can be used to evolve the model and inform policy and legislative requirements to support implementation. Figure 1: Key roles in the context of the Hybrid Model provides a conceptual view of the model and how each participant's technology platform will interact.

Each individual actor (DSO, DMO, Aggregator) will obtain detailed knowledge of the organisational competencies required to execute their respective roles. Project learnings will be used to evolve the Hybrid Model and inform future implementations. In addition, the Project will consider non-technical factors of the Hybrid Model, including customer sentiment and experience.

[2] Modified diagram. Original diagram available in the DER Roadmap, Figure 18, pg. 66.

The Project has delivered an end-to-end solution through the design, procurement, development, and implementation of software based 'platforms' and is in the process of testing capability to register, aggregate and orchestrate customer DER. Thus, the Hybrid Model is enabled by the effective integration of three platforms;

- A Market or 'DMO Platform' (AEMO);
- An 'Aggregator Platform' (Synergy); and
- A 'DSO Platform' (Western Power).

Significant systems interfaces were required between the platforms to simulate functionality of AEMO's existing market platform; enable registration and processing of aggregated facilities and constraints, management of bid and offers, dispatch instructions and settlement and validation of the services provided. The DSO Platform developed for the Project enables Western Power to perform in the role of Distribution System Operator for the first time in a simulated wholesale market for the WEM as defined by the Hybrid Model.

The end-to-end solution will demonstrate real value via four 'must have' scenarios[3] through simulation of market services (Bi-directional energy and Essential System Service – Contingency Raise scenarios) and non-market services (Network Support Services and Constrain to Zero scenarios).

1. **Scenario 1 Energy Services – Bi-directional Energy - Balancing Market:**
   a. The WEM balancing market (or real-time market) is a mandatory 'gross pool' market for dispatch and 'net pool' for settlement that determines the most economically efficient dispatch of generation to meet system electricity demand at a given time.
   b. All registered facilities, including DER aggregated generation facilities must be available to participate and must comply with the resulting dispatch instructions from the Market Operator (AEMO).
   c. The Aggregator is able to offer (sell) or bid (buy) energy into the balancing market whilst incorporating or adhering to a 'dynamic operating envelope' (DOE)[4], provided by the distribution system operator, which is designed to maximise or increase the amount of renewable hosting capacity on the network by publishing the total available power transfer capacity (load and generation) at a given time.
2. **Scenario 2 Network Support Services**
   a. A contracted service provided by a generator, retailer, or DER Aggregator to the Network Operator/DSO (Western Power) to help manage or solve localised network constraints.

[3] Project Symphony Project Management Plan, pg. 11.
[4] A dynamic operating envelope provides upper and lower limits to imports and exports at a customer site. Within Symphony the approach taken is to apply limits at the NMI in alignment with the national approach. This approach increases complexity for the aggregator associated with managing uncontrolled load at the customer site but allows flexibility in how the aggregator meets the limit by allowing multiple DER 'behind-the-meter' to provide the same result.

b. A network support service could alleviate distribution level peak electricity demand or reverse power flow and/or local voltage issues identified by the DSO at a cost that is less than traditional augmentation such as larger transformers, more 'poles and wires' or otherwise expanding capacity.

3. **Scenario 3 'Constrain to Zero':**

a. To demonstrate the ability of the AEMO Platform to instruct the Aggregator Platform to constrain energy output from DER to zero export (net) or zero output (gross) at the NMI connection point. The intention is that this be offered as a market service.[5]

4. **Scenario 4 Essential System Service (ESS) - Contingency Raise:**

a. Market provided response to a locally detected frequency deviation to help restore frequency to an acceptable level in the case of a 'contingency event' such as the sudden loss of a large generator or load.

b. An example of raise is the discharge of rapid generation such as starting a fast response generator on the network to bring frequency back to an acceptable level.

Identifying and measuring the costs and the benefits (the value) of each of these scenarios, individually and cumulatively, will be key to understanding their longer-term viability at scale, along with the technical solutions required to achieve them. The DSO Platform is largely analysing network conditions and DER monitoring data and publishing the Dynamic Operating Envelopes (DOE) at prescribed intervals aimed at maximising the renewable energy (predominantly rooftop solar) hosting capacity at any given time on the local medium voltage (MV) and low voltage (LV) networks.

Data is also flowing end-to-end through each of the project participants' platforms, from customer to off-market settlement via the DMO (AEMO) and will establish the framework that could be extended beyond Project Symphony to mainstream DER orchestration via an on-market DMO Platform.

Two 'nice to have' scenarios which were identified for development and testing should time, resources, and budget permit[6] were not proceeded with.

- **ESS - Contingency lower:** Market provided response to a locally detected frequency deviation to help restore (lower) frequency to an acceptable level in the case of a 'contingency event' such as a sudden surge in supply or a sudden drop in demand.

- **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 participant platforms.

[5] The intention is that customers will be renumerated appropriately if CTZ is offered as a future market service. AEMO's call for an NCESS for reliability for 2024/25 is an example of where this capability could be used.
[6] Project Symphony Project Management Plan, pg. 12.

3 Background

3.1 Project Symphony Overview

One of the critical objectives of Project Symphony (the Project) is understanding and evaluating the respective roles and responsibilities of the key participants defined in the Open Energy Networks[7] (OpEN) Hybrid Model. The Hybrid Model defines the roles and responsibilities for transitioning to a two-way power grid, allowing better integration of customer Distributed Energy Resources (DER) into the system. The Project is testing the Hybrid Model on a section of the South West Interconnected System (SWIS) located in the Southern River area southeast of Perth[8] (the Pilot area). The Project will evaluate the model's effectiveness, as well as substantiate learnings that can be used to evolve the model and inform policy and legislative requirements to support the integration of DER into the SWIS and the WEM.

3.2 WA Context

The West Australian context for the Pilot is important, noting that unlike the NEM, the SWIS is an isolated network that must balance all demand and generation loads internally without reliance on interconnectors. The independent Australian Energy Market Operator (AEMO), a participant in Symphony, has the role of ensuring this balance is maintained at all times as it manages the security of the SWIS and the WEM.

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

The WA Government owns three corporations with active roles in the WA electricity supply chain. Two of these corporations are involved in Project Symphony:

- Western Power, as lead participant, which is solely responsible for building, maintaining and operating the electricity transmission and distribution network within the South West Interconnected System (SWIS); and

- Synergy, which sells and generates power within the SWIS. Synergy is the sole retailer for most customers consuming less than 50MWh/year in the SWIS. Retail and export tariffs are regulated and set by the State Government for these customers.

The rapid growth in distributed energy resources (DER), such as rooftop solar, while delivering significant financial and environmental benefits for individuals owning DER, is leading to a range of emerging issues for network operators such as Western Power and challenging the traditional electricity generation and retail business models.

The WA community is installing rooftop solar at unprecedented rates. With one in three households in the SWIS already having a rooftop solar PV system, and around 4,000 households adding a new

7 https://aemo.com.au/-/media/files/electricity/nem/der/2019/oen/interim-report.pdf?la=en
8 The pilot will cover an area that includes locations in the Perth suburbs of Southern River, Piara Waters and Harrisdale.

system each month, customers with DER are already enjoying the benefits of lower electricity bills while contributing to de-carbonising the power system.

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

In response, the WA Government released the DER Roadmap of which Project Symphony is a key DER Roadmap Action.

Action	Element	Owner	Description	Priority
22	DER Orchestration	Synergy, EPWA Western Power	By July 2020, commence a comprehensive VPP technology Pilot to demonstrate the end to end technical capability of DER in the SWIS…and transition to market participation testing.	High
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Table 1 : DER Roadmap action 22 & 23

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

3.2.1 Partner Roles and Responsibilities

The Hybrid Model outlines three key roles that the participants in the Project are required to fulfill – the Distribution System Operator, the Aggregator, and the Distribution Market Operator:

- 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) or Network Operator, the DSO enables the optimal use of DER within distribution networks to deliver security, sustainability, and affordability in support of whole of system optimisation. As the existing Network Operator in the SWIS, Western Power has assumed the role of DSO and is responsible for developing a DSO Platform with the capability to identify the maximum renewable energy hosting capacity of a distribution system.

- An Aggregator facilitates the grouping of DER devices to act as a single entity when engaging in services for both the market and the system (both wholesale and retail) including providing services to the DSO. As the existing retailer for most small use customers, Synergy has assumed 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 of two Third Party Aggregators. Synergy is leading the customer interactions to achieve a suitable mix and concentration of at least 900 DER assets and has procured, designed, built, and integrated an Aggregator Platform that is in the process of being tested for capability to orchestrate DER assets to participate in the WEM. It is key for the Aggregator to build an understanding of DER customer sentiment in relation to more active participation in the WEM.
- A Distribution Market Operator (DMO) is a market operator that is equipped to operate a system that includes aggregations of small-scale DER, which are able to be dispatched at appropriate scale. As the sole operator of the SWIS and the WEM, AEMO is expanding its role as the System and Market Operator to perform the role of DMO. As the DMO, AEMO is responsible for providing a simulated Market Platform (DMO Platform) that facilitates aggregator access to wholesale energy and essential system services market processes.

3.2.2 Project Platform Build

For each of the partners to be able to perform their respective roles within the Hybrid Model, as the DSO, DMO and Aggregator, they were required to develop the platform designs and requirements to construct individual platforms. These platforms have been integrated to orchestrate DER to deliver energy, network and essential system services within a simulated WEM.

The DSO was responsible for the development and implementation of the DSO platform and infrastructure required to incorporate DER assets into existing network planning and asset management functions. The functions required of the DSO platform were:

- 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 safe operating 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.

The DMO was responsible for the development and implementation of the DMO's Market platform to test and simulate capability of DER Aggregators to participate in the simulated market. The functions required of the DMO platform were:

- 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).

The Aggregator was responsible for the development and implementation of the Aggregator platform to perform DER valuation, customer acquisition and procuring a minimum of two Third Party Aggregators. The functions required of the Aggregator platform were:

- 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.

3.3 Purpose of this report

The purpose of this report is to document the development and implementation of the DSO, DMO and Aggregator platforms and their interfaces. This report will provide a detailed description of the platforms developed to deliver the core set of DER functionality specific to the roles of the DSO, DMO and Aggregator as defined in the Hybrid Model and integration of these platforms into organisational systems and processes. The key elements documented in this report include:

- The design, build and test processes undertaken to develop each platform.
- The as-built solution architecture of each platform.
- The extent to which each solution meets the functional and non-functional requirements detailed in the ARENA knowledge sharing report Project Symphony Platform Functional and Non-Functional Requirements Report[9].
- How the three solutions integrate to create a holistic solution capable of executing the 'must have' scenarios end-to-end.
- A critical assessment of the whole solution built and implemented against business objectives, design and architecture principles.
- Key learnings from the project and solution build process.

This report will act as a reference document for other organisations seeking to take the pathway towards the development of a DER orchestration project and requiring guidance on the functional

[9] https://arena.gov.au/knowledge-bank/project-symphony-platform-functional-and-non-functional-requirements-report/

and non-functional requirements, design and architecture of these platforms within a market that incorporates DER into wholesale energy and network services.

4 Project Design Approach

4.1 Project Symphony Design Approach

This section details the design approach employed by the Project participants to collaboratively define the scenarios, common business rules and the integrations between the three platforms.

At the commencement of the Project, working groups were formed and facilitated workshops with a defined set of resources and accountabilities to deliver an aligned project design. The working groups included representatives from all participants and were tasked with defining the scenario and architecture designs for each of the four "must have" project scenarios.

- Scenario 1: Energy Services – Bi-directional Energy – Balancing Market Offer (BMO).
- Scenario 2: Network Support Services (NSS).
- Scenario 3: Constrain to Zero (CTZ).
- Scenario 4: Essential System Service (ESS) – Contingency Raise.

Platform development commenced with scenario 1, Energy Services, Bi-directional Energy – Balancing Market Offer (BMO) which was delivered as base platform functionality, with the remaining scenario functionality developed incrementally as designs were finalised. Tables of integration of the final design for each scenario are included in Appendix D.

Given the varied complexity and requirements of each scenario for each platform, each organisation had a different build and delivery schedule, resulting in overlap between design, build and deployment to enable shared testing, also known as cross-organisational system integration testing (X-SIT), of platform functionality.

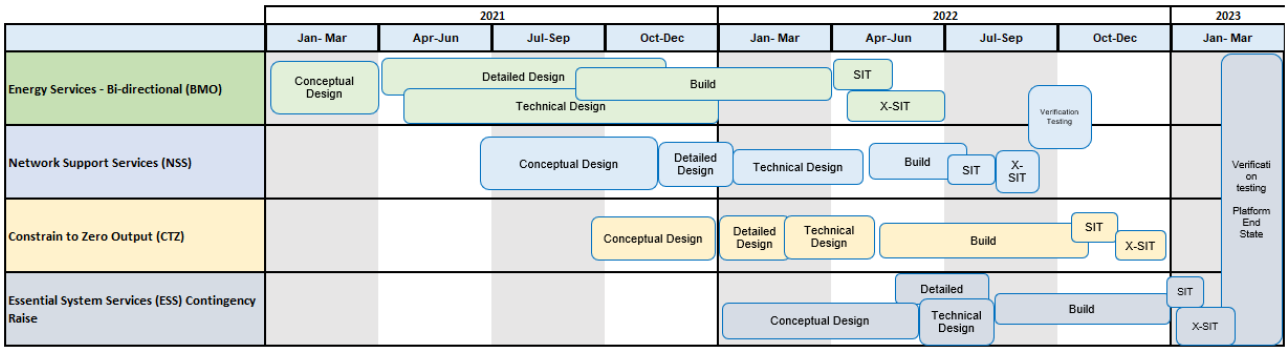

Figure 2. Project design timeline

4.1.1 Conceptual Design

Three working groups were created and tasked to create specific outputs to facilitate the platform design:

- A Scenario Design Working Group tasked with determining the scenario definition and use cases for each participant.
- The Architecture Working Group tasked with the architecture and integration design of the participant platforms.

- The Data Entity Working Group tasked with identifying the data models needed to be shared between participants to operate and analyse the operation of DER in the WEM.

The outputs from the conceptual design phase were as follows:

- Scenario diagrams including identification of each participant's use cases required to successfully deliver the service as part of the Pilot. These outputs identified the required platform capability.
- High level architecture definitions to identify required platform capability components and integrations to share operational data. These outputs identify the way that each participant platform interacts with the other platforms.
- Conceptual data model that defines a conceptual list of data objects to facilitate the operation of the market.
- A testing strategy and identification of business scenarios that validated that the operational capabilities of the partner platforms ensured a working solution.
- The additional data collection and partner reports included in the project to facilitate the "Test and Learn" project objective that would not ordinarily be expected in a scaled and mature VPP environment.

Each working group had an assigned facilitator, designated leads from each organisation and a term of reference to enable the design to be developed through conceptual, detailed and technical stages with artefacts and decisions shared and reviewed across all working groups.

4.1.2 Detailed Design

Each working group met to define and create specific outputs to facilitate detailed platform design and development.

The outputs from the detailed design phase were:

- Use cases including business and system processes that defined business rules and sequencing of tasks across the Project participants. These outputs identified the detailed platform requirements, validation rules and exception management scenarios.
- Detailed definitions of platform and integration capability. These outputs identified platform and integration requirements, data sharing arrangements and non-functional requirements.
- Messaging JavaScript Object Notation (JSON) designs to facilitate the build of messaging and APIs that will transmit data between partner platforms.
- Test scripts and steps to identify and articulate expected system functionality that validated the operational capabilities of the platforms to ensure a working solution.
- Internal System Integration Testing (SIT) and X-SIT test plans to coordinate with vendors and Project participants to conduct testing of the platforms in isolation and as a fully integrated solution.

4.1.3 Technical Design

Each working group met to define and create specific outputs to facilitate the technical design of the platform development.

- Operational data entities and attributes defined across the platforms to identify operational data required by each Project participant to operate in a market integrated with DER. The definition of data attributes determines the data required to be passed between each Project participant and the rules required to maintain data integrity.
- Test and Learn data entities and attributes defined across the platforms was used to identify the data required by each Project participant to analyse the effectiveness of the market platform operation and support learnings related to DER market hypotheses and research topics.

4.2 Test Approach

The test approach adopted for the Project platforms encompassed multiple levels of testing and involved all Project participants and vendor organisations. This resulted in the formation of internal test teams and cross organisation test teams to develop artefacts to facilitate test readiness assessment, test execution, post-test analysis and reporting across the various deployments.

Test strategy artefacts encompassing test environments, roles and responsibilities, test schedule, testing tools, test execution, issue management process, test and learn principles, governance, support and ways for working were developed for the project prior to the commencement of test & learn and are updated as testing progresses. The processes that were developed and documented cover the following activities:

- Test teams specific to each Project participant and their platform vendors conducted internal System Integration Testing (SIT). Multiple SIT phases were conducted on all platforms as per the agreed project technical design for each deployment. Internal test plans were developed in line with the drop design and business requirements. Each Project participant was responsible to ensure completeness of their platform's testing as a pre-requisite for X-SIT. At the completion of the internal testing, test summary reports were produced by each organisation.

- Cross organisational testing comprised of the X-SIT Working Group, which included representatives 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 (BMO, NSS, CTZ and ESS-CR). Test plans were developed based on the requirements defined for each drop specific to scenario's integrations. Test plans for each drop 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 run sheets were defined.

Verification Test was carried out in the trial environment and served as the entry gate to commence Test & Learn execution phases. The first execution cycle of verification test in Oct'22 was used to ensure all integrations were correctly configured in the trial environment in preparations for Test & Learn 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 test was an opportunity to complete a practice run of the processes and ceremonies outlined in the T&L Approach document 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.

Test Testing Levels:	Objectives
Vendor's' and Project participant's unit testing	To test smallest testable parts of an application, individually and independently to ensure proper operation.
SIT	Overall testing of the Platform including both business logic and Integration solution in line with the business requirements. SIT was undertaken for each of the vendor solutions underpinning the Symphony DER ecosystem.
X-SIT	Exercise all must-have cross-platform business logic, including negative scenarios and edge cases. Regression testing was included in all testing.
Verification testing	To verify the functionality operates as expected end to end prior to starting operation of the market in the Pilot
Performance testing	To verify that the platforms can operate to an acceptable level at the highest volume of transactions and scale of users expected during the Pilot

Table 2: Testing levels and objectives

5 Integrated Solution Overview

As indicated in previous sections, an overarching platform design was progressed to support the four “must have” (and other) scenarios. Figure 2 provides an overview of the overarching design illustrating the principal data flows between each of the constituent platform components.

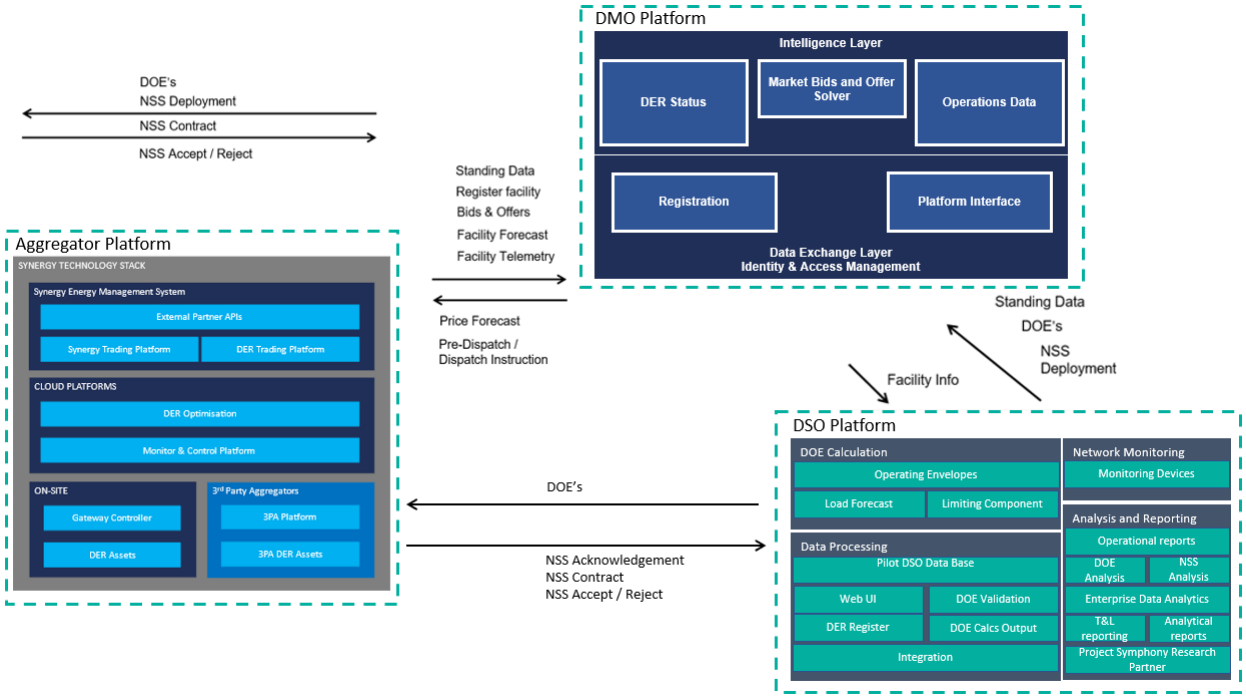

Figure 2. Conceptual platform design and function

5.1 Platform Integrations

Platform Integrations are foundational to the success of Project Symphony and detailed in Project Symphony Platform Functional and Non-Functional Requirements ,as well as in the figure above. As described in the testing approach section, a holistic integration design was developed as part of the project. Each integration was assigned a specific identifier and an associated name, a description, a set of integration characteristics, and a data payload. The following table (Table 3) summarises the automated integrations and provides a common reference for details in the DSO, DMO and Aggregator platform sections and associated appendices. A subsequent table features a manual integration list.

Integration ID	Integration Name	Integration Description	Frequency	From	To
IS0101A	National Metering Identifier (NMI) Standing	Provides registration data for each Distributed Energy Resource (DER) NMI facility. May have overlaps with DER register data.	Weekly	Aggregator	DMO
IS0101B	Device Standing	Provides registration data for each DER Device. May have overlaps with DER register data.	Weekly	DSO	DMO
IS0102	Facility Registration	Provides registration and technical characteristics data for the facility that is being registered. Aggregate of total unconstrained capacity of the devices	Weekly	Aggregator	DMO
IS0102b	Network Support Services Facility details	NSS facility composition details	As required	Aggregator	DSO
IS0104	(Facility) Registration Data	Provides registration data for each DER NMI facility.	Ad hoc	DMO	DSO
IS0105	Dynamic Operating Envelope (DOE)	Operating constraints for each NMI	Once per trading day	DSO	DMO & Aggregator
IS0106	Real Time Market Submission (RTMS)	Price/quantity bids sent from the Aggregator for energy and Essential Services (ESS)	As required	Aggregator	DMO
IS0107	Dispatch Instruction	An instruction of the dispatch quantity for the next dispatch interval for each market service (energy and ESS) to the Aggregator There is one dispatch instruction sent for each registered facility and is sent every 5 mins (start of the dispatch interval) The dispatch instruction is also the integration that informs the Aggregator of a CTZ event	Once per 5min dispatch interval	DMO	Aggregator

IS0108	Telemetry Facility	Telemetry data from the aggregator for the facility. Provides a view of the facility behaviour during past dispatch intervals	Once per 5min dispatch interval	Aggregator	DMO
IS0112	Forecast Energy Price	Energy and ESS Contingency Raise Price data from the Market Operations platform that is sourced manually by the user. The forecast price is used by the Aggregator to inform their RTMS. The forecast price is updated from the Market Operations platform at 16mins and 46mins past each hour	Once per 5min dispatch interval	DMO	Aggregator
IS0114	Pre-dispatch Instruction	A schedule of future instructions of the dispatch quantities for each market service (energy and ESS) to the Aggregator. The schedule covers the time period where the platform has valid • forecast price data • registered facility data • RTMS data There is one pre-dispatch instruction sent for each registered facility and is sent every 5 mins (start of the dispatch interval) The pre-dispatch instruction is also the integration that informs the Aggregator of future scheduled Constraint To Zero (CTZ) events	Once per 5min dispatch interval	DMO	Aggregator
IS0115	Network Service Registration	NSS requirements and service information	As required	DSO	DMO
IS0117	NSS Deployment Signal from DSO	NSS operational demand information for specific dispatch intervals during the trading day	As required	DSO	DMO
IS0118	Facility Forecast	Portfolio (Synergy's operating envelope for the trading interval) view of the facility's capacity for	Once per 5min	Aggregator	DMO

		future dispatch intervals. The solution is providing a forecast to AEMO every 6 hours.	dispatch interval		
IS0121	NSS Deployment Signal Acknowledgement/Reject	Acknowledgement signal sent to the DSO to confirm that a NSS deployment signal is received in the aggregator platform	As required	Aggregator	DSO
IS0123	NSS Deployment Signal to Aggregator	NSS operational demand information for specific dispatch intervals during the trading day	As required	DMO	Aggregator
IS0125	Dispatch Instruction Acknowledgment	Acknowledgement signal sent by the Aggregator to confirm that a dispatch instruction is received by the aggregator platform	Once per 5min dispatch interval	Aggregator	DMO

Table 3: Automated integration list

The following table details the integrations that were implemented as a manual process/activity.

***Table 4**: Manual integration list*

Interface ID	Interface Name	Interface Description	Frequency	From	To
IS0110	Network Model Master data	Exchange of Network Model (Distribution Transformer/Feeder/NMI) Master Data	Ad hoc	DSO	DMO
IS0111	Network Constraint / Limiting component report	Present the output from the DOE calculator indicating which components of the network model are acting as limiting factors when the load is applied.	Ad hoc	DSO	DMO
IS0119	NSS Requirements	Requirements between Aggregator and DSO (off platform)	Ad hoc	Aggregator	DSO
IS0120	NSS Requirements	Prerequisites specified by DSO (off platform)	Ad hoc	DSO	Aggregator
IS0124	CTZ Notification (informal)	A notification of a CTZ dispatch instruction sent to the Aggregator by the DMO and DSO for the purpose of conducting a Test and Learn experiment on certain NMIs over a specified timeframe. This does not require a formal data definition sheet; rather, an email notification is sufficient as this is an infrequent technical test.	Ad hoc	DMO	DSO
IS0126	HSDR data	Interval data from HSDR device(s) at a predetermined high frequency is gathered, consisting of two asset data type levels, namely NMI and device data.	Ad hoc	Aggregator	AEMO
IS0127	CTZ notification (Pre-dispatch)	An email message notifying an Aggregator of a CTZ dispatch instruction issued by the DSO and DMO for carrying out a Test and Learn experiment on designated NMIs over a predefined duration. This does not necessitate the compiling of a formal data definition sheet; instead, an email notification was determined to be adequate as this is an infrequent technical trial.	Ad hoc	DMO	DSO
IS0129	Copy of NSS Service Registration	Notification of NS service registration with DMO, including details such as service registration name.	Ad hoc	DSO	Aggregator
IS0130	HSDR Data	Data is transmitted from the DSO's HSDR. Interval data is collected from a HSDR device at a frequency that is predetermined by the WEM procedures and is expected to be at NMI level.	Ad hoc	DSO	DMO Aggregator

Table 4: Manual integration list

6 DSO Platform

The Project Symphony Functional and Non-Functional Requirements[10] (*Project Requirements*) document defines the requirements to deliver a Distributed System Operator (DSO) Platform for the Project Symphony Pilot. This section of the document:

- Assesses how well the as-built implementation of the DSO Platform satisfies the documented requirements; and,
- Provides learnings to inform how the solution and its constituent parts may be scaled to deliver an enterprise DSO Platform solution.

6.1 DSO Platform Requirements

The as-built DSO Platform was assessed against how well it meets the *Project Requirements*, including:

- **DSO Design Principles:** High-level business requirements the DSO Platform needs to satisfy to align with Western Power's values, policies, and operating procedures.
- **Solution Architecture Principles:** High-level requirements defined to align the DSO Platform build with Western Power's internal enterprise architecture, technical standards and policies that are based on industry best practice.[11]
- **DSO Platform Functional Requirements:** Detailed solution requirement statements detailing the functional capabilities the platform requires to support DSO functions[12] under the Hybrid model.[13]
- **DSO Platform Non-functional Requirements:** Constraints and expectations the solution will need to meet to be deemed fit-for-purpose.

6.2 DSO Platform Delivery Approach

Project Symphony's objectives, deliverables and constraints influenced the approach taken to deliver the DSO Platform. Key aspects of the Project that shaped the DSO Platform delivery approach include:

- **Project Scope.** To achieve the Project purpose - understanding how the opportunities and challenges of increasing DER can be managed to ensure a reliable, secure, and affordable electricity system[14] - the DSO Platform needs to support the execution of the four 'must-have' scenarios end-to-end,

[10] Project Symphony Platform Functional and Non-Functional Requirements, Electricity Networks Corporation, February 2022, Section 3
[11] This includes but is not limited to the Western Powers ICT Governance Standard (2017), Enterprise Architecture Standard (2015), and Cyber Security Standards.
[12] EA Technology, Open Energy Networks Report, July 2019, Pg. 23.
[13] Interim Report: Required Capabilities and Recommended Actions, AEMO and Energy Networks Australia, July 2019, pgs. 21-22.
[14] Project Symphony Project Management Plan, pg. 10-11

- **Timeframe.** To deliver within the Project Symphony Timeline and provide inputs to other Western Australian Government DER Roadmap projects[15] - The project is expected to publish timely Pilot learnings to inform necessary changes to regulations and market rules to support a two-way power flow electricity grid that allows for better integration of customer DER; and,
- **Learning Focus.** Project Symphony is focused on testing, documenting, and sharing learnings amassed from the Pilot to inform how aggregated DER can participate in future energy markets.

Western Power conducted an options appraisal to determine the best approach for delivering the DSO Platform to support Project Symphony objectives. Evaluation criteria included:

- **Project Requirements**. How the option supported Western Power in meeting its commitments under Project Symphony, including timeframe and scope,
- **Pilot Test and Learn Strategy**. Whether the option allowed for 1) incremental evolution in response to Pilot learnings and input from subject matter experts, and 2) retention of technology, learnings and/or other intellectual property,
- **Delivery of Requirements.** How well the option delivered the requirements outlined in Section 3 of the *Project Requirements*; and,
- **Longevity**. Whether the option could be reused more broadly within Western Power.

After considering the available options, it was decided to procure multiple functionally discrete solutions, including a Pilot Dynamic Operating Envelope (DOE) calculation solution and integrating with modules sourced from existing Western Power systems. This approach was assessed as meeting most of the evaluation criteria, including the ability to:

- Calculate DOEs in support of key functional requirements,
- Integrate with DSO systems and provide options for integrating with DMO and Aggregator Platform solutions,
- Evolve in response to learnings as part of the Project's test and learn strategy and input from subject matter experts; and,
- Deliver within Project Symphony timeframes.

Appendix B: DSO Module Diagram shows a detailed diagram of the DSO Platform solution, with new Modules sourced, built and/or implemented by Project Symphony highlighted in green.

As the options appraisal focused on selecting a solution to deliver a DSO Platform specifically to conduct the Project Symphony Pilot, options that satisfied *Project Requirements* and *Pilot Test and Learn Strategy* criteria were favoured over other options. Therefore, 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.[16]

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[15] DER Roadmap. Distributed Energy Resources Roadmap Two-year Progress report (www.wa.gov.au)

[16] 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."

6.3 DSO Platform 'As-built' Solution Overview

6.3.1 Solution Modules

To meet the requirements, the Pilot DSO Platform was developed using Western Power's existing information, communication, and technology (ICT) systems and complementing new applications only where necessary. In summary, the Pilot DSO Platform can be conceptually described as six integrated modules:

- **Network and Environment Monitoring**: Receives and processes network and environment[17] monitoring information from the local distribution network in support of DSO Platform functions.
- **Data Processing**: Contains Modules that organise, store, and manage Pilot DSO Platform data, including, the Network Module details and operating constraints.
- **DOE Calculator:** Contains Modules to support the calculation and allocation of DOEs.
- **Analysis and Reporting:** Contains modules to support reporting and analysis activities,
- **Data Exchange Service:** This area contains modules that support the secure exchange of information between the DSO Platform, Aggregator and DMO Platforms. Consequently, this area is critical to DSO Platform integration with DMO and Aggregator platforms in support of a holistic system that can be used to execute the 'must-have' scenarios, end-to-end.
- **Battery Service**: Provides a gateway to control the grid connected Battery Energy Storage Systems (BESS). The gateway will allow the Aggregator to control the grid connected BESS in support of VPP operations within the bounds of safe operating parameters defined by the DSO. Furthermore, Western Power Network Operations Control Centre (NOCC) will analyse various parameters of the BESS and have priority control to decide on a course of action for the BESS.

The diagram in figure 4, presents the conceptual model of the DSO Platform that was proposed in the Project Requirements. Appendix B displays the as built DSO Platform Module diagram and demonstrates how the conceptual modules were implemented. Lastly, Appendix C, explains how the as-built modules were measured against both functional and non-functional requirements.

[17] Environmental monitoring includes weather data, such as temperature, wind strength and precipitation, and solar irradiance data.

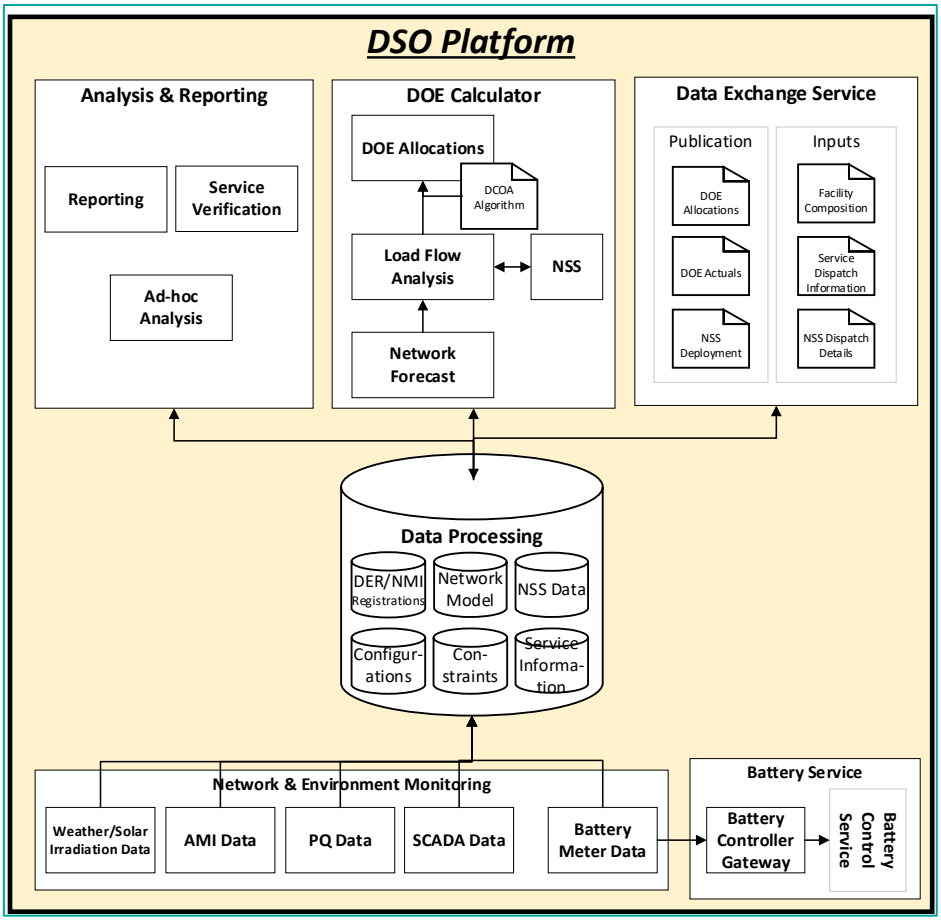

Figure 4: DSO Platform

6.3.2 Information Technology (IT) Environments

Four different IT virtual environments were created to host the development and testing of the DSO Platform. These environments are:

- Development: Support the development of software Modules used to manage Project Symphony data and integration with established Modules and partner systems,
- Test: Supports the system testing of software Modules,
- Cross-Test (X-Test): Support the end-to-end cross-project parties testing of the DSO, Aggregator and DMO solutions (this environment – including the data – is kept in a comparable state to the "pilot environment" for fast tracking issues arising during test & learn),
- Pilot[18]: Used throughout the stability period to execute the 'must-have' scenarios, with data collected and analysed as part of test and learn activities.

Some Modules had more environments established than others to cater for different development and testing requirements. The following table details the DSO Platform environments by a high-level component:

[18] This environment name is also known as "Trial" and is akin to a "Production" environment.

D[19]	Module	Development (DEV)	Test	X-TEST	Pilot
C-1	DSO Data processing	Yes	Yes	Yes	Yes
C-2	Network and Environment Monitoring		Yes		Yes
C-3	DOE Calculator	Yes	Yes	Yes	Yes
C-4	Analysis and Reporting	Yes*	Yes	Yes*	Yes
I-5 & I-13	Data Exchange Service			Yes	Yes
C-6	Battery Service				Yes

*Only available for reporting not for historical analysis.

Table 5: Environments by high-level modules

6.4 DSO Platform 'As-built' Assessment Methodology

The as-built DSO Platform was qualitatively assessed with respect to the project requirements by area. Two types of assessments were conducted by the DSO platform:

1. A detailed assessment on how the Modules meet individual requirement statements, available in appendix C; and
2. A high-level qualitative assessment based on the outputs from a workshop attended by DSO Project Symphony Team Members[20] against the criteria in Table 66:

Requirement Area	Assessment Description	Assessment Rating
Technical Readiness	How well the solution has progressed to support the readiness of Aggregator DER orchestration.	***Green***: System tested, ready & operational. ***Amber***: System / sub-system requires some development / Technology demonstration. ***Red***: Technology yet to be developed, Research required to prove feasibility and/or Basic technology research.

[19] See diagram and table in Appendix B – DSO Module Diagram for a more detailed description of each Module

[20] As-built Solution Evaluation Workshop held at Western Power Wellington St office on the 16/11/2022, attended by Western Power Project Symphony team members.

Project / Functional / Non- Functional Assessment	How well the solution area meets the relevant functional and non-functional requirements (including the Design and Architectural Principles) detailed in the Project Requirements[21].	***Green***: Meets relevant mandatory project Functional / Non- Functional requirements. May not meet desirable requirements. ***Amber***: Does not meet key mandatory Functional / Non- Functional requirements, but there is potential to modify and/or extend the module Modules to meet all mandatory requirements. ***Red***: Does not meet key mandatory project Functional / Non- Functional requirements, with major changes required, such as the replacement and/or redevelopment of one or more solution Modules.
Overall Assessment	How well the solution has progressed to communicate with the DMO and aggregator platforms to meet the relevant project outcomes[22].	***Green:*** Meets relevant project outcomes. ***Amber:*** *Does not meet* relevant project outcomes*, but there is potential to modify and/or extend the module to meet.* ***Red:*** *Does not meet* relevant project outcomes, *with major changes required, such as the replacement and/or redevelopment of one or more solution modules.*

Table 6: DSO Platform 'As-built' Assessment Methodology

6.5 Evaluation of the DSO As-Built Platform against the requirements

The following sections describe each of the solution modules and provides a relative assessment of each module, using the method described in section 6.4 Appendix C: DSO Requirements Mapped to Modules contains a detailed map of all requirements contained in Section 3.5 of the Platform Functional and Non-Functional Requirements document to the Module that delivers the requirement.

The colour code status (Red, Amber and Green) used in this assessment correlate to what extent the modules cover the requirements. Table 1 provides the evaluation of the assessment against Technical, Functional and Non-Functional Requirements.

Table 1: Evaluation of the DSO As-Built against the requirements

DSO Module	Technical Readiness	Functional / Non-Functional Requirement	Overall Assessment
Network and Environment Monitoring	GREEN ●	GREEN ●	GREEN ●

[21] Project Requirements, section 3.2
[22] Project Symphony Vision and Impact Pathway, section 3.5

DSO Module	Technical Readiness	Functional / Non-Functional Requirement	Overall Assessment
DSO Data Processing	GREEN ●	GREEN ●	GREEN ●
DOE Calculator	GREEN ●	AMBER ●	AMBER ●
Analysis and Reporting	GREEN ●	GREEN ●	GREEN ●
Data Exchange Service	GREEN ●	AMBER ●	GREEN ●
Battery Service	GREEN ●	GREEN ●	GREEN ●

Table 7: Evaluation of the DSO As-Built against the requirements

Table 8 provides the rationale for the RAG scoring provided in the table above. Table 2: Assessment Rationale of the DSO solution

DSO Module	Technical Readiness Assessment Narrative	Functional Requirement Assessment Narrative
Network and Environment Monitoring	• The DSO Platform has implemented a monitoring architecture to collect, store and manage telemetry and environment data. • Storage and management of data has been optimised through the use of discrete solutions to ensure efficient collection of data.	• Feeder, DSTR and Service Connection data have all been successfully recorded and stored with the required granularity. • High speed recording data is available. • Weather data has been successfully stored with the required history, granularity and availability.
DSO Data Processing	• The DSO Data Processing Module organises, stores and manages the collected data, making it available to other modules and partner platforms. • Integration points have been established to allow for the exchange of data with partner platforms, and the module stores two weeks of monitoring and output data in the operational database.	• Requirements for network components, connections, constraints, and service connections have been met. The DSO platform has managed network models, refreshed them, and tracked changes in the model, outage info and planned outages. • Additionally, it has provided registration data for facilities, service connections and DERs, as well as market service information, service requests, and dispatch.

DSO Module	Technical Readiness Assessment Narrative	Functional Requirement Assessment Narrative
DOE Calculator	• The DOE Calculator module, implemented on the Evolve Platform, can accurately calculate and allocate DOEs to NMI's. • The DOE Calculator module is able to identify network constraints and trigger processes for provisioning and dispatch of NSS DSO, DMO and Aggregator. • DOEs are calculated daily and 'default' DOEs are published for each NMI at short notice in cases of network changes.	• The relevant functional requirements have been met. Functionality was implemented to provide transformer level DOE allocation and other related capabilities. • There was a potential to modify or extend the module to meet further requirements such as Network Analysis, DOE Calculator Notification Configuration, DOE Calculation in Response to Incidents and Outages, Load Flow Analysis - Output, Optimal Allocation, Load Forecasting.
Analysis and Reporting	• The solution was effectively implemented by providing timely reports to support operational decision making and the ability to validate hypotheses as part of a Test and Learn strategy. • The technology readiness of Aggregator DER orchestration has been progressed by the provision of analytical capabilities to support longer-term planning. • The DSO Platform provides a suite of reporting and service verification tools, ensuring accuracy and compliance with DOEs, as well as NSS delivery for settlement.	• All relevant functional requirements have been met, such as DOE Compliance, Report Creation, Report Management, Schedule Report Publication, Data Visualization, Standard Derivations and Measures, Data Quality Reports, Ad-hoc Data Analysis, Ad-hoc Data Visualisation, Additional Data, Logical Separation of Activities, Data Retention and Identified NSS Constraints - Output. • A sufficient level of functionality has been achieved with all of relevant requirements, providing users with the ability to create and manage reports, schedule their publication, visualise data, calculate standard derivations and measures, and analyse data. • Features was delivered such as data quality reports, ad-hoc data analysis, ad-hoc data visualisation, additional data, logical separation of activities and data retention, to ensure that all requirements are met.

DSO Module	Technical Readiness Assessment Narrative	Functional Requirement Assessment Narrative
Data Exchange Service	• The Data Exchange Service module has allowed for the successful exchange of information between partner platforms, such as published facility registrations, DOE files, and NSS requests, to support the execution of 'must-have' project scenarios.	• The functional requirement capabilities were met to receive, publish and exchange additional files. • There was the potential for some modules to be modified or extended to ensure the module strictly follows the IEEE 2030.5 standard by exploring alternative integrations without causing performance or storage issues.
Battery Service	• The DSO Platform has successfully implemented a Battery Service module, providing detailed data on BESS functions and allowing Aggregators to monitor and use the battery as part of a VPP. • It has enabled integration of the BESS with the DSOs SCADA Distribution Management System and real-time data historian, allowing Network Operations to take control of the BESS in case of emergency. • The DSO Platform has progressed the technology readiness of DER orchestration, providing a comprehensive solution to facilitate the deployment of energy storage systems.	• The DSO Platform has met the relevant functional requirement capabilities of Aggregator Control, Aggregator Visibility, DMO HSDR Visibility, DMO BESS Visibility, HSDR Data Sharing Transactions, DSO Control and Prioritisation of Control. • The successful implementation of the SCADA RTU allowed the DSO to take full control of the BESS to monitor and manage the end of a BESS lease agreement. • Overall, the DSO Platform has met the relevant functional requirement capabilities effectively.

Table 8: Assessment Rationale of the DSO solution

Table 9 provides the rationale for the RAG scoring provided in the table above with regards to the non-functional requirements. Only the mandatory non-functional requirements have been addressed in this table.

RID	Non-functional Requirement	Assessment Summary
98	User Management	• User accounts for both DSO Web-UI and reporting modules are managed via Active Directory (AD). Web-UI roles are also governed by AD roles. DOE calculator cloud service not covered by single sign-on / federated AD.
99	Compliance with Australian Privacy Principles	• No confidential or personal information is stored in the Symphony Database of The DSO Platform, meeting the necessary non-functional requirements.
100	Cloud Risk Assessment	• Cloud risk assessments have been conducted for all cloud services that are currently operational in the DSO platform. Some services were classified as “CONTAIN” which means these were acceptable to be used in the context of the Symphony Pilot project, but cannot be used as-is for wider Western Power BAU purposes without further work to be done to address the risks identified.
101	Virus and Malware Detection	• The DSO Platform has met its non-functional requirements, as cloud software is regularly monitored for potential attacks, and the on-premises Virtual Machines are continually scanned for signs of malware or viruses as part of the DSO’s infrastructure services.
102	SSDLC	• The DSO Platform Modules have been designed and created according to Secure Software Development Lifecycle processes and principles and have met all necessary non-functional requirements. To ensure the highest level of security, a Penetration Test was conducted to identify any potential vulnerabilities and weaknesses.
103	Environment Provisioning	• Multiple environments have been set up to support the project's different activities to be run in parallel. Refer to section 6.3.2 for more information. • Release management, Testing Tool, Support, and Maintenance modules have met the non-functional needs.
104	Test Environment Equivalence	• This requirement has been met through establishment and maintenance of a lower environment equivalent of the pilot environment. Refer to section 6.3.2 – The X-SIT environment is on stand-by to reproduce issues found in the “Pilot environment”.
118	Data Provenance	• All modules (DSO Platform, DOE Calculator, Analysis & Reporting) keep basic records of when input data was received.

Table 9: Non-Functional Assessment Rationale of the DSO solution

6.6 DSO Platform Build Lessons

The following sections highlight early project lessons identified during the DSO Platform delivery phase of the project. They have been grouped under four sections:

- **Build to facilitate Test and Learn:** Issues and/or areas that impacted the enablement of Test and Learn for the DSO Platform.
- **Ability to Scale:** Issues and/or areas to be addressed to support future scalability of a DSO Platform,
- **Process Improvement:** Identified areas where DSO capabilities require review and improvement to support a future DSO; and,
- **Maturity and Supportability:** Issues and/or areas to consider that impact future support and management of the DSO Platform as-built solution.

6.6.1 Build to facilitate Test and Learn

Issues and/or areas that impacted the enablement of Test and Learn for the DSO Platform.

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	Symphony Network Model	**Benefit** During the earlier stages of the Test and Learn (T&L) phase of the Pilot, it became apparent that the DOE resulting from spare hosting capacity was higher than the total capacity of the DER assets. This prevented the Aggregator from successfully demonstrating that DER could remain within the DOEs while providing market services. The Symphony network model, enabled the project team to artificially make changes to the network ratings, such as lowering the distribution transformer (DSTR) and cable impedance ratings, without impacting Western Power's business as usual network model. **Benefit:** The DSO platform developed it's own network model that allowed it to enter certain DER assets, for example Symphony BESS, manually without impacting the BAU procesess.	**Outcome**: Alterations to the Pilot network model's import side of the network ratings generated the expected DOE constraints and allowed testing of DOE compliance for export. However, these changes led to unforeseen DOE compliance problems as a rules-based DOE QR Checker failed because the Import Ratings were too low, causing DOEs to not be published until the rule was disabled. **Lesson**: Keeping the Symphony network model isolated from the Western Power BAU Network Model will allow the project to reach its Test and Learn objectives. It is recommended to consider Test Objectives during the platform requirements phase of the project to allow flexibility in the future. **Lesson**: To avoid breached DOE compliance on the export side in the future, the network model could be altered to feature two different ratings (one for

			import and one for export) to avoid potential future consequences.
2	Alignment to Enterprise supported technology and support models	**Benefit:** The DSO's approach in developing the solution modules enabled the DSO Platform to focus on the Design principles “Learning over Obstacles”, as well as “Minimum Viable Product” to obtain the learning outcomes faster. **Barrier:** The Pilot DSO Platform was designed and built operationally independent from core Western Power BAU business systems and processes. As a result, Western Power BAU Support Process did not support several technologies included in the 'as-built' DSO Platform.	**Outcome:** The DSO Platform established its own Support and Maintenance team to manage technical assistance requests, troubleshooting issues, and new feature requests/enhancements according to its Service Level Agreements. **Lesson** It is important to ensure that business systems and process are operationally independent to not impact enterprise technologies during the Pilot, as well as ensure that the governance regarding corporate and technology strategy, assumptions, business requirements and design principles deliver the desired outcomes. This requires careful consideration on how the modules can be deployed quickly to acquire the learnings, whilst allowing for future growth and support from Maintenance and Support teams as time progresses past the Pilot.
3	Dependency management	**Barrier:** Parallel technology build and commercial framework development had been done in order to ensure that the technology build was completed in time for the summer testing period.	**Outcome:** Difference in the technical solution that was built vs the commercial framework agreed by the DSO and Aggregator for validation of NSS compliance. **Lesson:** Complete key commercial framework items prior to the commencement of technology design and consider a co-design approach between technology and commercial teams going forward.
4	Analysis and Reporting Tools	**Barrier:** Project Symphony's data output included intricate and varied datasets which could not be supported by existing Enterprise Data Analytics Platform tools alone for Test and Learn Hypotheses test cases.	**Outcome:** A corporate server Python environment and the associated data scientist libraries were needed for the analysis of large time series datasets. **Lesson:** When first starting a project involving large data sets, it will be important to

			consider the capabilities of data analytics toolsets in terms of their size and granularity to support the necessary statistical analysis. It is essential to evaluate these tools early on in the process.

Table 10: Build to facilitate Test and Learn Lessons

6.6.2 Ability to Scale

The Pilot DSO Platform was designed and built with an objective to deliver Learning Outcomes and as such, components of the design and build may not scale.

Issues and/or areas to be addressed to support future scalability of a DSO Platform.

Table 3: Ability to Scale Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	Functional Aspect to Scaling the DOE Calculator Module	**Barrier:** The development of the Pilot was centred around a single urban 22kV distribution feeder from the Southern River Zone Substation named "SNR 540". Characteristics of this network included: • High penetration of grid-connected solar photovoltaic power systems, • Large percentage of modern dwellings, • Serviced by majority underground power infrastructure, • Low number of commercial service connections or HV meters, • High level of advance metering infrastructure (AMI); and, Subsequently, modules developed and tested for the DSO Platform during the Pilot may not be easily transferable to different physical network topology due to the dependence on AMI meters and other characteristics specific to SNR540, which vary between networks. **Benefit:** Focusing on SNR540 feeder enabled the project to speed up the process of acquiring knowledge.	**Outcome** The acquired knowledge provided a pathway forward to inform the potential for broader deployment of VPP and DER orchestration across the SWIS. **Lesson:** When developing a module to calculate DOE's, it is important to ensure that it is transferrable to different networks and can be used in a variety of contexts, for example, low AMI penetration, rural properties, and above ground HV and LV networks. The key learning is that when testing a DSO platform, consideration should be given to the specific characteristics of the network it is being tested on and its potential implications for transferability. **Lesson:** Before scaling, it will be important to evaluate different network topologies and characteristics.

2	Load Forecasting	**Barrier:** The solution delivered relied on the DOE Calculator Module load forecaster (at NMI level) for: • DOE calculations: Load forecast was crucial for determining the available network capacity, which was used for DOE calculations, • Network Support Service (NSS) dispatch; Load forecast was used for determining whether an NSS dispatch was required – the capacity (MW), quantity (MWh) and timing (start and end times) However, the quality of the forecast at lower network segments such as NMI or Distribution Transformer Level was not accurate enough especially during sudden weather changes and very hot days, particularly for the Network Support Services dispatch.	**Outcome:** Inaccurate forecasting of NSS calls can lead to increased financial costs and operational inefficiencies, which could negatively impact the business and network. To mitigate this risk, a manual work around solution was implemented that relied on rules based on temperature forecast. This solution required DSO Platform users to check the weather forecast for temperatures above 35 degrees Celsius and a minimum of 20 degrees Celsius. **Lesson:** Accurate forecasting of load or demand is essential to make informed decisions and ensure operational efficiency going forward. Prior to scaling, define the level of accuracy required and test the forecast models for periods of sudden weather changes and very hot and cold days in the future.
3	DOE Calculation	**Barrier:** The Evolve Platform had calculated and allocated the publication of Dynamic Operating Envelope's (DOE) for the Pilot. Due to the need to transfer large amounts of data from the DSO Data Processing module to the Evolve Platform, and carrying out multiple power flows to assess and assign the entire DOE set (72 hours), including a high number of DER participating, a considerable amount of processing time had been required, resulting in the following scalability limitations: • As the acquisition of data can take up to two hours and current computing power needed to assess, calculate and assign the entire DOE set (72-hour forecast) for the network in the Pilot area requires up to 1 hour of processing time, this module did not allow for easy recalculation in	**Outcome:** An "exception" path had been created to enable the implementation of a short notice/ Default Operating Envelope (OE) in the event of outages, both planned and unplanned allowing, the Symphony engineer to publish the DOE in a timely manner. Evaluation is required to compare the DOE Calculator Module against the default/static seasonal Operating envelope to determine the best approach in

		response to deviations from forecasts, network outages and unplanned switching • In addition, it had been unlikely that the other parts of the DOE calculation process were feasible for a larger solution. For example, 72-hour DOE forecast time period would mean that calculations would have needed to be done on separate versions of the Symphony Network Model to take into account scheduled and unplanned outages in other networks. **Benefit:** By having implemented the default DOE process, including custom static values, unplanned outages were quickly identified, allowing the Symphony engineer to publish the correct DOE and maintain network stability. **Benefit:** Additionally, the default DOE process that had been implemented enabled the Aggregator to recruit customers outside of the original Pilot Area in order to meet customer and DER asset targets whilst still receiving a DOE.	maintaining DOE accuracy and reducing network risk. **Lesson:** It is essential properly design and architect the solution to be able to scale up and enable DOE computations to be done simultaneously for each feeder. It is recommended to assess other possible ways to improve the speed of DOE computations without compromising accuracy and/or network security. For example, calculating and publishing DOEs at shorter periods more frequently with lower Data Exchange or partial re-calculations will result in better forecast input, and network model accuracy in the future.
4	Analysis and Report	**Barrier:** The challenge of managing the amount and complexity of data Project Symphony generated for each partner, along with the lack of adequate tools and resources to carry out Service Verification activities created a barrier to developing an information architecture suitable for a larger DSO Platform. The Western Power reporting tool lacked the ability to easily support advanced statistical techniques for large datasets. **Benefit:** The reuse of existing Western Power reporting tools and adequate monitoring of DOE and NSS compliance for the Pilot through the Reporting area had ensured that, should the DSO platform scale, transitioning the reports to enterprise teams to maintain and support will be easy.	**Outcome:** The DSO Platform users had been unable to obtain all the necessary strategic and operational performance insights from the data without using intermediary applications (other than the Western Power reporting tool), resulting in additional work and resources being required. **Lesson:** Significant resourcing will be needed in Data Warehouse design, Data Engineering and Data Analysis to maximise the business and operational

			benefits from advanced data analysis. **Lesson:** When aiming to expand the solution, the architecture must take in account the need for Reporting, medium and long-term analysis, metrics, and key performance indicators that will be reported.

Table 11: Ability to Scale Lessons

6.6.3 Process Improvement

Identified areas where DSO capabilities require review and improvement to support a future DSO.

Table 4: Process Improvement Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	AMI Data Quality	**Barrier:** Utilising a headend system that was not created for telemetry data, the initial applications are more tolerant to communication interruptions and data losses. **Benefit:** The DSO Platform improved the 3-phase meter accuracy and reliability of data collected from service connections, which in turn improved load forecasting and service verification (DOE and NSS).	**Outcome:** The DSO platform is taking steps to investigate and resolve the component that is causing permanent PQ data loss. However, there is still a risk of not being able to verify DOE and NSS complaince and a potential decrease in the accuracy of load forecasting until the issue is resolved. **Lesson:** It is suggested that further investigation should be carried out to determine whether non-contestable customers should also move towards a 5-minute settlement in the future to help with the settlement process, as well as adhere to DOE and NSS compliance. This suggestion is in line with the plans in place in Western Australia about transitioning towards a 5-minutes settlement for contestable customers.
2	DOE Compliance	**Barrier:** The DOE Compliance Process had used AMI data to compare to DOEs for each interval and measure compliance. The processtook into account the number of NMIs that exceeded DOEs, the number of times DOEs were exceeded, how long	**Outcome:** DOE compliance was adequately measured using AMI data. Additional consideration was required to assess regulatory approval for policies or

		DOEs were exceeded, and the percentage of DOEs breached. The resultswere reported from the perspective of the NMI and formatted to be shared with the Aggregator. Challengeshad been experienced in establishing systems to accurately monitor and report on compliance in a way that is resilient to incomplete measurement data and the potential measurement and time differences between the Aggregator measurement system (using an inverter connected power meter at the NMI) and DSO's measurement system (using the revenue meter at the NMI). **Benefits**: Early indications through test dispatches with a constrained network and binding DOE limits demonstrated that compliance performance was acceptable.	measures to apply when compliance was consistently not met. **Lesson:** Careful planning and consideration are necessary to ensure that a DOE compliance system is resilient to incomplete measurement data, differences in measurement systems, and the potential for measurement and time differences between the Aggregator and DSO systems when establishing and implementing it in the future.
3	DER Asset Standing Data Process	**Barrier:** The DER Standing data created for Project Symphony was a combination of data collected via the Western Power's DER Register and Project Symphony's participating DER data, provided by the Aggregator. This is because the existing Western Power DER Register was deemed not fit for the purposes of the Pilot, both in terms of data timeliness and completeness, due to the following reasons: • The time difference between DER's being added, uprgraded and or removed did not align with the DSO Platform requirements for dispatch schedules in the load forecast. • The requirements provided for the DER register only allowed for certain types of DER to be registered, not any type of controllable load.	**Outcome:** It was determined that in order to ensure reliability, timeliness, and completeness of data, a solution was implemented that enabled the Aggregator to send the details of the as-installed DER directly to the DSO Platform for NMIs that had been registered, rather than using the usual BAU DSO/Western Power process to inform the Symphony project. Additionally, the manual process to enter DER assets had to be to be defined in order for a larger DSO platform. **Lesson:** The Pilot Asset Standing Data process is deemed fit for the purpose of the Pilot,but further improvement is required to enhance the data collection processes to be sufficient for DER Orchestration at scale. Additionally, further analysis is required to determine the best approach to accurately record electric vehicle charger data, and assess how these types of DER, as well as other controllable DERs such as Air-Con, Hot Water Systems and

			Swimming Pool Pumps, will affect the available network capacity. This work is expected to be undertaken through the AEMO initiated proposal[23] to amend the WEM Procedure: DER Register Information to incorporate new DER Types such as EVSE.
4	Outage Management	**Barrier:** Western Power existing processes for managing and communicating outages on the low voltage network were not responsive enough for effectively managing VPP operations, due to the following reasons: • Outage windows were often over-estimated in planning documents to provide field crews with flexibility, • Some planned outages did not go ahead as planned for various reasons, • much of the information related to planned outages was recorded in Western Power's systems in an unstructured format, including switching plans, • Western Power's GIS derived LV model was based on the "as-built" model, not the "as-operated" model, resulting in mis-alignment to the actual network state. **Benefit:** The DSO Platform had implemented the Outage Management Process for both planned and unplanned outages in order to preserve the steadiness of the network in the Pilot area. Almost in real time, outage information was utilised to warn the DSO Platform of major outages that could impact DOEs to ensure that the correct DOEs were published. Additionally, the DSO Platform had taken an innovative approach in combining "as-	**Outcome:** The process was not practical for DSO larger scale operations as it did not allow for the early identification and management of network changes that impacted Virtual Power Platform operations. **Lesson:** • The DOE calculation period needs to be shortened, for example, every three hours in order to better consider planned and unplanned outages in the future. Currently, there is a 72 hour forecast window which does not account for the numerous network changes that may occur in that time. • Investigating alternative solutions such as Network Model discovery through Neural Networks/Machine Learning or State Estimation could be done to improve accuracy of the network model, resulting in an optimised network and DOE performance. • Finally, combining the electrical network "as-switched" and "as-designed" data sources can provide a more comprehensive view of the system and the problems it will be facing. This can be especially useful when dealing with complex networks, as it will allow for a clearer picture

[23] https://www.aemo.com.au/consultations/current-and-closed-consultations/aepc_2022_02

		switched" and "as-designed" data to get a better understanding of the network model and the load created by the NMIs connected to the PPilot area.	of the current state of the network and address any potential issues that may impact VPP orchestration.
5	Pilot Processes	**Barrier:** Several processes and associated modules had been implemented to enable data sharing for the purpose of enabling testing and learning by all project partners with the intent to meet key project objectives such as informing future scale. Thus, to inform scale some processes and integrations are not suitable to scale outside of the Pilot, these include: • **End-to-end NSS process;** The solution built did not support the tracking and change of NSS calls, and the current data model made it challenging to validate NSS provision when multiple requests were made at the same time intreval. • **Facility registration;** The solution built relied on Facility Registrations to identify customers that required DOEs. This process assumed that participants were registered to provide services in the market and as such, did not allow for flexible exports for non-market participants. The solution built may not have allowed for customers who invest in expanded PV and battery capacity as they would have been prevented from dispatching above their static inverter connection limit, except when included by their Aggregator in a facility, even though there may be have been spare network hosting capacity. • **Robustness;** Some parts of the solution would have required further hardening to sustain them beyond the Pilot. For example, currently the DSO platform is still in the “Pilot” enviroment, the DSTR monitoring virtual machine server was a single point of failure,	**Lesson:** • Review the requirements, information architecture and associated data models for their suitability at scale prior to scaling. Wherever possible, align with a National Approach such as the adoption of IEEE 2030.5 and CSIP-AUS • Consider a policy position on whether customers will need to be part of a registered market faciliities to access DOEs and/or whether flexible exports can be made available without market participation. Following this, implement a separate mechanism, instead of Facility registrations, for the DSO and Aggregators to identify customers that will require DOEs. • Prepare the as-built modules for production environments, removing single points of failure, automating system integerations and implementing exception handling for integration between partners. This will ensure that the system is able to handle unexpected errors and maintain a reliable performance.

		manual system integrations were not responsive enough in their current state and the DMO platform ignored NSS requests with Service ID's that they were unaware of.	

Table 12: Process Improvement Lessons

6.6.4 Maturity and Supportability

Issues and/or areas to consider that impact future support and management of the DSO Platform as-built solution.

Table 5: Maturity and Supportability Lessons

No.	Topic	Benefit / Barrier	Outcome / Lesson
1	New Technology	**Barrier:** The 'as-built' DSO Platform included several technologies that were relatively new to Western Power and might not have been supported beyond the Pilot in their current state. These technologies included physical network devices, data platforms, and data routing technology.	**Lesson:** It will be essential to develop an enterprise transition plan at the outset of the process when developing new technologies in order to evaluate the scalability, upkeep, and how to progress beyond the Pilot phase.
2	Data Exchange Service	**Barrier:** The Data Exchange Service used in the PPilot was a product provided as part of the DMO Platform Vendor. A client was installed on the DMO, DSO and Aggregator Platforms to facilitate the use of this solution. The solution required all parties to have installed the same/correct version (at the same time), with limited backwards compatibility with major releases. This created difficulty in maintaining the solution as different versions were released and indicated that the solution may not have been as reliable or secure as more mature data transfer systems.	**Outcome:** This Module did not meet the DSOs solution architecture principles for Containerised Application Architecture and Open Standards Integration. The requirement to upgrade simultaneously with partner organisations impeded the ability to upgrade independently. **Lesson:** • Early enaging, aligning and agreeing between project partners on critical technology touchpoints such as integration technology is recommended to ensure future sucess. • When working with providers of innovative technology solutions that are less mature, it is recommended to factor complexity, time and risk into planning. This effort should not

			be underestimated; for example, factor in multiple upgrades during the lifecycle in project plans and consider decoupling timelines with other projects and shared environments. When scaling, consideration needs to be given to providing the following: • The practicality of coordinating multiple organisations for release management, as part of the ongoing service management processes, will be recommended for industry wide deployment. A more streamlined, standardised deployment model similar to other web-hosted applications will be suggested.. This could be a standard DevOps type solution to automate the distribution and deployment of updates and new versions. • The cost-benefit analysis of investing in capabilities to manage the product integrations that may persist after the Pilot will be assessed, • The risk associated with not having a direct relationship with the product's supplier will increase in the future. • The architecture principles of containerised application architecture and open standards integration will be essential when scaling a solution that uses the Data exchange services in the future.
3	Absence of industry standards	**Barrier:** The lack of established industry standards, for example CSIP-AUS,	**Outcome:** The outcome of this was that the lack of established industry standards made it

		posed a significant obstacle in the creation of a DSO platform, such as the Data Exchange Service.	difficult to develop all modules bespoke to the standard. **Lesson:** Establishing industry standards is essential for successful development of DOE platforms and services. The lack of established industry communication standards and protocols increases the difficulty of creating modules, leading to potential issues in the development process. Additionally, before beginning any large-scale project, where possible, it is important to ensure that the maturity level of the modules involved are up to industry standards and are able to be easily adapted and evolved as needed.
4	DSO Core Capability - DOE	**Benefit:** The Evolve Platform had been selected for the Pilot due to its ability to deliver the DOE Calculator module within the timeframe allocated based on prior experience as part of the evolve DER Project.	**Outcome:** While the platform had performed well for the Pilot, further analysis was required to ensure the platform and its supplier can deliver and support a robust calculation mechanism at scale. **Lesson** Having prior relevant experience will enable the DSO to complete development of technology necessary to publish DOEs within the Project Symphony timeline. To meet the DSO functional requirements, there are a number of components such as Default DOEs, NSS functions, Integration with DMO and Aggregator that will be built outside of the Evolve Platform and consideration should be provided to rationalising these components before scaling to reduce the total cost of ownership.
5	Change control process for database objects	**Barrier:** The DSO Platform Symphony Data Base and Enterprise Data Analytics Platform had received large volumes of inputs from the DMO and	**Lesson:** Deploying modern database tools, principles and administration procedures early on in the project will reduce development time, increase

		Aggregator which was very complex and required a significant amount of resource effort in database development time and change control.	robustness and improve the quality of database management.

Table 63: Maturity and Supportability Lessons

7 DMO Platform

7.1 DMO Platform Description

Driven by actions 22 and 23 in the Western Australian Government DER Roadmap, an approach was developed by AEMO that shaped a core set of requirements (functional and non-functional) for the DMO platform and target time frames for delivery of Project Symphony. Various industry and market trends, and the requirements of the National Energy Market (NEM) and AEMO's sister DER project, Project EDGE[24] were also considered.

Sharing the platform development with Project EDGE enabled a more comprehensive implementation, focussed on expanded hypothesis and test outcomes by leveraging AEMO's broad capabilities across a wide range of business areas.

The functional and non-functional DMO platform requirements were developed to deliver the capability to integrate with the DSO and Aggregator platforms to deliver the end-to-end solution, and to enhance the learnings from Project Symphony by including additional interfaces, reporting and assessment capability and integrations between the platforms.

AEMO sourced individual platform components to meet its identified business requirements and platform specifications. The core DMO platform solution consisted of two layers' market bids and offers solver, the data repository, and a user interface (intelligence layer) 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 platforms.

7.2 DMO Solution Architecture

7.2.1 Solution Overview

This subsection summarises the overall solution supporting the DMO domain.

Figure 3 provides a conceptual view of the DMO platform and how it interacts with both internal systems and infrastructure and partner platforms. Significantly, the figure does not include solution details of the DSO or the Aggregator as the overall Symphony solution supports the concept of "separation of concerns". This allowed the solutions relevant to the DSO and Aggregator to be developed separately and are detailed in other sections of this report.

Section 7.4 provides a more detailed breakdown of each of the capabilities specific to the DMO platform.

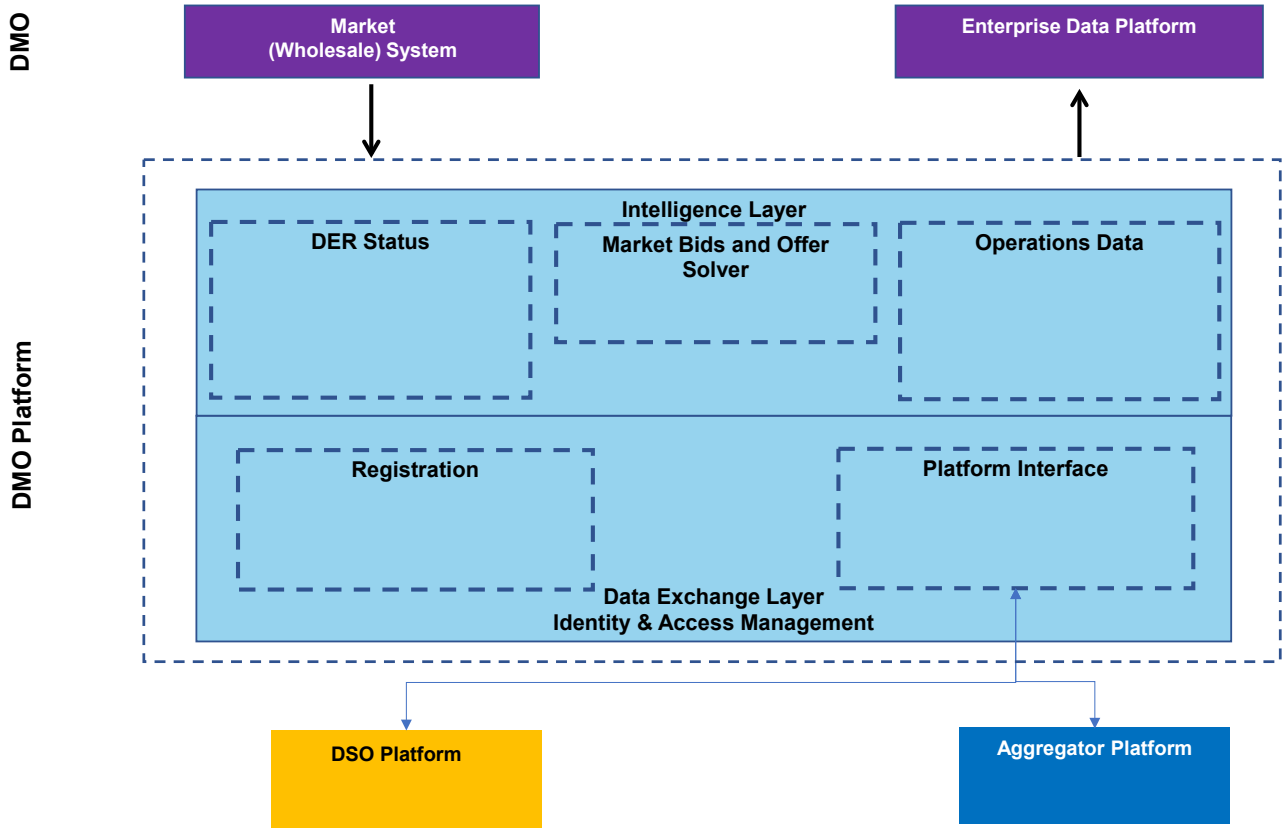

Figure 5: DMO Platform

Table 14 lists the capabilities inherent in the DMO platform and supported by DMO infrastructure to deliver the project objectives.

Domain	Capability	Description
DMO Platform - Intelligence layer	DER Status	This capability provides access to the status of the DER environment from the perspective of the DMO. For the DMO, access is via PI Vision as there is no direct access to the solutions underpinning the intelligence layer. This approach was driven principally by cyber security concerns.
	Market Bids and Offer Solver	This is the heart of the intelligence layer enabling core market functions such as: • Manage Bids and Offers; • Manage Dispatch Instructions; and • Control Signals.

Domain	Capability	Description
		These functions support the execution of the market pertinent to the role of the DMO.
	Operational Data	This capability provides the ability to view, analyse and report on the DMO real-time operational data covering historical and real-time data. The data contained is limited to the data associated with the DMO role.
DMO Platform - Data Exchange	Registration	This element of the solution maintains participant registration, facility, and asset details required for undertaking the DMO role. In the context of the Project, the registration data (standing data) is sourced from either the DSO or the aggregator rather than directly captured by the DMO.
	Platform Interface	The platform provides the Data Exchange / interface hub by which the data to manage and support the operational Pilot is handled. It serves as the centralised messaging hub for the overall solution.
DMO	Market (Wholesale) Systems	Leverages existing market systems, principally the existing dispatch engine, to provide pricing data to support the dispatch process in an off-market context. The data provided allow the market to be simulated with realistic market scenarios and behaviours.
	Enterprise Data Platform	This platform takes the Operational Data mentioned above and augments that data with content from the DSO and Aggregator to support the test and learn activities associated with the Project. The platform supports data storage, analytics and visualisation capabilities that extend and complement the Operational Data capability mentioned above.

Table 14: DMO Platform Capability

7.2.2 Solution Context

The DMO solution was developed in the context of a set of business objectives, principles/design criteria and overarching non-functional requirements that spanned the overall solution.

An overarching set of business objectives defined for the DMO solution are listed below:

- Demonstrate roles for the DMO, DSO and Aggregator (actors).
- Build and Pilot integration components between actors and simulated market systems, including demonstrating dispatch of DER.
- Demonstrate capability of DER to participate in WEM markets (post WEM Reform), in parallel with providing network support services (NSS).
- Provide key learnings and definition of the DER orchestration model and market participation model targeted to be implemented in the WEM from October 2025[24].
- Develop stakeholder understanding of expectations for DER orchestration in the WEM and SWIS.

Function ID	Capability (from the vendors Tech Spec)	Description	Business Function
F01	Participant Onboarding	Participant onboarding (Aggregator and DSO) refers to the set of activities involved in configuring, onboarding, and setting up the participant on the platform to facilitate Data Exchange.	Register Participant
F02	Participant Enrolment	This allows the participant to utilise their portfolio to participate in the market and publish Real Time Market Submission (RTMS) to provide wholesale energy services, NSS and ESS.	Register Participant
F03	Aggregator Facility Registration	Aggregator Facility Registration includes the Facility configuration provided by the Aggregator and published to the Platform. An Aggregator can	Register Participant

[24] At the time the DMO solution was conceived, the target date for DER orchestration and participation models to be implemented in the WEM was July 2023.

		also send multiple updates to their Facility Registration, for instance, to de-activate or re-activate a Facility (a condition specific to the Pilot).	
F04	NSS Service Registration Data Processing	The NSS service registration is published by the DSO to the Platform (and by DSO directly to the Aggregator off-platform). The Platform must receive, store, and process the NSS Service information if it meets the schema validations.	Process Facility and Constraint Data
F05	DSO NSS Deployment Signal Data Processing	The DSO NSS Deployment Signal is sent from the DSO to the Platform. The Platform stores and forwards the NSS Deployment Signal to the Aggregator.	Process Facility and Constraint Data
F06	Dynamic Operating Envelope Data Processing	NMI level (dynamic) operating envelopes (DOE) are published by the DSO to the DMO platform.	Process Facility and Constraint Data
F07	Market Forecast Price Data Publication	The forecast energy price is provided by the DMO via the Price Ingestion schema, processed by the Platform and published to the Aggregator using the Forecast Energy Price schema in support of creating/updating their RTMS. The forecast energy price message is republished to the Aggregator every 5-minutes for the remainder of the balancing horizon in conjunction with the pre-dispatch instruction	Process Facility and Constraint Data

		schedule post rate frequency.	
F08	Forecast and Market Price Data Processing	The market price ingestion file share data is generated by the DMO and published to the Platform. Price ingestion provide the market strike price. Platform will persist, store, and process pricing data to: • Publish the forecast energy pricing to the Aggregator using Forecast Energy Price data schema; • use the forecast pricing to construct the pre-dispatch instruction schedule; and • use the strike price to clear the RTMS quantity tranches and construct the dispatch instruction.	Process Facility and Constraint Data
F09	Facility Telemetry Data Processing	The Facility Telemetry data is the portfolio level telemetry data provided by the Aggregator. This is also referred as facility level actual operational data and refers to the actual instantaneous measurements at the facility level. The resolution is expected to be 1-minute interval data and a post rate of every 5-minutes.	Process Facility and Constraint Data
F10	Control Room User Interface	The Platform will provide AEMO with data visualization in the form of displays and charts to show the operation of the Pilot	Process Facility and Constraint Data
F11	Facility Forecast Data Processing	The facility forecast represents the future look ahead of available capacity for generation, load, and storage in an Aggregator	Process Facility and Constraint Data

		portfolio. Facility forecasts are produced per facility and only incorporates generation and load devices that are explicitly under control of the Aggregator. The Platform can receive Aggregator forecasts at any post rate.	
F12	Processing Real Time Market Submissions (RTMS)	c. RTMS are submitted by the Aggregator for intending to deliver wholesale energy services, NSS, ESS, and to provide operational visibility of their portfolio to the DMO. d. Standing RTMS - Aggregators will publish an RTMS Standing submission daily for the Trial context. An RTMS Standing submission will contain a maximum of 288 intervals. e. RTMS Variations - Aggregators can also publish RTMS Variations based on changes to their facility generation/load availability or NSS provision requested by the DSO. An RTMS Variation submission may only contain a subset of intervals representing the time period for which the bid/offer price-quantities are being changed. f. RTMS Consolidation - All RTMS Variations must be merged and consolidated with a consolidated RTMS Standing submission. This consolidated RTMS is then processed to determine the dispatch or ESS CR	Manage Bids and Offers

		enablement amounts for the next dispatch interval.	
F13	User Modifiable Test Variables - specifically • Out of Merit Dispatch (see below) • Price Ceiling/Floor Modifier • ESS Test Modifier • Constrain to Zero Scheduler (see below)	There are four use cases involving the user modification of platform variables and market solver override for out-of-merit dispatch events, to test different market outcomes during the Trial period. A DMO analyst will have limited access to Microsoft SQL Server Management Studio (SSMS) via a jump host to read and modify properties in select data tables relating to each user modifiable requirement. For all user modified test variable inputs, the platform will not provide the ability to cancel the submitted user input. The DMO analyst must overwrite the previous modified test variable input with a new test variable input.	User Modifiable Test Variables
F14	Out of Merit Dispatch	DMO analyst can manually construct a pre-dispatch and dispatch instruction, essentially 'overriding' the Platform in-merit market solver for a specific Facility. The manually loaded pre-dispatch and dispatch instruction data is then scheduled and published to the Aggregator based on the specified trading date and dispatch interval(s).	User Modifiable Test Variables
F15	Constrain to Zero Scheduler	A DMO analyst can schedule an out-of-merit 'Constrain to Zero' (CTZ) event. A CTZ event will result in a CTZ instruction	User Modifiable Test Variables

		being sent to the Aggregator, the CTZ flag is included in the dispatch instruction. This is platform capability used to undertake a technical verification test of the Aggregator's ability to constrain energy generation from the NMI to the network to 0 MW (gross) or constraining each NMI to zero export (net).	
F16	In Merit Market Solver	The Symphony DER Marketplace 'market solver' will process the accepted RTMS a few minutes before the start of each dispatch interval. The market solver will apply the market logic incorporating the market strike price (energy and ESS CR), service prioritisation rules and registered facility data to the consolidated RTMS including energy bid-offers for wholesale energy (BMO), NSS and/or ESS service provision and solves for the trading interval. The market solver will also prioritise services for dispatch to ensure priority services are dispatched in a defined priority order. In Project Symphony which is performed in an off-market environment, the priority is NSS, Energy and then ESS CR. Where a CTZ event is scheduled then this will override all services. In a real market environment,	Manage Dispatch Instructions and Control Signals

		energy and ancillary services (ESS CR) would be co-optimised and dispatched given the optimal outcome, this co-optimisation capability was out of scope for the Project.	
F17	Dispatch Instructions Publication	Dispatch Instructions (DI) are generated and issued by the Platform to the Aggregator for the purpose of meeting the balance of demand and supply in the DER Marketplace. The platform will construct and publish DIs every 5 minutes to the Aggregator. The dispatch instruction will also take in to account any out-of-merit CTZ dispatch events scheduled by a DMO analyst via the User Modified Test Variable interface.	Manage Dispatch Instructions and Control Signals
F18	Pre-dispatch Instruction Schedule Publication	The platform publishes a pre-dispatch instruction schedule to the Aggregator. This schedule will allow the Aggregator to plan and optimize their assets to for market services during the trading day. The pre-dispatch must be constructed and published to the Aggregator every 5-minutes for the remaining length of the balancing horizon (remaining Trading Day + next Trading Day). The pre-dispatch will also take in to account any out-of-merit CTZ dispatch events scheduled by a DMO analyst via the User	Manage Dispatch Instructions and Control Signals

		Modified Test Variable interface.	
F19	Platform Data Storage	The Platform stores all DER Marketplace data into the three Platform databases: • SQL (for transactional and static data) • Mongo (for incoming and outgoing messages) • PI Data Archive (PI DA) (for time series data)	Reporting and Performance Assessment
F20	Platform Data for Analysis	The Platform will enable AEMO Analysts access to market data via an Extract, Transform, and Load (ETL) process to the DMO's Enterprise Data Lake (called the AEMO's EDP later in this document). All data processed or published by the Platform is provided to DMO's Enterprise Data Lake.	Reporting and Performance Assessment

Table 15: DMO functional requirements

The ARENA Report outlined a set of principles/design criteria (Section 4.1.3) which are described in the following table. These principles/design criteria provided another lens against which the DMO solution was defined, designed and delivered.

Principle/Design Criteria	Description
Meet the Pilot requirements at a minimum.	The solutions and technologies need to facilitate each partner's ability to assess their roles and responsibilities in the Hybrid model's effectiveness, as well as identify any learnings that could be used to inform policy and legislative requirements for the introduction of DER into the WEM. Functional coverage must address the core business needs required for the Project.
Have the potential to scale to meet additional participants (Aggregators).	The underlying solutions and technology need to be able to support additional aggregators even though there is only one principal aggregator for Symphony.

Principle/Design Criteria	Description
Be simple for additional participants to join and utilise.	The solution must facilitate the ability for additional market participants to interact with the solution with minimal barriers to entry/adoption.
Be able to manage high frequency telemetry data.	The solution must enable visibility of DER facility performance when participating in energy or ancillary markets and is appropriate to support dispatch obligations.
Preferably be a SaaS solution and at a minimum be hosted on a Cloud based Platform.	This criterion is in line with: • Industry trends. • The DMO's intent to increase the cloud SaaS/PaaS solutions in its application landscape. • The intent of Project Symphony (and the NEM counterpart project called EDGE) to assess alternative market integration/messaging approaches to those currently adopted in both the WEM and NEM.
Have the ability to be easily modified to align to market rules once they are defined.	The solution must be modifiable or configurable to allow implementation of market rules identified during the Project.
Have the ability to integrate with market systems in the future.	As the Project was conceived as a Pilot, there is a potential to move the overall solution into a strategic market solution and incorporate aggregated DER into the WEM.
Align to the AEMO security principles and governance.	The solution must be able to meet non-functional security requirements.
Operate in an off-market environment for the duration of the Project.	The solution needs to be able to operate independently of, and without impacting or influencing, the WEM.

Table 16: Principle / Design Criteria of the DMO solution

Underpinning the solution was a set of non-functional requirements that was common across all components of the solution. From an overall perspective, a set of specific non-functional requirements (NFR) were developed with the intent of:

- ensuring the software system follows legal and compliance rules;
- ensuring the reliability, availability, and performance of the software system;
- ensuring a good user experience and ease of operating the software; and
- supporting the formulation of security policy.

The NFR's identified for the DMO components are listed in the following table along with a description of each. More detailed descriptions of each NFR can be found in the ARENA report.

ID	Non-Functional Requirement	Commentary
SEC01	Security of platform	The DMO platform (solution ecosystem and infrastructure) must assure and maintain the overall security of the solution in accordance with the DSO and industry cyber standards and/or obligations. The solution is required to provide non-repudiation (i.e., assure recipient validity of sender and transaction) through secure transfer of messages (ensure messages are not compromised, tampered, modified, or manipulated with when exchanged via a shared platform). Validation of this NFR would cover: - Auditing of the design and delivery against agreed cyber requirements; and - Penetration testing outcomes.
PER01	Platform performance measured by response time.	Degree to which a solution or component performs its designated functions with minimum consumption of resources and can respond to a request from the user / system that supports market operation needs such as a 5-minute dispatch capability and participant registration. As the Market Platform is operating as an off-market Pilot (non-business critical), the performance requirements for the Project are low due compared to a platform operating in a live market. It is expected that the majority of the transactions – e.g., enrolment of Participants, Registration of Facility and upload of some telemetry – do not require a high-performance target. This NFR will assess Bids and Offers being processed by the platform in under four seconds, and Dispatch Instructions being generated in under four seconds.
SCA01	Ability to scale up or out.	The underlying applications and infrastructure needed to be able to support additional; transactions, transaction volume, and number of participants/users across the DER DMO context without any noticeable impact to services.
SCA02	Capability of platform to add additional users without any noticeable impact to services.	A specific element of SCA01 but focuses on the ability to extend the users to cater for the test and learn activities, and ultimately to support a production capability. The solution must scale up to 10 concurrent users if additional participants are added in the Pilot, and/or data flows (number of messages processed within a given unit of time) increase, without any noticeable impact to services.

ID	Non-Functional Requirement	Commentary
AVA01	Capability of platform to run without a failure for a given period	The intention of this NFR requirement is to validate the underlying stability and robustness of the solution components that could support a 24x7 market operations environment. It was also intended to provide confidence that the DMO solution could be migrated from Pilot to a production capability. As the Market Platform is operating as an off-market Pilot, the solution will be available and fully operational for 99% of time for the period which the scenarios are run. The Maximum Tolerable Downtime per Incident is one day.
MAN01	Periodic maintenance window	To support the evolution, and the test and learn activities planned within the project, the solution must be able to support changes and maintenance of the solutions and the infrastructure. As per AVA01, this was also to confirm the “production” readiness of the underlying solutions and the vendors delivering the solutions.
REC01	System restoration objectives and ability to recover	As per previous comments, this NFR is intended to support the needs to maintain the data associated with the Project, as well as confirm the ability of the solution to be able to support a production target. Appropriate Recovery Point Objective (RPO) and Recovery Time Objective (RTO) targets have been defined for a Pilot project – being 48 hours for both measures.
REC02	Data backup and retention objectives	This NFR ensures that data backup and recovery targets can be met across the overall DMO solution ecosystem. Confirmation that system data is be backed up daily and retained for seven days. System messages and logs are stored and retained for the length of the Pilot will also be assessed.
DAT01	Backup daily	This NFR is principally focussed on the Pilot to ensure that data can be recovered should there be any issues with the solution or infrastructure to ensure the test and learn activities can continue. This NFR complements REC002. All system data must be backed up daily and retained for seven days. System messages and logs will be archived and retained for the length of the Pilot.

ID	Non-Functional Requirement	Commentary
INT01	Handle multiple versions of schema	The Pilot was conceived as progressively delivering market components and technical capabilities via a series of "drops". As a consequence, the underlying integration payloads would evolve and be extended during the course of the Pilot. Support for multiple schemas also enables participants to operate independently of each other. Support for multiple versions of API schema, i.e., provide message interoperability between versions, will be assessed.
AUD01	Audit record of user actions	The solution needs to capture and maintain appropriate audit record of significant user (and other) events/actions. This NFR is consistent with good practice and will assist in the test and learn analysis activities. Auditing would also support the cyber controls that have been established for the DMO solution ecosystem. It will also support tracing transactions from originator to approver to final disposition, through a system by an auditor. Specific validation of this NFR includes validation of user action (e.g., manual data modification) and recording all Business To Business (B2B) and Business to Market (B2M) communications.
SUP01	Technical and non-technical support required for the system. Solution must be supportable	Support from the DMO application providers would be required including: • Technical – to support the implementation, evolution and remediation of the underlying platform components • Non-technical support included project management, documentation, etc The DMO would provide the requisite support of the underlying infrastructure. Without appropriate support capabilities, extending the Pilot or migrate the solution to support a production solution would not be viable. The following specific aspects were going to be assessed: • System errors / failures will report back relevant error messages for troubleshooting; • System errors are logged and accessible for support staff; and

ID	Non-Functional Requirement	Commentary
		• Business support staff are able to manage and view test data being processed or configured.

Table 17: Non-Functional Requirements of the DMO solution

7.3 DMO Platform Delivery Approach

The Project Symphony Functional and Non-Functional Requirements[25] (*Project Requirements*) report details the approach AEMO undertook to develop the conceptual design, specifications and requirements and procurement of the DMO platform.

Two vendors were identified to jointly deliver the solution, and an incremental/agile approach was adopted for the delivery of the required technical capabilities for the allocated budget and project timelines. The approach enabled:

- The progressive delivery of the four core must-have scenarios.
- Separation from the existing market and system applications supporting the WEM to be maintained so there were no unintentional impacts on the WEM wholesale market.
- A Leveraging of the capability/solutions being developed for WEM reform:
    - Allowed these changes to be considered within the project scope (particularly integration requirements)
    - Allowed the ability to extract and adjust real wholesale market data to drive the DER market behaviour/test scenarios
- Support for a test and learn process to demonstrate the necessary organisational and technology capabilities needed for Project Symphony.
- A data reporting and analysis platform to support the execution of the project and the test and learn process.
- Evolving the DMO solution as new learnings and requirements emerged from the various implementation drops and evolving industry/market context.
- Alignment and support with the delivery of similar capabilities for Project EDGE to minimise the overall costs and maximise value to both the WEM and the NEM.

Upon execution of the vendor contracts, intensive workshops were held with vendors to further define the platform requirements and develop technical specifications to guide the platform build. A third party helped project manage the vendors to deliver and support the single solution. As the design was completed in conjunction with the project participants, the initial platform build commenced once the BMO scenario design was progressed to detailed design for the core functionality and data models, platform integration methodology and schemas were defined.

The initial platform deployment for the BMO scenario was considered the minimum viable product (MVP) and deployed and tested with partner platforms during the first phase of customer recruitment

[25] Project Symphony Platform Functional and Non-Functional Requirements, Electricity Networks Corporation, February 2022, Section 3

of PV and battery DER assets. An associated delivery and defect resolution process was developed and adopted to support delivery of the DMO platform and the partner requirements.

Subsequent platform deployments over the next 16 months delivered the remaining three scenarios, final functionality and final assets. Test and learn hypothesis, data management systems, and reporting templates were developed in parallel to align platform capability with project objectives.

7.4 DMO Platform Assessment

This section assesses the DMO platform delivered by Project Symphony using the solution context defined in Section 2.3.2. This section follows the same order, namely

1. Functional Requirements
2. Principles/Design Criteria
3. Non – Functional Requirements.

The following table provides a rationale and assessment of how well each core requirement has been supported by the solution. The framework uses the Red, Amber, and Green (RAG) assessment scoring approach. The meaning of each of the RAG scores follow:

- Green: All relevant aspects are supported/delivered.
- Amber: Most of relevant aspects are supported/delivered.
- Red: None or minimal relevant aspects are supported/delivered.

Business Function	Functional Assessment	Functional Assessment Commentary
Register Participant	GREEN ●	• The ability of an aggregator to nominate to participate in the DER energy market - Participant Onboarding & Participant Enrolment • The ability of the aggregator to successfully register a facility with AEMO - Aggregator Facility Registration
Process Facility and Constraint Data	GREEN ●	• The solution components delivered allows the DMO platform to receive, then process and store, the operational market data from the Aggregator and DSO. • The solution integrations allow the DMO to receive data that represents NMI constraint, NSS contractual commitment and facility capacity and status.
Manage Bids and Offers	GREEN ●	• The solution components delivered allows the DMO platform to receive, then process market bids and offers from the Aggregator. • The solution also allows for the ability to manage variations to standing bids and

Business Function	Functional Assessment	Functional Assessment Commentary
		offers in response to NSS, market demand and price triggers . • The solution integrations allow the DMO to receive RTMS data in a manner that supports AEMO's capability to maintain operational control of the WEM.
Manage Dispatch Instructions/Control Signals	AMBER 🟡	• The solution components delivered allows the DMO platform to send pre-dispatch instructions and dispatch instructions to the Aggregator. • The solution caters for instructions to be sent for all services including energy, NSS and ESS-CR as well as for a CTZ scenario • The solution integrations allow the DMO to send instruction data in a manner that supports a real time DER market and also receive a confirmation response from the Aggregator
Reporting and Performance Assessment	GREEN 🟢	• The solution components delivered allows the DMO platform to collect and provide to the DMO data lake the following DER Marketplace data 1. transactional and static data 2. incoming and outgoing message data 3. time series data • The solution provides all data processed or published by the platform to DMO's Enterprise Data Lake within the DMO data lake allows the DMO to perform analysis of the operations of the market and expected outcomes of DER orchestration in the WEM/SWIS
User Modifiable Test Variables.	GREEN 🟢	• The solution components delivered allows system variables within the DMO platform to be configured without coding effort

Table 18: Assessment of DMO Platform Against Initial Requirements

As indicated in section 7.1.2, a set of principles and design criteria was defined. These are assessed in table 18 below.

Principle/Design Criteria	Alignment	Commentary
Meet the Pilot requirements at a minimum.	GREEN 🟢	The DMO solution meets the Pilot requirements. Refer to Appendix C which covers the alignment of requirements and solution capabilities in more detail

Principle/Design Criteria	Alignment	Commentary
Have the potential to scale to meet additional participants (Aggregators)	GREEN 🟢	The underlying solution and technologies could scale vertically and horizontally to support additional aggregators and facilities. Determination of the scaling limits of the overall solution has yet to be determined. AEMO's sister project, Project EDGE, has confirmed the ability for the platform to support multiple Aggregators (parent). Project Symphony does not require additional Aggregators to be added.
Be simple for additional participants to join and utilise.	GREEN 🟢	From a DMO perspective, this requirement has been met as the DMO consumes the data from the DSO and the Aggregator. The Data Exchange solution enables participants to install their solution within their environment. For Project Symphony, this has been less of a challenge due to the smaller cohort of actors involved and their associated digital capabilities than that for Project EDGE. However, the solution has demonstrated the capability and benefits of multiple participants joining via the Data Exchange solution
Be able to manage high frequency telemetry data.	AMBER 🟡	The ability for the overall solution to transfer high frequency telemetry data in a timely fashion (i.e., less than five minutes) has been identified as a potential issue. Further analysis will be required in this area.
Preferably be a SaaS solution, and at a minimum be hosted on a Cloud based Platform.	GREEN 🟢	The two core elements of the solution, the "integration layer" and the "Data Exchange / Identity and Access Management layer", are deployed in a cloud environment. Refer to section 7.1.1 for further details.
Have the ability to be easily modified to align to market rules once they are defined.	AMBER 🟡	The DMO platform was implemented to deliver a specific set of scenarios per the Project agreed scenarios and detailed design. As there is uncertainty around both the requirements for the DMO and Aggregator under future rules the flexibility needs of the platform is unclear

Principle/Design Criteria	Alignment	Commentary
Have the ability to integrate with market systems in the future.	AMBER 🟡	As mentioned in Section 7.1.1, market pricing dispatch data is currently provided into the Pilot. As WEM reform[26] is still progressing, the ability to fully integrate with the relevant systems (e.g., WEM Dispatch Engine) has yet to be assessed.
Align to the AEMO security principles and governance.	GREEN 🟢	The solution has been assessed against AEMO security requirements and has been endorsed. Alignment with AESCSF has also been included as part of the cyber assessment.
Operate in an off-market environment for the duration of the Pilot.	GREEN 🟢	The market operates in an off-market environment. However, as mentioned in section 7.1.2, data ingested into the solution represents both real and simulated market conditions to enable the Pilot objectives to be met.

Table 19: Assessment of the DMO solution

Non-Functional Requirements (NFR) are an overarching element spanning the DMO solution. Table 20 assesses the degree to which the DMO solution met each NFR.

ID	Non-Functional Requirement	Alignment	Commentary
SEC01	Security of platform	GREEN 🟢	Penetration testing has undertaken and identified no critical issues or exposures. Cyber design obligations confirmed.
PER01	Platform performance measured by response time	GREEN 🟢	Formal validation yet to be undertaken of the performance of the solution. Informal assessment indicates target response times are being achieved.
SCA01	Ability to scale up or out	GREEN 🟢	Project EDGE has confirmed the ability of the solution to support additional aggregators. In project Symphony, there is no requirement to go beyond one parent aggregator. Internal performance testing with up to 10 Aggregators demonstrated the ability of the solution to support additional aggregators

[26] AEMO | WEM Reform program

ID	Non-Functional Requirement	Alignment	Commentary
SCA02	Capability of platform to add additional users without any noticeable impact to services	GREEN ●	The solution could scale to support additional users. Project EDGE has confirmed this requirement can be met. Additional users have been provisioned to access components associated with the intelligence layer. Internal performance testing with up to 10 Aggregators without noticeable impact to services. The effective upper limits for the solution have yet to be determined.
AVA01	Capability of platform to run without a failure for a given period of time	AMBER ●	The project is ongoing so the solution has not yet demonstrated the ability to run without failure for the duration of the project.
MAN01	Periodic maintenance window	GREEN ●	This NFR has been successfully met.
REC01	System restoration objectives and ability to recover	GREEN ●	RTP and RPO targets can be met from the current solution and supporting infrastructure.
REC02	Data backup and retention objectives	GREEN ●	The DMO infrastructure provides these capabilities.
DAT01	Backup daily	GREEN ●	The DMO infrastructure provides these capabilities.
INT01	Handle multiple versions of schema	GREEN ●	The Data exchange layer provides these capabilities.
AUD01	Audit record of user actions	GREEN ●	Vendor solutions provide auditing of user actions and messaging. The DMO platform includes other forms of auditing that complements these two solutions, principally in the cyber domain.
SUP01	Technical and non-technical support required for the system. Solution must be supportable	GREEN ●	Support has been provided by the vendors and the DMO for the Pilot.

Table 20: NFR Assessment of the DMO solution

7.5 DMO Platform 'As-built' Solution Overview

7.5.1 Component Overview

This subsection describes the core components making up the DMO platform solution. The solution components introduced in section 7.1.2 are described in further detail in figure 4. The additional detail provides the framework to describe how the overall solution meets the Pilot requirements. Note, figure 4 has a set of identifiers that provide the link between it and table 20, which defines each component in more detail.

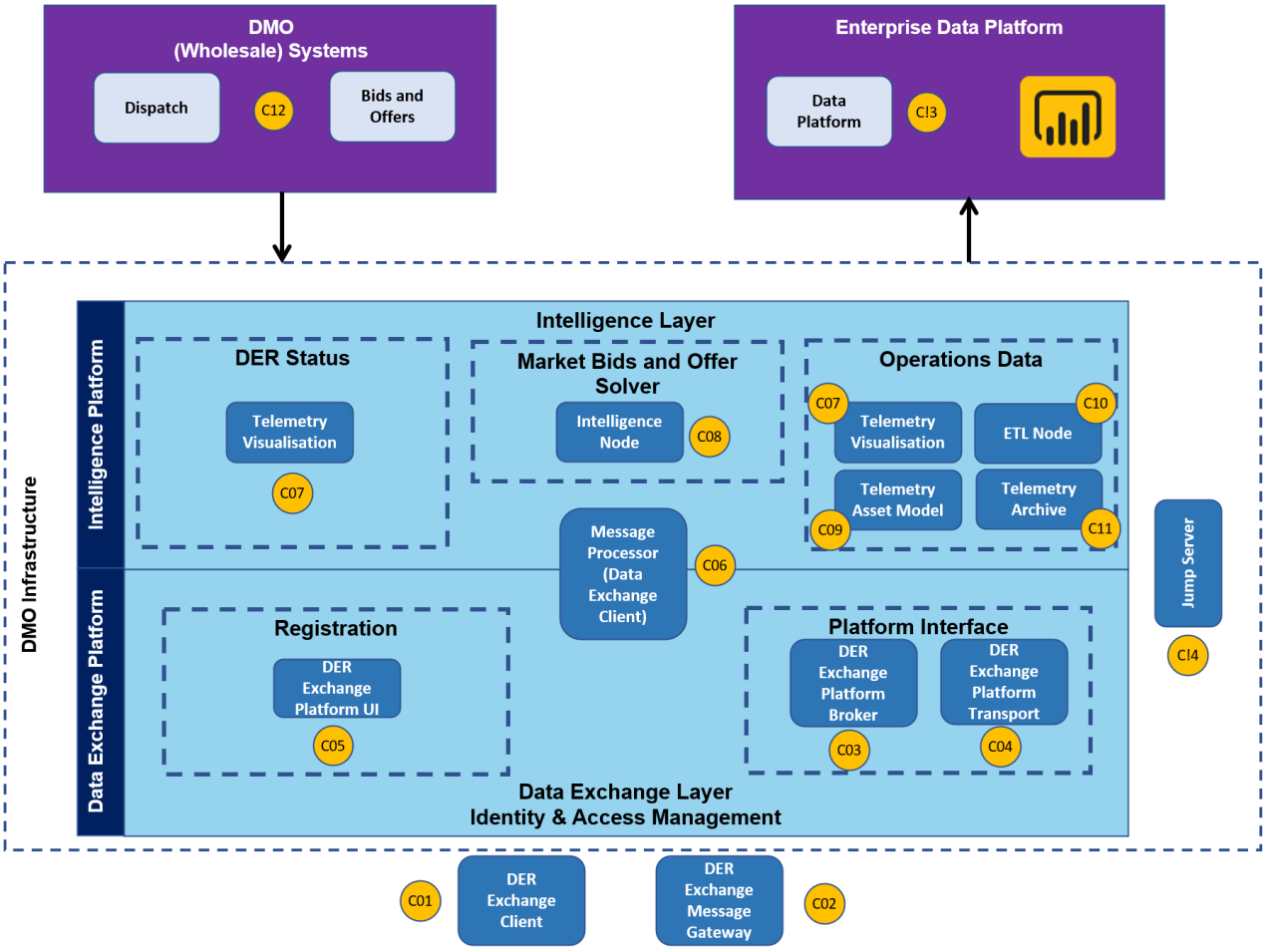

Figure 6. DER Integration Platform Solution

The table below describes each component in more detail using the IDs in the figure above as a cross-reference between the table 20 and figure 4.

Component ID	Component Name	Description
C01	Data Exchange Client	Data Exchange Client is the messaging service of the Data Exchange Message Gateway. Data Exchange Message Gateway SDK is intended to run on-premises or in participants' cloud environment to interact with the Data exchange layer Broker (C03) via a gateway (C02). The gateway is the central point for participants' integration with the solution. The client will authenticate, authorize, and encrypt messages using self-sovereign identities and verifiable credentials (rather than centrally trusted and managed approaches seen in legacy solutions).
C02	DER Exchange Message Gateway	Message gateways have endpoints to authenticate, publish, and subscribe for the message sending/receiving (via Topics which define the channels by which messages can be exchanged). Users/systems need to implement a client application to make a call to those endpoints successfully. To make this process easy and user-friendly, a Data Exchange Client library was developed which consists of publish, subscribe, authenticate, and sign functions.
C03	Data Exchange Message Broker	The Message Broker is the endpoint to which the users/systems connect to publish or subscribe to the message delivery system. The Data Exchange Message Broker checks if the channel name exists and users/systems have the right roles to publish/subscribe to messages.
C04	Data Exchange Platform Transport	The Transport capability is used to transmit messages from one Message Broker to the other. Message Transport stores the messages until they expire. Only Message Brokers can publish and subscribe on the Message Transport.
C05	Data Exchange Platform UI	A dApp (decentralized app) allows users to manage role definitions and participate in credentials exchange (request/issuance) for role credentials.
C06	Message Processor	The purpose of the Message Processor is to receive messages from market participants and to send messages to market participants Data Exchange layer using the DER Exchange Client. The Message Processor will subscribe to messages from the Data exchange layer Broker, authenticate them to determine the sender, map the sender to the appropriate Role within the

Component ID	Component Name	Description
		Intelligence Layer, and perform the requested operation associated with that role.
C07	Telemetry Visualisation	There is no direct communications to Intelligence Platform components with the exception of the Telemetry Visualisation capability. Telemetry Visualisation "tool" displays data using the Telemetry Asset Model and the Telemetry Archive solution. The Aggregators and DSOs access to specific data in the DER market platform will be provided via the Data Exchange Platform Brokers using pre-defined SQL queries.
C08	Intelligence Node	The Intelligence Node runs the Market Solvers. The applications running on this node are responsible for assessing the data fed into the Market Place, apply the relevant business rules for each market, and output results to the data stores. Message Senders on the Message Processor will pick up the result set and publish them to appropriate recipients via the Data exchange layer Broker(s).
C09	Telemetry Asset Model	The Telemetry Asset Model holds configuration information as well as Model information for all participants and resources under their control related to the Market Place. Its underlying storage consists of tables stored in the Virtual Machine running Microsoft SQL Server.
C10	ETL Node	The ETL Node will be responsible for extracting data out of the Intelligence Layer (and Data exchange layer Broker, if needed), Transforming the data into a format acceptable for ingestion into the DMO Data Platform and loading the data into the related Warehouse/Lake. This ETL processes running on this node require credentials to access the DER Exchange Platform Broker, query the Intelligence Layer, and write into the DMO Data Platform.
C11	Telemetry Data Archive	The Telemetry Data Archive is responsible for storing time series data (i.e., data that varies over time), telemetry and dispatches, but not data for which multiple alternative values coexist at the same time (e.g., past boffers for a given time period that were superseded by revised boffers from the same Market Participant).
C12	Dispatch Bids and Offers	The current DMO's Wholesale Market dispatch engine used to provide dispatch interval pricing data to allow the off-market simulated pricing for both Energy and ESS Contingency

Component ID	Component Name	Description
		Reserve Raise to be operated using real market data as an input.
C13	Data Platform	Data warehouse and visualisation capability provided by DMO used to support analysis of relevant data associated with the Pilot.
C14	Jumper Server	Before any users may access any virtual machines in the Trusted or Secure Zones, users must first go through a Jump/TS Server. The use of a Jump/TS Server seeks to maintain a strong cyber security posture in the overall solution.

Table 21: Components of the DMO solution

Table 22 maps the solution components against each of the relevant functions/capabilities defined in section 7.1.2 and illustrates which solution components are required to enable each capability.

Function ID	Solution Capability (from the solution Tech Spec)	C01 – Data Exchange Message Gateway	C02 – Data Exchange Client	C03 – Data Exchange Message Broker	C04 – Data Exchange	C05 – DER App UI	C06 – Message Processor	C07 – PI	C08 – Intelligence Node	C09 – PI AF	C10 – ETL Node	C11 – PI Data Archive	C12 – RTDE	C13 – EDP/PowerBI	C14 – Jumper Server
F01	Participant Onboarding	✓	✓	✓	✓	✓									
F02	Participant Enrolment	✓	✓	✓	✓	✓									
F03	Aggregator Facility Registration	✓		✓	✓										
F04	NSS Service Registration Data Processing			✓	✓										
F05	DSO NSS Deployment Signal Data Processing			✓	✓		✓		✓						
F06	Dynamic Operating Envelope Data Processing			✓	✓		✓		✓						
F07	Market Forecast Price Data Publication				✓		✓		✓						
F08	Forecast and Market Price Data Processing				✓		✓		✓						

Function ID	Solution Capability (from the solution Tech Spec)	C01 – Data Exchange Message Gateway	C02 – Data Exchange Client	C03 – Data Exchange Message Broker	C04 – Data Exchange	C05 – DER App UI	C06 – Message Processor	C07 – PI	C08 – Intelligence Node	C09 – PI AF	C10 – ETL Node	C11 – PI Data Archive	C12 – RTDE	C13 – EDP/PowerBI	C14 – Jumper Server
F09	Facility Telemetry Data Processing				✓		✓		✓						
F10	Control Room User Interface									✓					✓
F11	Facility Forecast Data Processing				✓		✓								
F12	Processing Real Time Market Submissions (RTMS)		✓	✓	✓		✓		✓				✓		
F13	User Modifiable Test Variables						✓		✓						
F14	Out of Merit Dispatch						✓		✓						
F15	Constrain to Zero Scheduler						✓		✓						
F16	In Merit Market Solver						✓		✓						
F17	Dispatch Instructions Publication	✓	✓	✓	✓		✓								
F18	Pre-dispatch Instruction Schedule Publication	✓	✓	✓	✓								✓		
F19	Platform Data Storage										✓	✓			
F20	Platform Data for analysis							✓			✓			✓	✓

Table 22: Solution components mapped to functionality

7.5.2 Data exchange layer

The Data exchange layer is a core part of the solution architecture described in Section 7 of the ARENA Project Symphony Platform Functional and Non-Functional Requirements[27] report. The Data exchange layer provides the underlying capability to enable the interfaces described in table 21 (above). The layer includes many elements, this section focuses on the two most significant aspects – the Data Exchange mechanism and the authorisation and authentication (authn/authz) mechanism.

[27] Project Symphony Platform Functional and Non-Functional Requirements refers to the data exchange layer as a distributed service bus.

7.5.2.1 Data Exchange Mechanism

The simplified model of the Data Exchange mechanism is illustrated in figure 5. The core component of the model is the Data Exchange message broker which serves as a messaging hub for the principal actors in the project. The message broker is equivalent to the distributed service bus mentioned in the ARENA Project Symphony Platform Functional and Non-Functional Requirements[28] report, and supports the list of capabilities enunciated in Section 7 of that report.

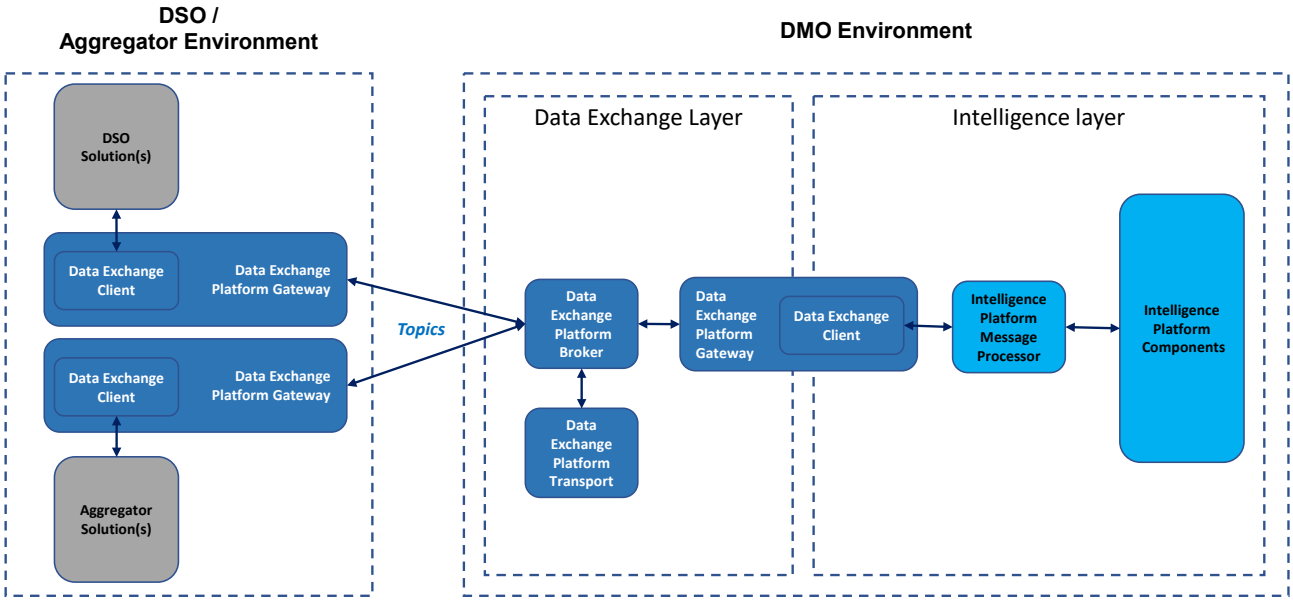

Figure 7. Data Exchange Mechanism

The key components comprising the Data Exchange mechanism, as illustrated in figure 5 are:

- Data Exchange Client – the mechanism by which solutions outside the vendors environment can exchange (publish or subscribe) data with the intelligence layer in a consistent and secure manner.
- Data Exchange Platform Gateway – the container containing the software components to support the interacting with the message broker.
- Data Exchange Platform Broker – a messaging hub (or distributed service bus) through which messages are published or subscribed to across the DER ecosystem.
- Data Exchange Platform Transport – provides a mechanism through which messages can be "bridged" between different message gateways securely and reliably. A message archive associated with the transport component is used which keeps a persistent log of all messages exchanged.

[28] Project Symphony Platform Functional and Non-Functional Requirements refers to the data exchange layer as a distributed service bus.

Each participant's container (Data Exchange Platform Gateway) provides the capability to send/receive messages asynchronously with other peers within the common messaging infrastructure.

The container contains topics or channels which act as a conduit through which messages can be published or subscribed to in the Broker. Access to topics is managed via the authn/authz approach which is described in the next section. Schemas are defined for each topic describing the nature of the data (or the interface payload) that is exchanged. Schema for each channel or integration are listed in Appendix D of this report.

7.5.2.2 Authorisation and Authentication

The authorisation and authentication element implemented by the vendor is principally based on the use of blockchain technology and open-source standards.

Registration to use the system is via a Gateway UI which establishes a credential, a decentralised identifier (DID) enabling participation (when approved by the DMO) and for encryption/decryption of messages (delivered by topics). Localised DID documents provide the mechanism by which the credential and associated claims (i.e., what can be done) are managed and maintained within the containers mentioned above.

The use of Self-Sovereign Identity (SSI) technologies to support the DID documents enables participants to maintain their own credential certificates for accessing the hub or Data Exchange Message Broker. Secure communications between participants (the DSO and Aggregator) and DMO is managed by IP Whitelisting and MTLS certificates. The use of Distributed Ledger Technology (DLT) allows a verifiable data registry to be managed across all the DER market without relying upon a centralised authority. The Verifiable Credentials (VCs) maintained with the registry provide the digital credentials that support the identification and non-repudiation of the messages exchanged.

7.5.2.3 Multiple Data Exchange Message Gateway Nodes

To bring the Data Exchange mechanism and the authorisation and authentication (authn/authz) mechanism together, each participant or actor hosts their own container in their environment (the Data Exchange Message Gateway). The distributed service bus or hub environment is composed of multiple Data Exchange Message Gateway nodes interacting with each other through the transport layer (Data Exchange Message Broker). Each node (or multiple nodes) in the cluster is identified with a unique Decentralised Identifier (DID).

Blockchain technology enables each participant to create and maintain this unique and persistent identifier (DID) for which they retain full control. This identifier enables the encryption of any messages they generate and determines which topics they can access and use.

7.6 Platform Technology

At a combined level, the principal technologies associated with the solution components are illustrated in figure 6. These are colour coded according to the technology type.

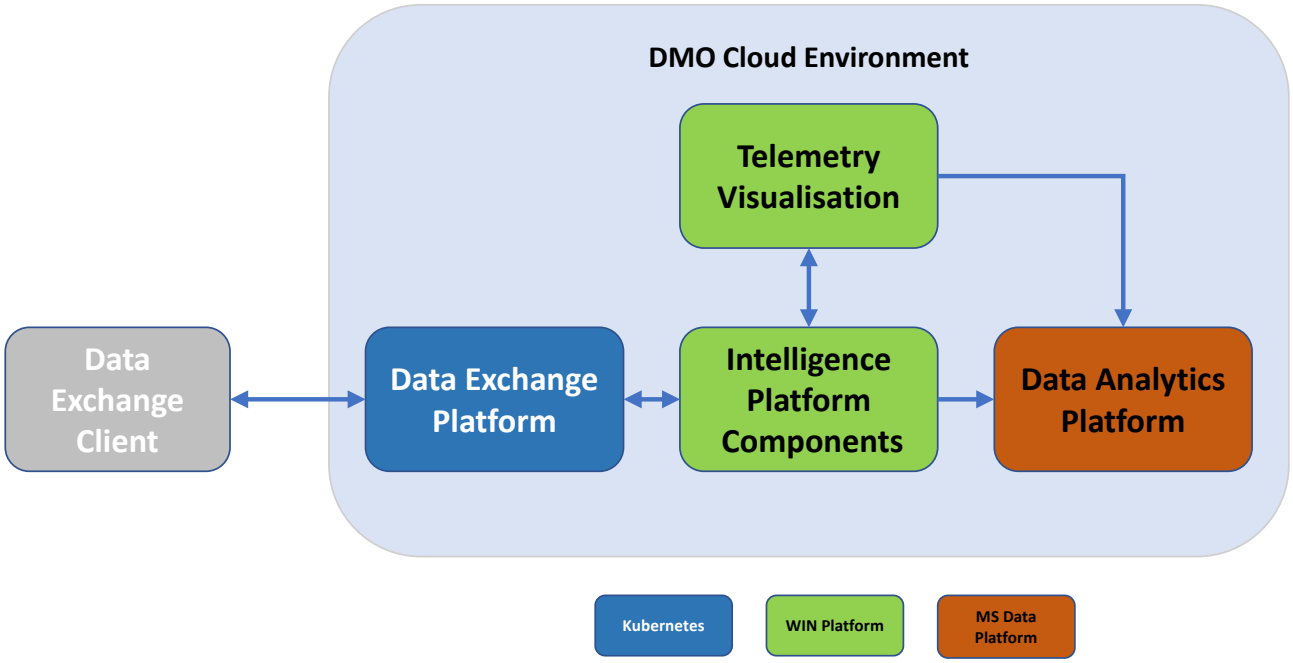

Figure 8. DMO Platform Solution Components

Table 23 describes the supporting technology for each of the solution components detailed in section 7.2.1. Note, some components of the DMO solution are Commercial Off-the-shelf (COTS) products, this report will not cover the technologies used in each product, noting that some products are open source.

Component ID	Component Name	Technology
C01	Data Exchange Client DSB Data Exchange	Microsoft AKS
C02	DER Exchange Message Gateway DSB Data Exchange	Microsoft AKS
C03	Data Exchange Message BrokerDSBData Exchange	Microsoft AKS Microsoft Cosmos
C04	Data Exchange PlatformTransport DSB Data Exchange	Microsoft AKS
C05	Data Exchange Platform UI	Microsoft AKS
C06	Message Processor	Windows Server Mongo DB
C07	Telemetry Visualisation	Windows Server
C08	Intelligence Node	Windows Server

Component ID	Component Name	Technology
C09	Telemetry Asset Model	Microsoft SQL Server Windows Server
C10	ETL Node	Windows Server Microsoft SQL Server
C11	Telemetry Data Archive	Windows Server
C12	Dispatch Bids and Offers	Bespoke developed application
C13	Data Platform	Range of technologies with the Microsoft Azure data offerings including: • Azure Data Factory • Azure Blob Storage • Azure Synapse Microsoft PowerBI
C14	Jumper Server	Windows virtual server

Table 23: Supporting technology of the solution components

7.7 DMO Platform Build Lessons Learnt

This section describes a range of topics and the associated outcomes and/or lessons learnt that pertained to defining and building the DMO platform solution. Whilst the content in this section is perhaps more pertinent to the scope in the ARENA Project Symphony Platform Functional and Non-Functional Requirements report, a range of topics have arisen since the development of that report. Hence, they have been included for completeness.

7.7.1 Defining the Solution

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Adoption of emerging technologies and standards	**Benefit:** The selection of the two DMO principal vendors introduced a range of new technology capabilities. **Barrier**: There was a lack of fit-for-purpose DMO systems in the marketplace.	**Outcome:** A workable solution was established that demonstrated the viability of emerging technologies and approaches. **Outcome:** The solution aligned with emerging DER technology developments worldwide specific to how DER is being supported in other

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			jurisdictions. The adoption of alternative solutions may have reduced the impetus to consider the technology supporting Project Symphony. **Barrier:** There is a lack of skills and understanding of the technology in the local market. **Benefit:** Consideration of new technologies and standards will inform and shape future directions. Particularly the data exchange solution which will demonstrate concepts such as Distributed Ledger Technology (DLT), Self-Sovereign Identity (SSI) and Decentralized identifiers (DID). **Outcome:** The solution required a high level of customisation to ensure if was fit-for-purpose for the Pilot. **Lesson:** The impact and risks of adopting new technologies need to be assessed and mitigated as part of the early project planning and execution. **Lesson:** Initial use and performance testing has demonstrated the data exchange solution has high potential to manage the increased scale of data and higher number of participants expected to be transacted to support DER orchestration.
2	Non-Functional Requirement specification	**Barrier:** Some of the metrics used to confirm the NFR was met were inherently difficult to define given the initial use of the solution as part of a Pilot. The nature of the Pilot meant that the level of investment in technical capability precluded fully meeting various NFR metrics. Likewise, the scale and scope of the NFR was constrained in line with the Pilot.	**Outcome:** Some of the NFRs, whilst valid, were difficult to directly measure and meet. **Outcome:** The underlying monitoring and logging capability to confirm the metrics were not established or the time/cost was prohibitive in implementing them. **Lesson:** A balance between metrics relevant for a Pilot versus a production requirement to be carefully assessed to ensure the correct and appropriate definition.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			Lesson: Confirm the availability of capabilities to support the measurement of NFR targets when the NFR are framed to ensure they can be adequately measured.
3	Vendor relationships	**Barrier:** Although the two principal DMO vendors had relevant experience and track record, they had not previously been engaged to deliver a combined commercial or technical solution. Relationships needed to be established as a necessary prerequisite to undertaking the Pilot. **Barrier:** No integrated software delivery platform was available to support both vendors.	**Outcome:** The adoption of two separate vendors with no previous relationships added complexity and time to the delivery of the Pilot. **Lesson:** The impact and risks of adopting vendors with no previous history would need to be assessed and mitigated as part of any project planning and execution.
4	Alignment with Technology Standards	**Barrier:** The DMO technology standards and patterns imposed a set of requirements on the vendors, which was different to the standard technologies they typically used. **Benefit**: Alignment with technology standards provides benefits such as efficient support and operational activities. The adoption of standards also provided economies of scale, reduced security exposure, etc across the enabling platform(s). Alignment with standards would also facilitate the transition from a Pilot to a more production capable solution	**Outcome:** The requirement to adopt a different set of enabling platform technologies introduced additional risk, cost, and time to the delivery. Vendors had to adjust / augment their delivery/technical resources and practices to deliver solutions. **Lesson:** The impact of technology standards and patterns on vendors be established and factored into the project plan and approach as early as possible.

Table 24: Lessons Learnt: Defining the Solution

7.7.2 Delivering the Solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering delivering the DMO's solution for Project Symphony.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Multiple repositories across DMO & vendors	**Barrier:** DMO managed its design and technical artifacts within its own document management systems. Artifacts needed to be duplicated across all vendor & DMO document management systems	**Outcome:** The DMO had to manage multiple repositories and ensured duplicated documents were maintained. This caused additional effort for version control and artifact management. **Outcome**: Despite multiple repositories, a set of shared documents were developed and maintained to keep the solutions aligned (principally in integration) in lock-step with each other. **Lesson:** A single repository for technical documentation could be adopted and shared across DMO, partners and vendors.
2	Awareness of delivery delays	**Barrier:** A framework for communicating and tracking key dates and requirements was established to ensure there was a common understanding with vendors. However, notification of the inability of vendors to deliver capability was often late in the testing planning and mobilisation activities.	**Outcome:** Testing planning and coordination activities had to be modified, which resulted in project delays and additional costs. **Lesson:** Ensure that the awareness and communication of the delivery timeframes, requirements, and completeness (entry/exit) criteria are well defined and communicated.
3	Incremental delivery approach	**Benefit:** To support a rapid test and learn process and to provide rapid feedback to Project participants, an incremental delivery approach was adopted in which capability was progressively	**Outcome:** Some early design decisions and specifications had to be reversed as a more comprehensive solution was delivered after delivery limitations were identified. In some cases, the original intent of the DMO's

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		delivered across the hybrid business "ecosystem". **Barrier:** Early design decisions and specifications had to be reversed as a more comprehensive solution was delivered. **Benefit:** Incremental delivery supported the ability to provide rapid feedback on the suitability of the overall solution, and to assist in the evolution of the overall solution and market. Functional enhancements and defects were identified earlier in the delivery process. These items could then be incorporated into subsequent solution iterations. **Benefit:** The test and learn process was able to commence early in the process to assist in the delivery and confirmation of capabilities delivered.	approach/solution had to rebuilt/refactored as the project progressed. (For example, the original intent was for the Aggregator to dispatch from the DI but was changed to dispatching off pre-dispatch).
4	Deployment in non -production environments	**Barrier:** To reduce costs and to maximise flexibility in code delivery and solution configuration, the DMO solution was delivered and operated from a test environment rather than production environment. The standard monitoring and logging technologies deployed in a production environment were not available to the project (imposing additional costs and support overheads).	**Outcome:** Monitoring capabilities were not in place to rapidly identify issues such as lack of data delivery which impacted test and learn activities. Manual monitoring and invention were required as a result of automated monitoring and alerting capabilities not being in place. **Lesson:** The rationale and implications of this deployment approach needed to be communicated to partners to ensure expectations and a shared understanding of the

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			benefits of cost and flexibility in code and solution vs. the processes and disciplines of a production environment is required.
5	Visibility of Vendor's System Integration Testing (SIT) Outcomes	**Barrier:** Vendors' SIT approach and outcomes were not made visible to the project team in the early part of the project. As a result, the completeness of internal testing before release was unclear which had adverse impacts. **Benefit:** In response to these challenges, a robust three phase process was established: • The DMO developed a list of test requirements • The vendor would take this information and develop a detailed vendor SIT plan. The vendor executed a walkthrough of the testing (live or a recording) according to the test plan	**Outcome:** Some gaps in the solution were exposed during cross SIT in the QA environment and other testing, resulting in delays and additional costs. **Lesson:** Robust vendor-related SIT processes are established early in a project, which also produces auditable evidence of the vendor's SIT outcomes.
6	Different projects shared the same environments	**Barrier:** Two projects, Project EDGE and Project Symphony, shared the same underlying infrastructure and solutions. This created delivery complexities due to each project's schedules. **Benefit:** The overall cost to the DMO was lower than otherwise would have been the case. **Benefit:** The sharing of the same platforms enabled developments to be shared across both projects (where there was common needs),	**Outcome:** The shared environment created a direct set of dependencies between the project influence and the project execution and timing of both. **Lesson:** Ensure the impacts and implications are fully explored at the commencement of the two projects that share common infrastructure to understand delivery dependencies and impacts.

Table 25: Lessons Learnt: Delivering the Solution

7.7.3 Supporting the Solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering supporting the DMO's solution.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
1	Deployment automation	**Barrier:** The vendor solution did not easily support the use of a Continuous Improvement /Continuous Delivery (CI/CD) pipeline. Manual intervention was required to promote software changes to the test (and QA) environments.	**Outcome:** Operational overheads were higher when CI/CD pipelines could not be used – this also impacted the ability to support automated code inspections. **Lesson:** In line with modern practices, ensure that software can be deployed in via a CI/CD pipeline primarily to support a DevSecOps approach which that underpinned the delivery of the Pilot (and supports the cyber security obligations of the DMO).
2	Configuration consistency	**Barrier:** The configuration between the development and the test/QA environments were different for a period of time.	**Outcome:** Software migration issues and testing outcome misalignment between the different environments created additional support and testing issues until the root cause was identified. **Lesson:** Ensure appropriate documentation, configuration and change management across all technical environments. **Lesson:** Ensure all the correct environments are in place for managing the migration of code through to a "production" environment. For example going from QA to trial without a "pre-prod" env that mirrors "production" (i.e. the trial environment).

Table 26: Lessons Learnt: Supporting the Solution

8 Aggregator Platform

8.1 Aggregator Platform Build Approach

The Project Symphony Functional and Non-Functional Requirements[29] (*Project Requirements*) document defines the requirements to deliver a Aggregator Platform for the Project Symphony Pilot.

Synergy's Aggregator solution – known as the Synergy Energy Management System, or SEMS – was developed using Agile-based practices by both Synergy and the aggregator platform vendors. This approach aligned with the explorative nature of Project Symphony, allowing Synergy to incrementally deliver capabilities as required by the overall Project Symphony 'Drop' schedule, to respond to feedback from testing cycles, incorporate new requirements, and to re-prioritise work as needed to meet evolving project objectives.

The SEMS solution, as explained in Section 8.2, consists of both custom-built elements and vendor sourced SaaS-hosted COTS solutions.

The initial build of SEMS based on the misalignment of requirements did not include support for third party aggregators being incorporated into one Virtual Power Plant (VPP) Facility, despite it being a requirement of the scope. When the requirement was later aligned and considered within the platform it lead to rework and increased complexity for a significant portion of the custom build elements.

The custom build elements of the solution were developed using a substantial element of cloud-hosted Platform as a Service (PaaS) services. This allowed Synergy to invest in system capabilities only as required, to pivot on technical platform choices as and when new requirements necessitated change. It also allowed Synergy to take advantage of the breadth of technical platform options available in the major cloud vendor environments to deliver requirements.

The bespoke or custom build elements were coded using modern scripting languages and server-side application frameworks, deployed into cloud hosted application containers, to support Agile development practices and incremental feature delivery.

Given the context of Project Symphony as a Pilot initiative, the solution was built largely on stand-alone implementations of solution components – even where the selected solution is an incumbent technology or vendor platform within Synergy – to minimise risk to the stability or operational behaviour of existing enterprise systems. At the same time, the custom solution components developed by Synergy for Project Symphony have been hosted within Synergy's cloud tenancy to benefit from existing enterprise-wide capabilities – such as network and cyber-security controls.

[29] Project Symphony Platform Functional and Non-Functional Requirements, Electricity Networks Corporation, February 2022, Section 3

8.2 Aggregator Solutions Architecture

8.2.1 Solutions Principles

The following four Synergy Enterprise Architecture principles have specifically influenced the design of SEMS:

Principle	Description	Applicability
Secure End to End	Technology and information is secured in accordance with technology policies, security patterns and the risk to the grid, enterprise or it's stakeholders, customers, partners and employees	SEMS will have operational control of customer assets, with the potential for financial, safety and reputational damage if asset control is compromised. The platform will therefore apply best-practice security end-to-end to reduce risk to customer assets so far as is reasonably practical.
Mature Solutions	Cutting-edge technology or vendors were avoided to minimise technical risk and resource constraints, unless specifically innovating for business advantage.	While mature solutions were preferred, operational control of DER assets aggregated as VPPs is a still developing solution domain, with no one vendor providing a complete end-to-end solution. To achieve test and learn goals, Synergy worked with multiple vendors to meet project objectives, including developing local customisations or enhancements.
Reuse, Buy, Build	Re-use existing applications within the Enterprise, if determined 'fit for purpose'. If there is no option to re-use, select proven COTS solutions to reduce delivery risk, increase supportability and reduce TCO. If there is no fit for purpose COTS solution, develop the solution.	Due to the "best of breed" vendor selection approach (documented previously in The Project Symphony Functional and Non-Functional Requirements[30] the specific requirements of Project Symphony's 'simulated market rules' and operational processes, a substantial element of custom build was required to support both integration between multiple vendor platforms and implementation of features not available in COTS solutions.

[30] Project Symphony Platform Functional and Non-Functional Requirements, Electricity Networks Corporation, February 2022, Section 3

		Therefore, while "buy" was the primary strategy for obtaining many of the core DER/VPP capabilities, "build" was adopted where necessary to integrate or supplement procured solutions.
Cloud First	If appropriate, leveraging SaaS or PaaS solutions is preferred in order to reduce Synergy's overall PaaS debt.	Project Symphony is a Pilot to assess future solution options and business models for incorporating DER assets into the SWIS and WEM. At the completion of the Pilot some or all the current Pilot SEMS solution may be retired, contained or may need redevelopment in light of Test and Learn outcomes. As such, solution components and capabilities were sourced where practical through subscription-based SaaS or PaaS platforms.

Table 27: Architecture Principles

8.2.2 Solutions Overview

At the completion of The Project Symphony Functional and Non-Functional Requirements[31], a high-level logical model was proposed for the Aggregator solution, based on a market assessment of potential vendors and an understanding of their capabilities. That model is repeated here to provide traceability from the logical to the final physical design.

[31] Project Symphony Platform Functional and Non-Functional Requirements, Electricity Networks Corporation, February 2022, Section 3

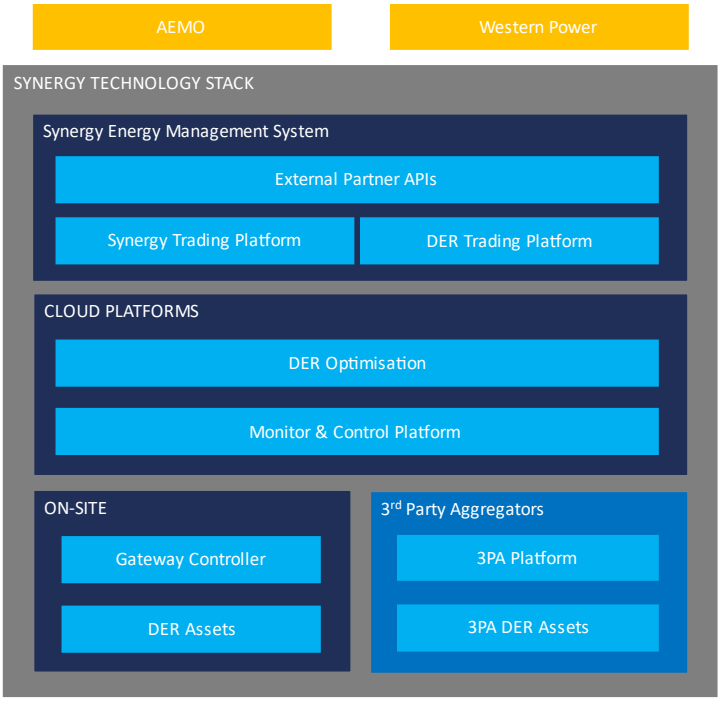

Figure 9 – Aggregator High-Level Logical Solution

The following diagram and table (below), provides a high-level overview of the as-built integrated platforms that make up SEMS. As can be seen by comparing elements across the diagrams, there is a close correspondence between the envisaged solution and the actual platform components implemented to provide the Aggregator solution.

Note that Third-Party Aggregators (3PA) are included in this diagram for contextual completeness. Synergy required 3PAs to provide services to Synergy that possessed an Energy Management System (EMS) for controlling their customer's DER assets. From Synergy's perspective each 3PA's EMS is viewed as a "black box": Synergy provides outcomes-based instructions to the 3PAs and expects the 3PAs to control their assets to those objectives. It is not within the scope of this report to describe or assess each 3PA EMS.

In addition, while 3PAs provide details of their enrolled DER assets to Synergy to enable Synergy to fulfill other market obligations (such as Asset Registration with AEMO acting in its role as the Distributed Market Operator), SEMS does not directly monitor or control individual 3PA DER assets. 3PAs register collections of DER assets as "Asset Groups" with SEMS, and Synergy dispatches and receives telemetry to/from 3PAs at the Asset Group level[32]. As such individual 3PA DER assets are not represented in the following diagram.

[32] See Section 7.2.4,' for further details.

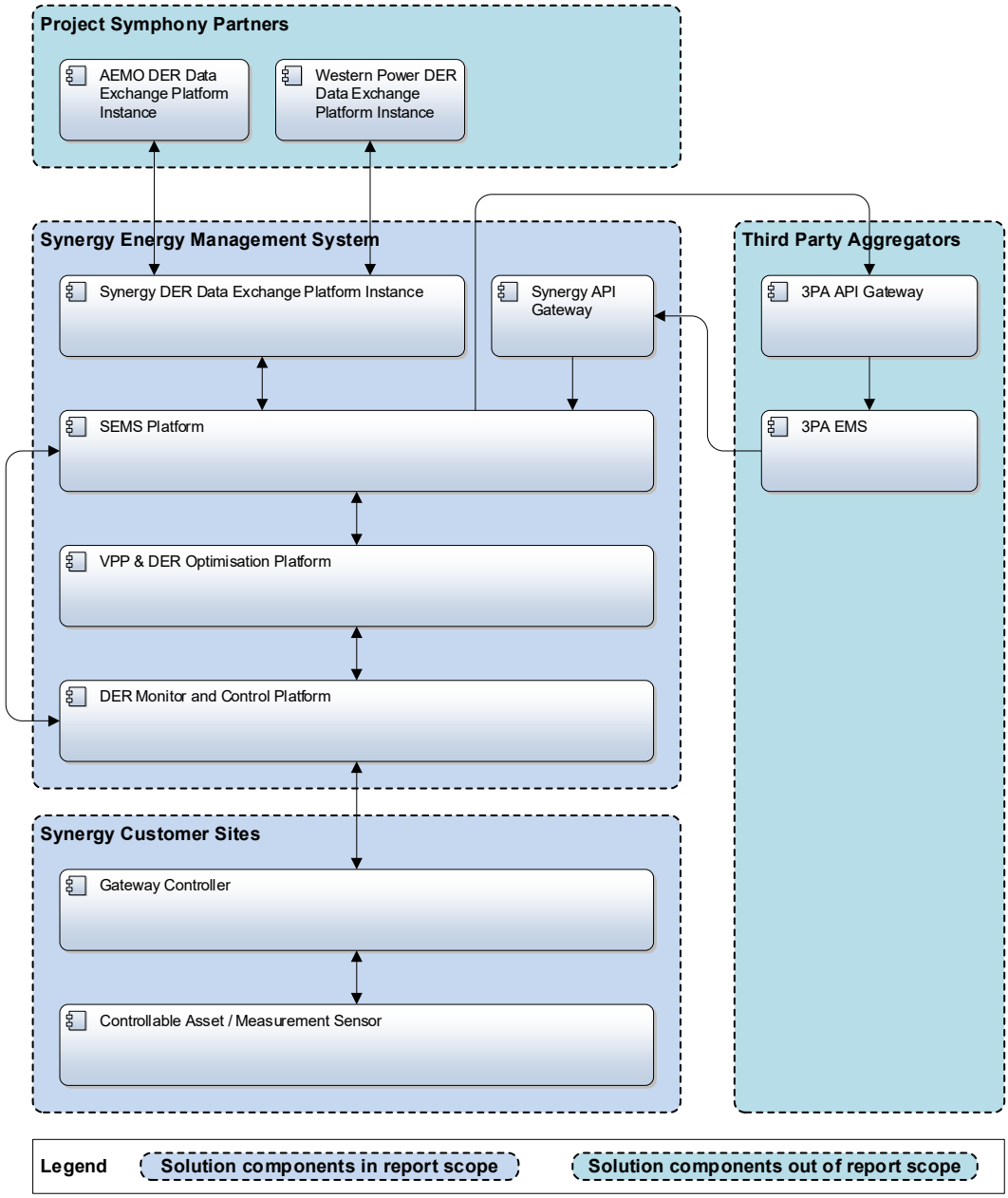

Figure 10 – Aggregator Solution Platform Overview

Component	Purpose
3PA EMS	3PA Energy management System. Each Third-Party Aggregator's functional equivalent to Synergy's SEMS solution. Responsible for forecasting, optimising, controlling and monitoring DER assets operated by the 3PA.

API Gateway	A platform for hosting web-services based on open industry standards such as REST, JSON and HTTPS. Enables the secure publishing of internal APIs to external business partners via the internet. In the case of Project Symphony, used by Synergy to expose SEMS hosted APIs to Third-Party Aggregators. 3PAs are assumed to have an equivalent API Gateway capability to make their internal APIs available to Synergy.
DER Monitor & Control Platform	Provides consolidated management and control of sites where the vendor's Gateway Controller has been installed. Depending on the type of service required, may provide asset level optimisation based on site level objectives provided from the up-stream VPP & DER Optimisation Platform. Provides a centralised location for observing DER asset health, collecting monitoring data and sending setpoint commands to individual Gateway Controller. Provides data from DER asset monitoring to validate a service was dispatched correctly to enable payment of the service.
SEMS Platform	The platform is the designed to interface with AEMO, and Generac to allow RTMS, forecast and Dispatch of the VPP facility submitted Synergy's custom developed solution, used to: • Consume messages from and publish messages to the DER Data Exchange . • Manage reference data and business processes that are not otherwise supported within any of the selected vendor solutions. • Provide contextual awareness for routing messages to either internal systems (for Synergy managed DER assets) or 3PAs (for assets under their control). • Provide a Web UI for SEMS Operators and Traders to manage data and submit and review market transactions. • Provide aggregation of multiple VPPs up to AEMO registered Facility level. • Provide scheduling services for regularly recurring tasks. Route and transform messages between DER Data Exchange and selected vendor solutions.

VPP & DER Optimisation Platform	A SaaS hosted COTS solution responsible for modelling the composition of Virtual Power Plants, defining their operational objectives, and generating events to control DER assets in support of the operational objectives. Determines which DER assets will meet the required demand directly from the DMO or as part of the aggregator optimisation for safety or financial outcomes.

Table 28 – Aggregator Solution Overview – Element Catalogue

8.2.3 Solution Control Loop

As illustrated in the following diagram, the component layers within the overall SEMS solution have been designed to provide increasing scheduling granularity and localised autonomy as control authority moves closer to the actual DER asset.

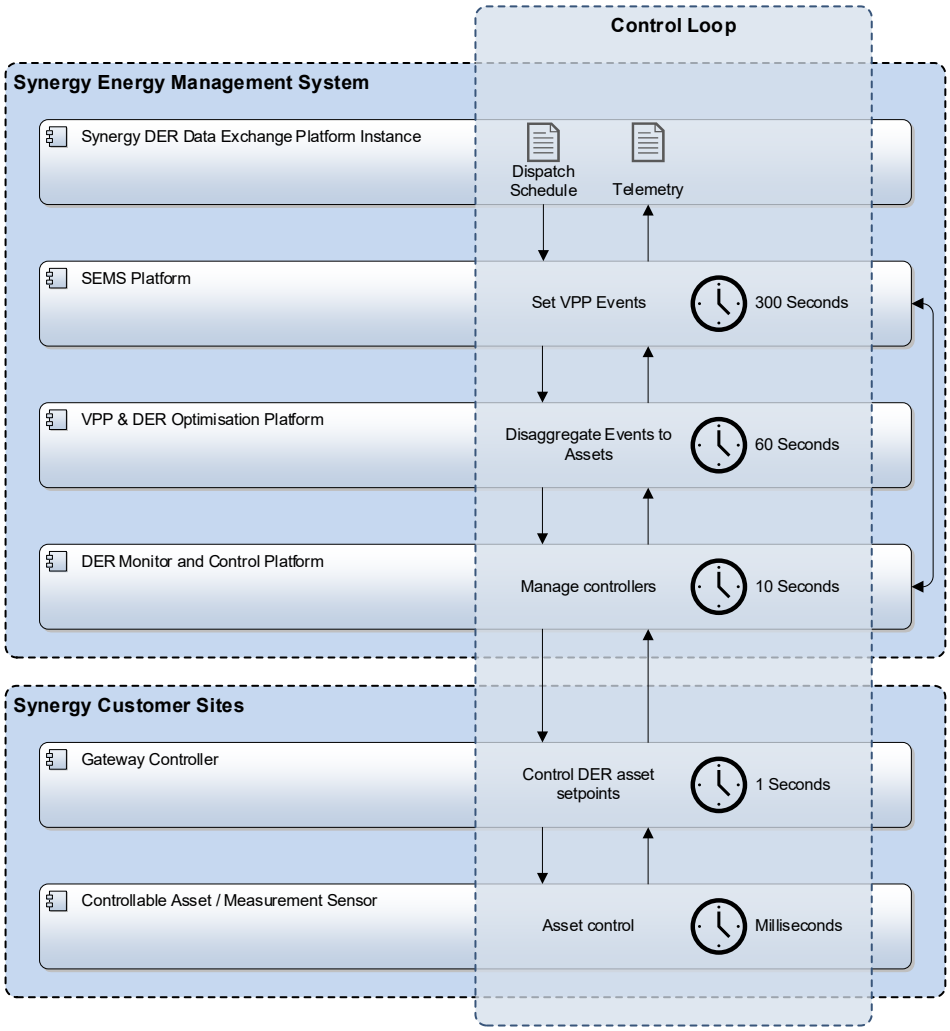

Figure 11 – Aggregator Control Loop Overview

The higher-level platforms maintain an understanding of the behaviour of the system as a whole, while monitoring and optimising over longer time intervals (e.g., market intervals) while lower-level

platforms operate on a more limited view of the state of the overall system but can monitor and react on shorter timeframes.

Each layer applies instructions to the layer below based on:

- Instructions issued from the immediately higher layer in the control hierarchy.
- Aggregated telemetry reported from the immediately lower layer in the control hierarchy.

The layering approach has been designed to provide several outcomes:

- Localised self-optimisation at each layer within the overall objectives that the DER assets are being controlled to.
- Reduced communications and processing workload at each layer.
- Faster response to transient local conditions at the customer site.

8.2.4 Primary Aggregator Managing Third-Party Aggregator DER Asset Control

The following diagram illustrates how SEMS represents and manages 3PA managed DER assets, given that SEMS does not have direct control or visibility of 3PA DER assets.

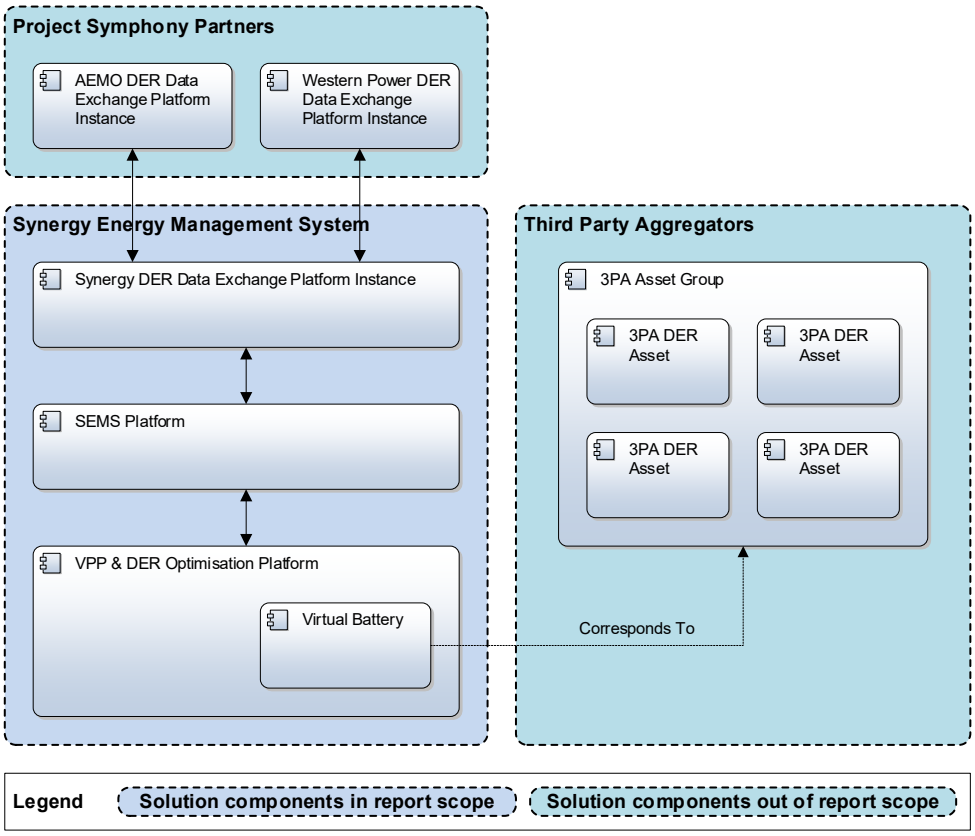

Figure 12 – 3PA DER Asset Control

Each 3PA self-nominates one or more “Asset Groups” to represent a collection of DER assets under their control and management. Each nominated Asset Group is represented within the Aggregator

VPP & DER Optimisation Platform as a corresponding “Virtual Energy Resource”. A Virtual Energy Resource is not in direct communication with the actual DER assets in the Asset Group. Instead, based on information provided by the 3PA, a Virtual Battery is configured for expected load and generation behaviour, including regular updates to forecast base capacity and flex-up and flex-down.

The expected behaviour of the Virtual Energy Resource is to be aggregated together with Synergy managed DER assets when participating in market transactions such as forecasts and bids and offers. When pre-dispatch and dispatch instructions are received, the VPP & DER Optimisation platform SEMS Platformdisaggregates those instructions between Synergy managed DER assets and 3PAs based on the expected Virtual Battery behaviour. The 3PA-specific dispatch instructions are generated at the Asset Group level, and the 3PA is responsible for further disaggregating the instructions to the individual DER assets within the Asset Group. To close the control loop and confirm the requested behaviour was delivered, the 3PA provides after-the-event telemetry summarised to the Asset Group

8.2.5 Solution Component Integration

Automated integrations between SEMS components have been implemented using authenticated, web standards-based, API endpoints over encrypted public internet infrastructure (e.g., REST/JSON over HTTPS).

Integration between the DER Monitor & Control PlatformDER Monitor & Control Platform and the Gateway Controller at a customer site is a singular variation from this pattern: communications between these platforms is provided via 3G/4G infrastructure, secured using a VPN.

Connectivity between the Gateway Controller and any Controllable Asset/Sensor at the customer site is via physical connection to the customer’s home network (e.g., via Ethernet cable). Due to DER assets typically lacking more than one isolated data port (and that port already connected to the customer network for OEM monitoring) the Gateway Controller also needs to be joined to the customer’s home network to gain access to DER assets installed at site. However, communication between the DER Monitor & Control PlatformDER Monitor & Control Platform and the Gateway Controller for DER asset control and reporting is via the internal 3G/4G modem, and does not traverse the customer’s home network.

Some one-off or infrequent and ad hoc information exchanges between Synergy and other Project Symphony partners have been implemented using an authenticated, cloud hosted file sharing service.

8.2.6 Customer DER Asset Integration

The following diagram illustrates the foundational architecture pattern for physically integrating the Aggregator solution with DER assets at Synergy controlled customer sites. Note that there may be minor variations on this architecture for specific customer sites[33], but the substantial portion of customer sites follow this approach. In the diagram, the orange/brown lines are the power

[33] For example, installing a second Gateway Controller in a cluster to support control of DER assets that are too physically distant from each other at a site to connect to a single device.

connection. A core capability for the aggregator is to monitor, control the DER assets and the the collection of aggregation data, The customer data is collected at both the DER and connection point. In addition to this diagram, The grey lines are the communications and control connections

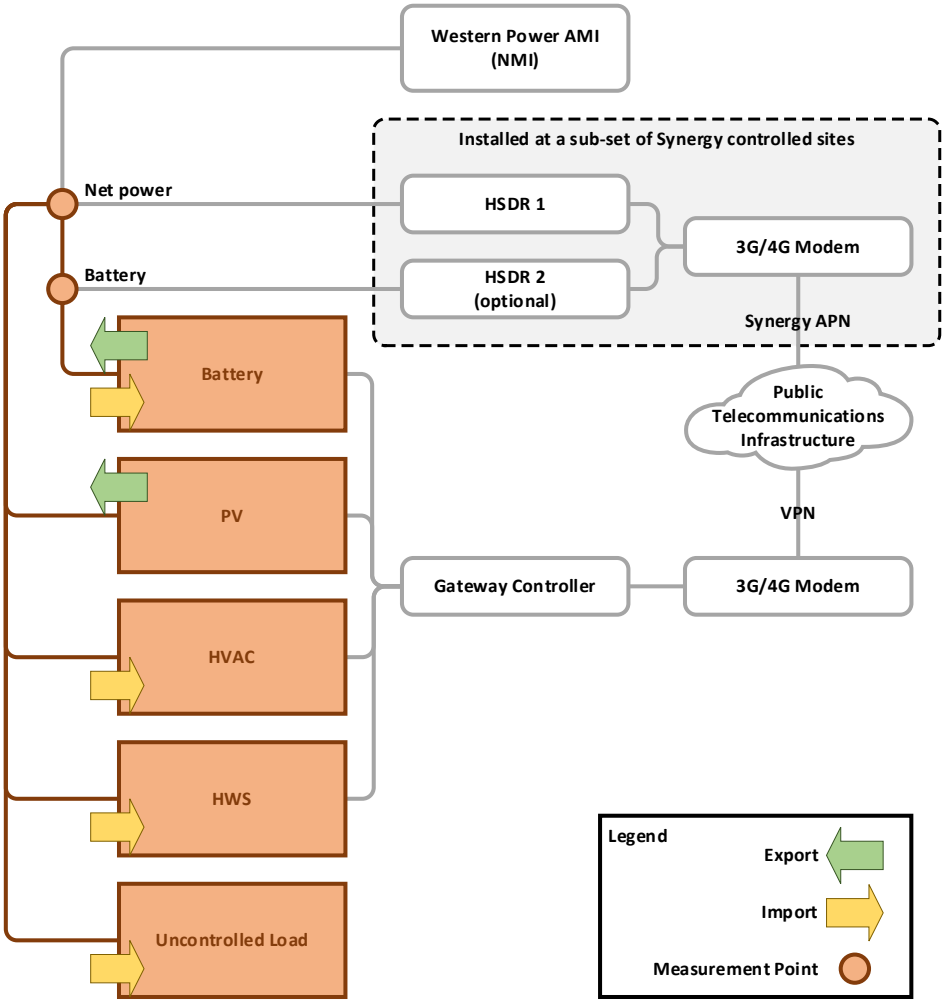

Figure 13 – Customer Site Deployment Model

Controllable DER assets are physically connected to the Gateway Controller installed at the customer site. Given the range of DER asset vendors and models that have been encountered at recruited customer sites and lack of API standards for local integration, installation of the Gateway Controller as built for Project Symphony will need to consider additional configuration or protocol adaptor updates to support DER asset connectivity and control.

To achieve the objectives when conducting Essentinal System Services Contingency Reserve Raise (ESS-CR) Test and Learn events, a sub-set of enrolled sites with AC-coupled batteries have been selected for instrumentation with High-Speed Data Recorders (HSDR). For those sites where Synergy has installed a HSDR, one of two configurations apply: all HSDR measured sites have an HSDR deployed to measure net power (HSDR 1), while approximately a third of sites have an additional HSDR deployed to measure the battery performance (HSDR 2).

Neither the Gateway Controller nor the HSDR have a dependency on a site's home network for operational control and reporting. The Gateway Controller uses a dedicated 3G/4G modem to securely communicate with the overDER Monitor & Control Platform public telecommunications infrastructure via a Virtual Private Network (VPN). A separate 3G/4G modem is similarly used to communicate with the DER Monitor & Control Platform,SEMS Platform although in this case it is over a Synergy specific private APN (Application Private Network) service.

8.2.7 Site Deployment Metrics

The following table provides some key metrics on the scope of the Project Symphony client site footprint[34]:

Metric	Value	Comments
Number of Deployed Sites	356	Individual Customer sites
Number of PV Systems	295	
Number of Inverter Manufacturers	7	
Number of Inverter Models	32	
Sites with Residential BESS	150	120 AC-Coupled, 30 DC-Coupled
Number of BESS Manufactuers	3	5 different models
Network Battery	1	Located at Harrisdale
C&I Behind The Meter Battery with Existing PV array	1	City of Armadale
Third Party Aggregators Assets	195	Across 3 vendors
Third Party Aggregators Customers	163	Across 3 vendors
Sites with Hot Water Systems	30	
Sites with Air Condioners	211	
Number of HSDR	100	
Sites with HSDR	73	

Table 29 – Site Deployment Metrics

From a customer site integration perspective, the most significant metrics are the number of inverter manufacturers and models encountered. The effort and cost for integration between the Gateway Controller and the assets at site are impacted by the lack of standards across manufactures and models, and the resulting need to develop custom adapters.

[34] As at 03/05/2023.

8.3 Aggregator Platform Description

8.3.1 DER Data Exchange Layer

The DMO sourced data exchange layer is provided as a containerised image to each Project Symphony partner. The following remarks on the data exchange layer solution is limited to the perspective of Synergy as a systems integrator: that is, primarily in terms of ease of deployment and integration into the SEMS environment, without making any assessment of the internal design or implementation qualities of the solution.

Name	DER Data Exchange Layer
Description	AEMO provided data exchange layer for authenticating participants and securely exchanging market messages between primary Project Symphony partners. Each partner hosts their own instance of the data exchange layer
Technology	Containerised image provided by DMO to project participants. Deployed into Aggregators cloud hosted, container management environment.
Conformance with Requirements	Message payloads exchanged through the Der data exchange layer have been agreed specifically for the requirements of Project Symphony, and therefore are well aligned.
Scalability	Throughput of single instance sufficient for Project Symphony message volumes.
Reuse	The Data Exchange Platform was specified by AEMO (DMO) for the purposes of data exchange in Project Symphony. Extended use beyong this is a consideration of project recommendations rather than requirements. The DER Data Exchange is viewed as a project specific solution.
Standards	The DER Data Exchange publishes and consumes messages using common industry transport protocols (e.g., web sockets and REST), assisting integration with Synergy systems without dependency on vendor specific client libraries. Provision of a containerised image facilitates deployment into Synergy's cloud environment.
Security	Fit for purpose as a stand-alone solution. Lacks integration with enterprise authentication and authorisation systems.

Technology / Market Maturity	As a Data exchange layer that is being enhanced in response to project requirements, the DER Data Exchange lacks some features commonly found in commercial, enterprise quality messaging platforms. This has necessitated some additional compensatory development in the SEMS Platform component. Further functional enhancements will be required to establish parity with mainstream messaging platforms.

Table 30: DER Data Exchange Platform

8.3.2 API Gateway

Name	API Gateway
Description	A platform for hosting web-services based on open industry standards such as REST, JSON and HTTPS. Enables the secure publishing of internal APIs to external business partners via the internet. In the case of Project Symphony, used by Synergy to expose SEMS hosted APIs to Third-Party Aggregators. 3PAs are assumed to have an equivalent API Gateway capability to make their internal APIs available to Synergy.
Technology	Project Symphony has levereged Synergy's enterprise APIM platform to provide the API Gateway capability. The APIM is a commercial product which is available either as a SaaS offering or as a self-hosted installation. The selected platform supports a wide range of messaging protocols and authentication standards. For Project Symphony, the APIM is self-hosted within Synergy's Cloud tenancy using a containerised image provided by the APIM vendor.
Assessment	
Conformance with Requirements	Published APIs are designed specifically for Synergy's Aggregator requirements of Project Symphony, and therefore well aligned.
Scalability	Self-hosted instances can be scaled as required by deploying additional instances behind a load-balancer.
Reuse	The API Gateway is a general purpose platform for exposing APIs, and is re-usable outside the project. Published APIs for Project Symphony are specific to the requirements of Synergy's Aggregator role, and not intended for use outside that context.
Standards	The API Gateway supports common industry protocols for API publication, and has an extensible architecture for developing custom protocol handlers if required.

Security	While anonymous API access is supported, access to the API Gateway for Project Symphony published APIs requires authentication and authorisation using pre-shared credentials.
Technology / Market Maturity	Synergy's selected platform is well established in the relevant market segment, and there are a number of prominent vendors with equivalent platforms available should the need arise to replace the incumbent.

Table 31: API Gateway

8.3.3 3PA EMS

Description and assessment of individual 3PA EMS is outside the scope of this report. The following comments are limited to the perspective of a systems integrator consuming services from, or publishing services to, Third-Party Aggregators.

Name	3PA EMS
Description	Each Third-Party Aggregator's functional equivalent to Synergy's SEMS solution. Responsible for forecasting, optimising, controlling and monitoring DER assets operated by the 3PA.
Technology	Synergy has no insight into, or dependency on, the internal technologies realising 3PA EMS behaviour. It is not in the scope of this solution to describe the 3PA systems. Interactions are via authenticated REST/JSON-based API calls in either direction, and therefore not tightly coupled to any technical platforms operated by 3PAs.
Assessment	
Conformance with Requirements	API contracts with 3PAs were designed specifically for Synergy's Aggregator role, and therefore are well aligned.
Scalability	Not assessed. 3PA EMS API services support the target recruitment numbers for Project Symphony.
Reuse	Due to their specific design scope, 3PA EMS APIs are limited to supporting only those behaviours required for the in-scope Test and Learn scenarios.
Standards	Interaction with 3PA EMS is via web-based APIs using well supported, industry standard protocols such as HTTPS and REST/JSON.
Security	Access to 3PA EMS APIs require authentication and authorisation using pre-shared credentials.
Technology / Market Maturity	Due to the fact that the 3PA operating model is new to this market, the API definitions and underlying behaviours have required exploration and agreement with contracted 3PAs. Each contracted vendor has been required to develop and publish APIs specific to the needs of Project

	Symphony, as no existing API definitions existed for this type of market participation.

Table 32: 3PA EMS

8.3.4 SEMS Platform

Name	SEMS Platform
Description	Synergy's custom developed solution, used to: • Consume messages from and publish messages to the DER Data Exchange . • Manage reference data and business processes that are not otherwise supported within any of the selected vendor solutions. • Provide contextual awareness for routing messages to either internal systems (for Synergy managed DER assets) or 3PAs (for assets under their control). • Provide a Web UI for SEMS Operators and Traders to manage data and submit and review market transactions. • Provide aggregation of multiple VPPs up to AEMO registered Facility level. • Provide scheduling services for regularly recurring tasks. • Route and transform messages between DER Data Exchange and selected vendor solutions.
Technology	SEMS Platform is a containerised, cloud hosted solution using an assembly of PaaS solutions for foundational capabilities (such as data persistence) and bespoke development for SEMS specific business behaviour. Due to the explorative nature of Project Symphony, SEMS Platform has used modern web-based application frameworks and languages to support agile-based development practices.
Assessment	
Conformance with Requirements	Solution was designed and built to support the specific functional requirements of Project Symphony.
Scalability	In principle could be scaled out due to utilisation of PaaS capabilities to host solution components. Ability for a cluster of SEMS instances to reliably consume messages from a single DER Data Exchange instance not investigated.
Reuse	Implemented capabilities are specific to the requirements of Project Symphony. While consideration has been given to good software development principles, developing a solution that anticipates requirements other than those of Project Symphony has not been a driving concern given the explorative focus of the project. Designing for reuse has also been constrained by balancing project deadlines, budget and resource, requiring tactical decisions at times to achieve project outcomes.

Standards	Integration between SEMS Platform and other platforms is based on open industry standards (e.g., REST/JSON).
Security	Access to the web UI for the solution is limited to authenticated internal Synergy users. Internet accessible APIs are restricted to authenticated and authorised users. API access requires pre-approval and internal configuration by Synergy administrators: self-registration is not a supported option.
Technology / Market Maturity	The underlying PaaS capabilities used by the SEMS Platform are available and well supported across all major cloud vendors (although migration between cloud vendors would require rework to address vendor specific APIs and management controls). The SEMS Platform as a whole has no market equivalents for comparison due to the specific requirements of Project Symphony, which has necessitated custom development.

Table 33: SHEMS Platform

8.3.5 VPP & DER Optimisation Platform

Name	VPP & DER Optimisation Platform
Description	A SaaS hosted COTS solution responsible for modelling the composition of Virtual Power Plants, defining their operational objectives, and generating events to control DER assets in support of the operational objectives. Determines which DER assets will meet the required demand directly from the DMO or as part of the aggregator optimisation for safety or financial outcomes.
Technology	The VPP & DER Optimisation Platform is a SaaS-hosted solution. Automated integration with the platform is via authenticated REST/JSON APIs. User interaction with the Platform is via a HTML5-based web application. While the Platform vendor has shared material with Synergy on their hosting environment, as a SaaS-hosted solution the underlying technology selection and design is not within Synergy's remit and for the purposes of this document is viewed as a "black box".
Assessment	
Conformance with Requirements	Solution selected for best alignment amongst assessed vendors for the VPP optimisation requirements.
Scalability	Subscription based SaaS hosted solution.
Reuse	As a commercial, enterprise level solution designed for VPP and DER optimisation, potentially reusable as a solution platform outside the specific requirements of Project Symphony use cases. Actual scope for reuse would

	be dependent on the specifics of any future operational requirements and relevant market rules.
Standards	Integration APIs are specific to vendor.
Security	Token based authenticated APIs for integration. User account based authentication for web-based customer portal.
Technology / Market Maturity	Partial solution for VPP based DER asset optimisation and control, requiring integration with a DER Monitor & Control Platform solution.

Table 34: VPP & DER Optimisation Platform

8.3.6 DER Monitor and Control Platform

Name	DER Monitor & Control Platform
Description	Provides consolidated management and control of sites where the vendor's Gateway Controller has been installed. Depending on the type of service required, may provide asset level optimisation based on site level objectives provided from the up-stream VPP & DER Optimisation Platform. Provides a centralised location for observing DER asset health, collecting monitoring data and sending setpoint commands to individual Gateway Controller. Provides data from DER asset monitoring to validate a service was dispatched correctly to enable payment of the service.
Technology	The DER Monitor and Control Platform is a SaaS-hosted solution. Automated integration with the platform is via authenticated REST/JSON APIs. User interaction with the Platform is via a HTML 5-based web application. While the Platform vendor has shared material with Synergy on their hosting environment, as a SaaS-hosted solution the underlying technology selection and design is not within Synergy's remit and for the purposes of this document is viewed as a "black box".
Assessment	
Conformance with Requirements	Solution selected for best alignment amongst assessed vendors for the DER asset control requirements.
Scalability	Subscription based SaaS hosted solution.
Reuse	As a commercial, enterprise level solution designed for DER asset control, potentially reusable as a solution platform outside the specific requirements

	of Project Symphony. Actual scope for reuse would be dependent on the specifics of any future operational requirements and relevant market rules.
Standards	Integration APIs are specific to vendor.
Security	Token based authenticated APIs for integration. User account based authentication for web-based customer portal.
Technology / Market Maturity	Partial solution for VPP based DER asset optimisation and control, requiring integration with a VPP & DER Optimisation Platform solution.

Table 35: DER Monitor & Control Platform

8.3.7 Gateway Controller

Name	Gateway Controller
Description	A physical device installed at each Synergy-contracted customer site, and responsible for the IoT Edge Compute function. Provides: • Integration and protocol translation for interoperability with a broad range of widely-used DER devices and types for monitoring, control, diagnostics, and analysis • Site-level control of individual devices for consolidated management of diverse assets to optimise energy outcomes (e.g., self-consumption or export management).
Technology	The Gateway Controller is an internet connected embedded computer which provides all necessary local Input/Output (I/O), compute, communications and storage resources required to support its site role. The Gateway Controller supports network connectivity either through the customers internet (using Ethernet and Wifi), this has not been used for the project, or through an included dedicated 4G modem.
Assessment	
Conformance with Requirements	Ability to control DER assets subject to capabilities exposed by the specific vendor and/or model of assets installed at client sites.1 Support for default DOE schedule-based behaviour initially proposed by Western Power is missing, although the device could be enhanced to implement this behaviour.
Scalability	The selected Gateway Controller has a fixed number of ports for connection to DER assets. Where the number of ports on a single device is insufficient multiple devices can be installed at site and operate in a clustered

	configuration, or a Synergy provisioned network switch can be attached to increase the number of available ports.
Reuse	The installed Gateway Controller is provided by, and specific to, the selected DER Monitor & Control Platform. A change of DER Monitor & Control Platform would require replacing the Gateway Controller.
Standards	The selected Gateway Controller supports a number of industry standard and vendor specific communications protocols. The Gateway Controller supports IEEE2030.5 client, although this was not used as it does not support all of the project scenarios.
Security	The Gateway Controller supports connectivity via either 3G/4G or via a local network router (e.g., the customer's LAN). For improved security, Gateway Controllers have been commissioned with 4G SIM cards and communicate to the DER Monitor & Control Platform via a secure VPN. The Gateway Controller provisioning process establishes a trust relationship between the device and the DER Monitor & Control Platform using the platform vendor's Public Key Infrastructure (PKI). All data paths between the Gateway Controller and the DER Monitor & Control Platform are encrypted.
Technology / Market Maturity	Support for standards including IEEE2030.5, CSIP-AUS IEEE 1574-2018, AS/NZS 4777.2:2015 are still evolving. In the interim, local connectivity to specific vendor DER assets requires the development of vendor specific local protocol adaptors by the Gateway Controller vendor.

Table 36: Gateway Controller

8.3.8 Controllable Assets/ Measurement Sensors

Name	Controllable Asset/Sensor
Description	Any DER asset at site capable of controllable generation and/or load, or any device at site capable of measuring and reporting on the behaviour of DER assets. Currenty enrolled DER assets includes: • AC and DC-coupled batteries • Solar PV systems • Hot water systems • Airconditioning system • Front of meter battery (one instance)
Technology	Variable across asset types and vendors.

Assessment	
Conformance with Requirements	Customer sites were targeted for recruitment based – in part – on the presence of DER assets suitable for the test and learn objectives of Project Symphony.
Scalability	Not applicable for customer owned DER assets.The DER platform scales capability rather than the assets scaling themselves.
Reuse	Not applicable for customer owned DER assets.
Standards	Support for relevant standards, such as IEEE2030.5, is still evolving. In the interim, local connectivity to specific vendor DER assets can require the development of vendor specific local protocol adaptors by the Gateway Controller vendor.
Security	Varies across devices by vendors and devices, ranging from Basic authentication through to PKI based authentication.
Technology / Market Maturity	Developing. While DER assets typically make use of well supported industry network protocols (e.g., TCP, Modbus, etc), API capabilities and definitions vary across vendors.

Table 37: Controllable Asset/Sensor

8.4 Aggregator Platform Build Lessons

It is not within the scope of this document to address non-build project facets such as customer sentiment or the viability of commercial models. The following “Lessons Learnt” are specifically limited to the activities undertaken by Synergy to design and build an Aggregator platform for Project Symphony.

8.4.1 Project Management

Project Management lessons reflect on the way the project’s build activities were scoped, scheduled, and controlled.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Scope Control	**Barrier:** The delayed scoping of Third-Party Aggregators into the platform design impacted the build and develpopment of the platform which resulted in a significant increase in requirements mid-project. **Barrier:** Engaging suitable and willing Third-Party Aggregators was difficult as many potential DER asset operators are asset providers with a focus on site-specific behind the meter optimisation,	**Outcome:** The Third-party Aggregators scope added significant complexity to existing processes and solutions, including: agreeing API contracts for automation; sharing TNI/NMI mapping and identifying recruitment geographies; exchanging asset information for DMO requirements; and obtaining “after

	rather than managing larger aggregations of DER assets.	the event" reconcilation telemetry for DER asset performance. The contracts with platform providers had to be re-negotiated to define the scope, functions and timing and the need for Synergy to develop a bidding model for Third-Party Aggregators, to determine the best time to incorporate their DER assets into market transactions, added further process complexity. **Lesson:** Having a in-depth understanding of third party aggregator functional and non-function platform requirements is essentail as part of intial plaform scoping. The introduction of significant new functionality mid-build leads to both (a) significant rework of existing solution components, and (b) challenges with resource allocation and scheduling.
Methodology	**Barrier:** Use of different project management methodologies between the Project Partners: Agile and Waterfall.	**Outcome:** The key principles of both methodologies are not consistently applied between Project Partners, leading to some frustration in application, confusion and delays due to re-work. **Lesson:** Attempt to document, agree, communicate, and apply the project management methodology for the overall program upfront. Funding models which better reflect the uncertain nature of developing technology pilots could be considered.

Table 37: Project Management lessons

8.4.2 Aggregator Platform Development

Aggregator Platform Development lessons address the actual construction of an integrated platform for supporting Aggregator functions.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	COTS / SaaS Capabilities	**Benefit:** The utilisation of SaaS platforms decreased the time to deliver solutions, both from a operations perspective and a functional perspective.	**Outcome:** Operationally, there were no lead times for procurement and installation, along with a reduced scope for support activities. Functionally, the ablity to leverage vendor experience, based on a larger (international) industry exposure, was beneficial in exploring potential solutions to requirements. **Lesson:** Using “best of breed” solutions provided a richer set of capabilities overall, than would have been possible with a single platform approach.
	COTS / SaaS Capabilities	**Barrier:** SaaS solutions - even best of breed aren't feature complete enough to support the new market participation ecosystem explored by Project Symphony. A particularly evident expression of this issues is access to orchestration and telemetry data in SaaS platforms. **Barrier:** SaaS platforms are set up for limited sharing of real-time data at scale. **Barrier:** SaaS platforms may need improved enterprise integration capabilities to support up-stream reporting and asset visibility, management and analysis. **Barrier:** SaaS platforms currently focus on industrial automation boundaries, as such Synergy needed to develop a significant element of bespoke platform behaviour to fill the functional gaps not provided by COTS solutions. **Barrier:** Much of the market specific behaviour (e.g., forecasts, bids and offers, DOE instructions) required bespoke development.	**Outcome:** Vendor solutions are largely designed as "stand-alone" solutions or as with the intent of being integrated in a suite of solutions with different market roles and responsibilities. SaaS solutions focus more on an extension of traditional industrial automation boundaries. While "best of breed" has capability benefits, it comes at the cost of requiring custom development to deliver end-to-end interoperability and to supplement market specific behavoiurs. There are limited standards in the market integrated space, and integration is a significant effort. **Lesson:** SaaS vendors plays a role in delivering DER into the market, but significant gaps remain for supporting market operations. **Lesson:** There is an opportunity for SaaS players to expand their capabilities. **Lesson:** Aggregators will need to plan and scope for the effort required to build market capabilities as part of the expansion of DER. **Lesson:** Aggregators will need to develop significant components of the solution stack while

			waiting for vendors to recognise the opportunity and develop their solutions.

Table 38: Aggregator Platform Development lessons

8.4.3 DER Assets

DER asset lessons address the physical activities of installing assets and once provisioned, maintaining connectivity and control.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Integration	**Benefit:** Use of a local Gateway Controller provided additional services not available through an OEM cloud API control approach. **Barrier:** VPP control requires asset re-selection as the optimisation platform attempts to control assets that were either slow to respond or failed to respond effectively. When assets don't respond to event instructions in a timely manner, or at all, the platform is obligated to frequently update its strategy, leading to less than optimal operations.	**Outcome:** Lack of availability of qualified/competent installers resulted in repeat site visit to complete work, and delays in commissioning DER assets into SEMS. Lack of support for emerging standards for controlling DER assets made connecting vendors and models more onerous, as edge devices needed updates to interact with specific assets. Once assets were commissioned, a number of issues were noted, including: • Some published peformance specifications for DER assets did not match testing performance results. • Residential grade assets provide more variable level of performance than would be expected in industrial grade assets • DER assets can become disconnected, and depending on the cause of the loss of connectivity, require a truck roll to resolve. • Each DER asset can only be controlled for a single market service, at one time however the facility can be used for multiple services. • Quality of DER asset health (responsiveness, availability) is an issue for control of achieving optimal VPP performance. This is a factor that needs to be considered. **Lesson:** Improved conformance to relevant industry standards will reduce the

			cost, effort and time to test and incorporation DER assets into VPPs. Optimisation requires attention at the aggregate and device level, and significant attention in tuning to deliver services reliably
	Local Asset API standards	**Barrier:** DER assets expose APIs for control monitoring, but the APIs are typically vendor/model specific.	**Outcome:** There is a lack of consistent and uniform implementation of proposed industry standards (e.g., IEEE2030.5, CSIP-AUS) for local asset APIs. A "plug and play" model for DER assets is not currently available, and consequently significant effort can be required to integrate each new vendor/model. **Lesson:** Improved conformance to relevant industry standards will reduce the cost, effort and time to test and incorporation DER assets into VPPs. State and federal government agencies have a role in helping to drive down the cost of implementation of DER by working collaboratively with vendors to agree and implement consistent API standards within their on-site assets. Refer to ARENA's Distributed Energy Integration Program[35]
	Communication Network Services	**Barrier:** DER assets typically lack a full suite of network and cyber-security services, assuming the customer's network will provide those controls (such as firewall-based traffic segmentation).	**Outcome:** Given that the DER assets are also joined to the customer's home network for other network services (such as DHCP) the Gateway Controller must also be joined to the customer's network to establish access to the IoT asset. **Lesson:** DER asset device manufacturers will need to improve their network services and cyber-security capabilities, to enable multiple network domain connectivity (e.g. via virtual network interfaces), and in the process offer better separation of DER asset network traffic between the

[35] https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/

			Gateway Controller (for control) and the customer network (for OEM monitoring). Needs to align with national cyber security standards.
	Costs	**Barrier:** The per-site commissioning costs to estabish physical connectivity with DER assets, and the on-going site-based license model offered by SaaS vendor platforms, are both significant.	**Outcome:** Widespread integration of DER assets into the network will be cost prohibitive if the site commissioning and on-going licensing costs are not materially reduced. **Lesson:** Work with DER asset manufacturers and SaaS vendors to encourage greater interoperability between DER assets and gateway controllers through uniform adoption of technical and API standards. Explore alternative licensing models with SaaS vendors for grid-scale management of DER assets, conditional upon greater standardisation.
	Industry API Coverage	**Barrier** Alignment with industry APIs for DER has proved problematic across two axis: Vendor support for existing standards – such as IEEE2030.5 & CSIP-AUS – is incomplete. Where API standards do exist, they are focused on individual asset control and monitoring.	**Outcome:** While usage of CSIP-AUS is a goal, the reality currently is that many of the DER assets encountered at sites required vendor and model specific adaptors or configuration. There are capability gaps in API standards for DER aggregation and optimisation at higher levels of aggregation (such as sites, VPPs and market facilities). In the absence of relevant standards, Synergy has had to work with individual vendors to define behaviours and agree interoperability contracts. Both the incomplete support for existing standards, and the lack of standards in some areas, contribute to increased development and operational costs. **Lesson** DER management and control would benefit from developing interoperability standards for orchestrating and optimising at higher levels of aggregation. Further work is

			required in this area to align vendors and industry participants. Support amongst vendors for existing standards needs to be encouraged or mandated.

Table 39: DER asset lessons

8.4.4 Operational Experience

Operational Experience lessons address *preliminary* insights from the day-to-day monitoring and control of DER assets in both Test and Learn and Stability phases. These observations may need amendment or revision as greater operational experience is gained by all participants.

No.	Topic	Benefit / Barrier	Outcome / Lesson
	Scalability	**Barrier** The current command, control and telemetry reporting approach to DER assets may not scale.	**Outcome:** Early indicators of concern include: • Processing large DOE instruction payloads that bundle mutliple DOEs over multiple days cause system load and processing challenges in the selected Aggregator solution. • Central control requires detailed customer telemetry data to be provided to the Aggregator. Telemetry reporting data volumes grow proportionally as larger numbers of sites are brought into the system, causing increasing load and processing challenges. Confirmation of DER asset response is required for VPP control. Symphony's design of a central command control may not scale as more VPPs and DER assets are brought into operation, leading to delays in receiving and processing confirmations. **Lesson** Further investigation is required around how to keep data and optimisation control closer to locally distributed control nodes. While a centralised command and control model works in an

			environment that consists of a small number of industrial scale generation assets, it may prove problematic as a model for controlling localised DER assets at scale.
	Forecasting	**Barrier:** Designing VPPs around local geographical regions tends to amplify impacts of local variability (e.g.,cloud cover affecting all PV at the same time), impacting on the ability to achieve accurate VPP forecasts over short timeframes.	**Outcome:** The VPP Operational demand and capacity has been observed to diverge from forecast. Key variables impacting VPP forecasting accuracy are the short term impacts of local weather conditions impacting solar PV and unanticipated short term customer load. To operate a VPP optimally, the forecasting needs to be accurate and revised regulary. An example to improve the accuracy of the forecast, the inclusion of the latest Aggregated telemerty should be factored into the calculation and reset every hour or 5 minutes. **Lesson:** Structuring VPPs to distribute DER assets over larger geographic regions or customer profiles would also help to lessen the impact of transitory local conditions.

Table 40: Operational Experience lessons

9 Common Outcome or Lessons Learnt

This section describes a set of topics and associated outcomes and/or lessons learnt that relate to the overall Project Symphony end-to-end solution.

9.1 Defining the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that pertained to defining the overall solution.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Understanding of the end-to-end market	**Barrier:** As the test and learn process was undertaken, it was apparent that the interpretation of the end-to-end market operation as a coordination mechanism was not consistent across all the partners despite the work done in the development of the architecture, use cases, design and testing. **Benefit:** A range of mechanisms were established to facilitate alignment. For example, joint design sessions to scope the platform build through working groups enabled: alignment of understanding of new concepts, resolution of technical issues, collaboration in test planning	**Outcome:** The implementation of individual partner solutions resulted in misalignment. A lack of understanding of each other's data requirement needs did not factor in the extended enterprise / intra- organisational,-operational and data requirements, resulting in delays to test and learn processes and additional project costs. Challenges were encountered as a result of the delivery / build learning curve. The approach to / exploration of each partner's hypotheses was not clearly understood, and this resulted in initial misalignment during the project, which was resolved over time. **Outcome:** A set of run sheets to provide a more detailed view of different business events was developed to increase holistic understanding of business events / transactions. **Lesson:** Ensure that an understanding of the overall market operating model, processes, and rules of the DER market across the partners. **Lesson:** As the nature of the DER market characteristics evolved, partner understanding, and awareness were kept in lock step with this evolution to ensure the capabilities being delivered remain aligned across the hybrid operating model. **Lesson:** The development of use cases shaping the solutions delivered by the

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			partners includes more detail on the underlying market context. They need to say 'why' as well as 'what'. **Lesson:** Face to face, co-located opportunities to work together be established from an early stage and facilitate (and sustain) close collaboration throughout the project.
	Understanding of how the solution would support the Pilot	**Barrier:** The early use case shaping processes could have included more discussion and feedback on the broader purpose of market and power system operation, and the changes outlined in the DER Roadmap, to avoid misalignment later in the delivery of the project. Various collaboration activities (such as the joint design sessions) had sought to provide a holistic view of the market from the perspective of all actors. This included amendments being Piloted which were consistent with holistic operation as defined in the hybrid operating model. These activities proved to be insufficient.	**Outcome:** The early use case shaping processes could have included more discussion and feedback of the broader market context to avoid misalignment later in the delivery of the project **Outcome:** Business process and information flow was not understood at the level of detail to ensure the successful execution of the test and learn process **Lesson:** Incorporate additional business rules that exist in the current market, or expected to exist in the reform market, to guide participant behaviour. The benefits of this approach need to be weighed against the impact of limiting the scope of T&L activities and the learning that could be attained from attempting innovative approaches
	The lack of an end-to-end solution design for all partner solution	**Barrier:** E2E system process and data flow was not understood at the level of detail to ensure the solutions delivered by all three partners could successfully execute the test and learn processes	**Outcome:** DMO, DSO and Aggregator vendors completed solution design independently. Integration and capability misalignment issues were only identified later, either in the development process, during cross-organisation testing of the combined functional and operational capability, or during T&L activities during the Pilot **Lesson:** Ongoing integrated system design flow to be developed to ensure that each partners platform can support end to end T&L scenarios and testing outcome.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			Recommend that the Project Management Office have technical oversight of the end-to-end solution.
	Project resource turnover	**Barrier:** Considerable resource turnover experienced over the duration of the project	**Lesson:** Where team members leave the project their knowledge and understanding needs to be passed to their replacement. Hence knowledge management frameworks and practices need to be adopted for projects of this nature.
	Adoption and availability of emerging and new technologies	**Barrier:** For all the 'as built' platform solutions, there was a lack of fit-for-purpose solutions available in the marketplace, thus each platform solution required modification or new capability to be developed to meet the solution functional and non-functional requirements. Given the relative immaturity of some these technologies and vendors, the solutions delivered would not be supported beyond the Pilot in a production environment in their current state.	**Lesson**: It will be essential for each partner to develop a transition plan for adoption and implementation of new technologies and processes beyond the Pilot phase. This will ensure the future phased integration is planned, developed, implemented and supported appropriately to ensure adequate investment and collaboration with industry partners and vendors. This will help mitigate any adverse impacts to organisation operating systems and processes.

Table 41: Lessons learnt that pertain to defining the overall solution.

9.2 Delivering the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering delivering the overall solution with all project partners.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Detailed end-to-end test entry/exit criteria	**Barrier:** The rigour and completeness of testing scenarios was less than required when more detailed testing was undertaken during the test-and-learn process	**Outcome:** Testing activities were impacted, resulting in project delays. **Outcome:** A focus on functional capability, such as system integrations, did not assess operational capability of DER using the delivered and tested functions. **Lesson:** In a complex environment that includes multiple actors, evolving

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			technology and solutions, and changing market constructs, the rigor of the testing criteria (entry and exit) needed to aid in shaping and assessing delivery risk/misalignment be known early in the project. A shared understanding of what is intended to happen, functionally and operationally, during a test and the ability to understand if it happened or not is critical to testing.
	Commercial bias	**Barrier**: More easily measured commercial outcomes shaped the focus of effort rather than the overall test and learn objectives (e.g., NSS related capabilities).	**Outcome**: Solution delivery did not cover all aspects of the test and learn process, or core delivery capability but had a bias in the design and delivery focus. **Lesson:** Ensure that overarching project outcomes drive the design and delivery focus of all actors **Lesson:** Better communication required within organisations to ensure that pilot projects maintain ongoing alignment with larger objectives and programs of work. **Lesson:** Entering the project facilities into commercial arrangements related to some project scenarios and not others distorted the design process and potentially project outcomes. Recommend taking an all or none approach to contracts can impact on project outcomes.
	Data consideration	**Barrier:** When data was exchanged in the ecosystem the underlying data was not correct / meaningful despite adhering to the syntactic requirements of the data integration payload (i.e., schema). **Barrier:** Essential data was missing for some period of the test and learn process due to gaps in capability, or appreciation for the need for such data by different partners in the hybrid business model.	**Outcome:** Testing and analysis of the overall solution was compromised resulting in project delays and additional costs. **Outcome:** The ability to identify data gaps or issues was delayed as the data had to have progressed through the whole solution before being visible in any reporting solutions. **Lesson:** Include data business rules and sample data in parallel with well-

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		Barrier: The uploading of data into the analytics and reporting platforms was possible only after data had moved through the integration framework, been processed, and then provided for uploading into the DMO's EDP **Benefit:** The integration models provided a mechanism to understand the linage (and provenance) of the data used in the Pilot **Benefit:** The DMO EDP platform provided an effective mechanism to provide visibility of the data needed to validate the overall solution (from a DMO perspective).	defined business processes/run sheets to assist in ensuring improved integration and solution design outcomes **Lesson:** Ongoing reviews and agreement on the end-to-end view of the process and data requirements ensure that complete sets of data are provided (commensurate with the scope of the solution at that time)
	Requirement currency	**Barrier:** While the capability required by partners evolved over time and was documented, development of capabilities were sometimes based on incomplete or out-of-dated requirements.	**Outcome:** The end-to-end solution was misaligned and that only became evident during joint testing activities. The result was blockers in running test scenarios that needed re-planning and rework resulting in schedule delays. **Lesson:** Undertake cross participant desktop run-throughs of mutual processes and expectations for testing. **Lesson:** An iterative approach to incorporate learnings and associated capability into the platforms over the course of the Symphony Pilot to support the evolving definition of the DER market.
	Collaboration Systems and Tools	**Barrier:** Whilst there was a common project sharepoint that housed all project artefacts, data and information and was assessable to partners, each partner used separate collaboration tools and systems for sharing information and communicating both internally and with their vendors. Outside of meetings and email there was not an efficient method to	**Lesson:** Utilisation of centralised integrated project management, collaboration, software development lifecycle and test management tools, with robust governance capabilities to facilitate communication and development of the 3 platform solutions, would have enhanced delivery of the project, through greater visibility and traceability, reduced duplication and reduced manual documentation and reporting.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
		communicate or provide visibility between partners. A common testing tool was used to manage testing during X-SIT and T&L, however setting it up and creating traceability was a duplication of effort already carried out in individual partner third party tools. Additionally, common software development tools were not utilised in the project across all partners.	
	Visibility of Vendor's System Integration Testing (SIT) Outcomes	**Barrier:** Vendors' SIT approach and outcomes were not consistently visible to the project teams, particularly in the early phase of development. As a result, the completeness of internal testing prior to release was unclear which had adverse impacts. **Benefit**: In response to these challenges, detailed SIT plans were developed with vendors.	**Outcome:** In delivery of the platform solution, each party encountered gaps that were exposed during cross organisation SIT's and in further testing, resulting in project delays and additional cost for remediation. With the introduction of robust internal test plans, gaps were significantly reduced. **Lesson:** Robust vendor-related SIT processes and plans should be established early in a project and shared with each party. This will provide auditable evidence and visibility of each vendor's SIT outcomes.

Table 42: Overall Lessons Learned in defining the solution

9.3 Supporting the solution

This section describes a range of topics and the associated outcomes and/or lessons learnt that were identified when considering support of the overall solution with all project partners.

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
	Change control and management issues	**Barrier:** Configuration and data payload changes were made by vendors without due notification of these changes to partners. Barrier:	**Outcome:** Testing and data analysis impacts as the messaging schema changed and impacted the ability to ingest data into the reporting platform. **Outcome:** Cascading impacts on partner development/delivery activities due to the requirement to have the same versions. **Lesson:** Ensure that, even in a trial/Pilot context, appropriate degree of change control disciplines and communications

No.	Topic	Barrier Or Benefit	Outcome and/or Lesson
			are established and maintained from the outset of the project.
	Messaging extensibility	**Benefit:** The vendor platform enabled additional channels to be established with minimal effort and via configuration to support emerging Data Exchange requirements.	**Outcome:** Reduced cost to the project and rapid implementation of additional capability.

Table 43: Overall lessons learnt in supporting the solution

10 Conclusion

The Project Symphony Pilot has been built with the intent to test, understand and observe the functions and capabilities required from the key roles defined in the Open Energy Networks (OpEN) Hybrid Model against discrete test scenarios. Each Platform was designed and built specific to each Project participants role, the requirements of each platform and how they integrate with each organisational systems and processes.

DER Orchestration technologies and standards are emerging in the industry and solutions and vendors are innovative are still maturing, this meant that each organisation faced a number of challenges in defining their platform solution for the Pilot. Each organisation also had differing internal drivers, delivery approaches and schedules, this increased the complexity and alignment of the co-design and delivery of the platform solutions to meet the Project objectives.

The lessons learnt documented is this report outline barriers, benefits and lessons specific to this complexity such as adopting emerging and new technologies not available 'off the shelf', from multiple vendors, and 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.

A number of 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.

From a DSO perspective, a number of 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 BESS dual control, high-speed data recorders to measure high speed droop events and benchmarking of the WEM compliance HSDR's against cheaper alternatives.

These improvements have enabled the DSO to have greater control of hosting capacity over network changes and system outages and have provided better insights into the operation of its networks. Furthermore, this has allowed for the implementation of the world's first open hybrid model at a program level, thus improving the ability to identify and address any potential issues to maintain a safe network while managing the uptake of DER.

Nonetheless, some challenges experienced included the document management when using shared workspaces, choosing a fit for purpose data analysis and visualisation tool, early engagement and alignment, as well as agreement for core shared technology between partners.

The DMO Platform was developed independently to AEMO market and operating systems to simulate the operation of the WEM, interfacing with the DSO and Aggregator platforms to execute

the four key test scenarios. Notable achievements included adoption of an innovative data exchange layer 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.

Another achievement was the development of user modifiable variables in the DMO platform to manually trigger events or instruct changes to pricing and gate closing times to enhance testing and learnings. This was particularly useful to simulate a response to system wide events in the SWIS to test the ESS-CR and CTZ scenarios.

Inclusion of pre-dispatch and forecasting integrations enabled greater insights into the capability of DER Aggregations to meet service requirements and enhance how VPP's can optimise. Finally, the development of a real-time DMO platform dashboard user interface enhanced visibility to the testing teams of day-to-day activity as well as providing visibility of Aggregated DER facilities to AEMO's system management teams.

From an Aggregator perspective; several broad themes have emerged through the design, build and initial operation of the Aggregator platform:

- Innovation projects would be better served by focusing on delivering smaller clusters of closely related functional capability in shorter periods of time.
- Vendor platforms, while important to delivering DER asset control, are still somewhat immature, both in terms of operating at scale, and in terms of optimising across a range of (potentially competing) market objectives and services.
- It is likely that operating DER assets at scale (e.g., 100,000-plus DER assets) will require rethinking control and optimisation models and vendor solution architectures (e.g., introduce more localised autonomy and control).
- The cost to integrate DER assets into a common management platform is currently high due to both a lack of consistent standards and DER assets lacking strong network and security capabilities.
- Legacy generation models are not optimal for the highly distributed, small-scale generation/load behaviours observed from DER assets. As more data and operational experience is collected from the 'Test and Learn' and the Stability periods, further discussion is required on how operational value can be unlocked from VPPs and DER assets.

Appendix A: Glossary

Glossary of acronyms and terms – common terms the same for all parties.

Acronym	Term	Definition
	Active power	Active power is the actual power that is consumed or utilised within an AC Circuit. This is also known as real power and is measured in kilowatts (kW) or megawatts (MW).
AEMO	Australian Energy Market Operator	AEMO manages Australia's electricity and gas markets including operating the systems for energy transmission and distribution, and the energy financial markets. NB: AEMO manages the WEM separately to the NEM, under different rules, funding, and governance structures.
AGC	Automatic Generation Control	A system through which AEMO can remotely adjust the output of a generator in order to maintain frequency stability, where the setpoint refresh rate is 4s.
	Aggregation Zone	The region of a network within which operating envelopes can be aggregated.
	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).
AKS	Azure Kubernetes Service	Service to manage a kubernetes open source platform for container orchestration
AMI	Advanced Meter Infrastructure	AMI typically includes smart meters (that measure bidirectional energy flows, in shorter time intervals), upgraded communications networks (to transmit large volumes of data), and requisite data management systems.
API	Application Programming Interface	An API is a set of functions through which two software systems can communicate without any human intermediation.

ARENA	Australian Renewable Energy Agency	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)
AS/NZS 4755.3:2016	Australian Standard AS 4755	Demand response capabilities and supporting technologies for electrical products. This Standard details requirements of Demand Response Modes for Energy Storage Systems (AS/NZS 4755.3) and the requirements for Demand Response Enabling Devices (AS/NZS 4755.6).
AS/NZS 4777.2:2015	Australian Standard AS 4777	Grid Connection of Energy Systems via Inverters. This Standard specifies the electrical installation requirements (AS4777.1) and the inverter performance requirements (AS4777.2) for inverters connected to the electricity distribution network.
BC	Business Case	Provides financial justification for undertaking a project, program or portfolio
BESS	Battery Energy Storage System	Batteries are an energy storage technology that use chemicals to absorb and release energy on demand. Lithium-ion is the most common battery chemistry used to store electricity. Batteries require additional components that allow the battery to be connected to an electricity network.
	Bid and Offer	Bid is to buy (consume) energy and offer is to sell (generate) and export energy
BMO	Balancing Market Offer	Offering (Sell) or bidding (Buy) energy into a bi-directional energy balancing market.
BTM	Behind the meter	Any technology located on the customer's side of the customer-network meter.
	Commitment	Definition of the Aggregator DER portfolio of capacity they have committed for SR or LRR during the agreed time period.

	Connection Point	Network location which is electrically connected into the electricity system. A connection point may be metered (i.e. customer service connection point) or unmetered (i.e. streetlight, traffic light etc.)
	Consumption Bid	A bid that includes only load
	Contestable Customers	Customers that consume greater than 50 MWh of electricity per annum, who can choose their electricity retailer.
	Control Signal	Used to provide dispatch instructions for market and non market services: A set of 4 second contol signals sent to the market particiapant / facilities.
CTZ	Constrain To Zero	A service whereby instructions can be sent by AEMO to the Aggregator and executed by the Aggregator to constrain energy output to zero.
DEBS	Distributed Energy Buyback Scheme	Replacing the Renewable Energy Buyback Scheme, DEBs was launched by the WA Government in August 2020. It offers customers 10c kilowatt-hour of exported energy at peak times between 3pm- 9pm and 2.75c at all other exporting times.
DER	Distributed Energy Resources	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.
DERIP	Distributed Energy Resources Integration Platform	A DERIP is a platfrom that combine and interarte diverse and distributed DER assets such as solar photovoltaic, batteries and electric vehicles. A Market Platform integrating DER enables platfroms that aggregate DER into facilities and operate as a VPP to bid as aggregated portfolios to

		create shared value between asset owners and the larger surrounding grid.
DLC	Direct Load Control	DLC is where utilities provide a payment to customers to control the operation of their equipment e.g. an air-conditioning unit or hot water system.
	Dispatch	Dispatch refers to the instructions from AEMO to generators delivering power to the system. Dispatch instructions are provided in the form of generation, timing, and ramp rate information. AEMO dispatches generation with consideration for the prices offered by generators, network limitations, and system requirements.
	Disaggregation	The process of determination of the assets selected and their control setpoints to fulfill a dispatch instruction.
DCOA	Distribution Constraint Optimisation Algorithm	The calculation of available network capacity that enables the publishing of the dynamic operating envelope in a given time interval for a given location within a segment of an electricity distribution network utilising a number of capacity allocation principles.
DMO	Distribution Market Operator	DMO is a market operator that is equipped to operate a market that includes small-scale devices aggregated and able to be dispatched at appropriate scale (Energy Transformation Taskforce, 2020). The term is interchangeable with 'Market Platform'.
DNSP	Distribution Network Service Provider	DNSPs are the organisations that own and control the hardware of the distributed energy network such as power poles, wires, transformers and substations that move electricity around the grid.
	Distribution storage	Storage attached in directly to the distribution network as distinct from storage connected behind the meter at a customer site.
DOE	Dynamic Operating Envelope	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.
DSO	Distribution System Operator	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).
	Embedded network	Embedded networks are private electricity networks which serve multiple premises and are located within, and connected to, a distribution or transmission system through a parent connection point (and an associated “master meter”).
	Epic	A sequence of use cases that form a process. It can be thought of as an end-to-end process that combines the capabilities of all parties to achieve a desired outcome.
ESOO	Electricity Statement of Opportunities	The ESOO provides technical and market data that informs the decision-making processes of market participants, new investors, and jurisdictional bodies as they assess opportunities in the Wholesale Electricity Market (WEM) over a 10-year outlook period.
	ESS Contingency Raise	Market provision of a response to a locally detected frequency deviation to help restore frequency to an acceptable level in case of a contingency event (such as the loss of a large generator or load). Will be known as the Contingency Reserve Raise in the future WEM FCESS

	ESS Contingency Lower	Market provision of a response to a locally detected frequency deviation to help restore frequency to an acceptable level in case of a contingency event. Will be known as the Contingency Reserve Lower in the future WEM FCESS
	ESS Regulation Raise / Lower	Market provision of a response to Automatic Generation Control (AGC) signals to correct for small movements in frequency during a dispatch interval.
ESS	Essential System Services	A range of services designed to address or respond to deviations in system frequency
EV	Electric vehicle	EVs are cars or other vehicles with motors that are powered by electricity rather than liquid fuels.
FCESS	Frequency Co-optimised Essential System Services	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 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, is due to go live in October 2023 and comprises the following five services: • Regulation Raise • Regulation Lower • Contingency Reserve Raise • Contingency Reserve Lower • Rate of Change of Frequency (RoCoF) Control Service
FOM	Front of (the) Meter	Any infrastructure located on the distribution network side of the customer meter (i.e. not behind the meter).
	Frequency response	Primary frequency response is available relatively quickly to arrest the rapid decline of frequency and establish a temporary stable operating state. Secondary frequency response is characterised by system-wide control, typically

		through coordinated changes to the setpoints of multiple facilities.
GIS	Geographic Information System	A GIS is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface.
	Grid architecture	Grid architecture is the specialisation of system architecture for electric power grids. As such, it includes not just information systems, but also industry, regulatory, and market structure; electric system structure and grid control framework; communications networks; data management structure; and many elements that exist outside the utility but that interact with the grid, such as buildings, merchant DER, and microgrids (Taft and Becker-Dippmann, 2015).
HVAC	Heating Ventilation and Air Conditioning	HVAC systems are responsible for heating and cooling and include products like furnaces, air conditioners and heat pumps, as well as ductwork, thermostats and other comfort controls.
	Hosting capacity	DER hosting capacity is defined as the typical amount of DER that can be connected to a distribution network without requiring network augmentation while the network (and the electricity system as a whole) remains within its technical limits.
ICT	Information & Communication Technology	
	Low Voltage (LV) Network	Part of the distribution network which carries electricity from distribution transformers to customers who take supply at the low voltage level (240 V).
	Marginal Unit	A Balancing Market Offer scenario where a different dispatch instruction is sent every 10

		minutes based on a manual upload to Distributed Energy Resources Integration Platform
	MS Teams	MS Teams SharePoint Document Management – Repository where all project documents are to be stored and shared between project participants.
MVP	Minimum viable product	A version of a product with just enough features to be usable by early customers who can then provide feedback for future product development.
NEM	National Electricity Market	The NEM is a wholesale market through which generators and retailers trade electricity in Australia's six eastern and southern states and territories (not Western Australia and the Northern Territory), and the power system that interconnects these regions. The NEM delivers around 80% of all electricity consumption in Australia.
NMI	National Metering Identifier	The NMI is a unique 10 or 11 digit number used to identify electricity network connection point in Australia.
	National Metering Identifier (NMI) Standing Data	Site data that changes infrequently, maintained, and accessed within internal AEMO systems
	Network Constraints	When a section of an electricity network approaches its technical limits.
NCESS	Non Co-optimised Essential System Services	A contracted service, not covered by other ESS categories, provided by a generator / retailer / demand side program / DER aggregator to AEMO to help maintain power system security / reliability.
	Non-contestable Customers	Non-contestable customers are those who consume 50 MWh or less of electricity per annum and includes most residential households and small businesses in Western Australia. In the SWIS, only Synergy can supply non-contestable customers.

NSS	Network Support Service	A contracted service provided by a generator / retailer / demand side program / DER aggregator to help manage network limitations on the LV network. Services relieving transmission network constraints are provided under the Non-Co-optimised Essential System Services framework, part of the WEM construct.
	Offer (or bid)	Submitted by generators to provide power/energy (power generation). The term is interchangeable with 'Bid'.
	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
OSI	OSI PI (Process Information)	OSI is a proprietary software product for real-time data management – capturing, processing, analysing and storing – of process information.
PV	Photo-voltaic	A PV cell, commonly called a solar cell, is a nonmechanical device that converts sunlight directly into electricity.
	Pilot	A Pilot project is an initial small-scale implementation that is used to prove the viability of a project idea. This could involve either the exploration of a novel new approach or idea or the application of a standard approach recommended by outside parties, but which is new to the organisation. The Pilot study will confirm viability and scalability and enable proposed processes and procedures to be tested. It will confirm the appropriateness and safety of any tools proposed and also confirms that any working practices are safe and comply with organisational/statutory standards. It also enables the benefits to be tested and a more reliable investment appraisal to be created for the Project.

PMP	Project Management Plan	
PSR	Project Status Report	
RoCoF	Rate of change of frequency	RoCoF is the market provision of a service to manage the rate of change of power system frequency. This is an Essential System Service.
	Reactive power	The power which flows back and forth meaning it moves in both the direction in the circuit or react upon itself, is called reactive power. The reactive power is measured in kilovolt amperes reactive (kVAR) or megavolt amperes reactive (MVAR).
REBS	Renewable Energy Buyback Scheme	This energy buyback scheme has been replaced by DEBs but prior to August 2020 customers were receiving a flat 7.135 cents per kilowatt-hour of exported energy.
	Regulation raise / lower	Market provision of a response to Automatic Generation Control (AGC) signals to correct for small movements in frequency during a dispatch interval.
RTMS	Real Time Market Submission	
SCED	Security Constrained Economic Dispatch	
	Scenario	A collection of epics and / or use cases that together define how DER could participate in a post SCED market or provide a service. The MVP has been defined at a scenario level.
SG/NSG	Scheduled Generator/Non-Scheduled Generator	

	Small-scale Renewable Energy Scheme	The Small-scale Renewable Energy Scheme is component of the Commonwealth Government Renewable Energy Target. It creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems such as solar panel systems, small-scale wind systems, small-scale hydro systems, solar water heaters and air source heat pumps.
SWIS	South West Interconnected System	TheSWIS 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.
SR	Spinning Reserve	Spinning reserve is generation capacity that is held in reserve but ready to respond quickly if another generator suffers an unexpected outage. This helps maintain an uninterrupted supply of electricity to customers.
	System architecture	System architecture is a discipline for describing, analysing, and communicating structural representations of complex systems. Colloquially, a system architecture is a model of a (complex) system, the purpose of which is to help think about the overall shape of the system, its attributes, and how the parts interact (Taft and Becker-Dippmann, 2015).
	System Restart	System restart service allows parts of the power system to be re-energised by black start equipped generation capacity following a full (or partial) black out.
	Telemetry data	The automated recording and transmission of data from remote sources into a central system in support of monitoring and analysis.
	Time-of-use tariff	A retail tariff structure that includes different variable charges for energy depending on the time of day the energy is consumed by the customer.
3PA	Third Party Aggregator	An aggregator that is aggregatored by a parent aggregator (Aggregator)

TNI	Transmission Node Identifier	The component on the network which denotes the transmission from the transmission network to a local distribution network. It is anticipated that Facilities involve 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.
	Trading Interval	Is the half hour interval where the aggregator commits to provide or consume energy
UFLS	Under Frequency Load Shedding	UFLS schemes are emergency mechanisms that are designed to arrest a fall in frequency.
	Use Case	An activity within a scenario or epic that is owned by a particular project participant.
VPP	Virtual Power Plant	A VPP broadly refers to an aggregation of distributed energy resources (such as decentralised generation, storage and controllable loads) coordinated to deliver services for power system operations and electricity markets.
	Volt-var response	Volt-var function smooths the grid voltages by using the customer's inverter to absorb reactive power from the grid when voltage levels rise. Further to this, when voltages fall below (V2) 220V, the volt-var mode will cause the customer's inverter to generate reactive power to support the grid voltage.
	Volt-watt response	The volt-watt response mode reduces the inverter power output when needed in order to prevent exceeding the voltage limits. If this mode is not enabled the inverter may experience frequent nuisance tripping when the network is lightly loaded.
WoSP	Whole of System Plan	The WoSP is a long-term and detailed plan developed by Western Power, the State Government, EPWA and AEMO. It documents how the generation, management and distribution of

		energy in the SWIS will change over the next few decades, and what needs to be done to respond, such as the investment or infrastructure required.
WEM	Wholesale Electricity Market	The WEM, operated by AEMO, controls the supply and trading of wholesale electricity between retailers and generators on the South West Interconnected System.

Appendix B: DSO Module Diagram

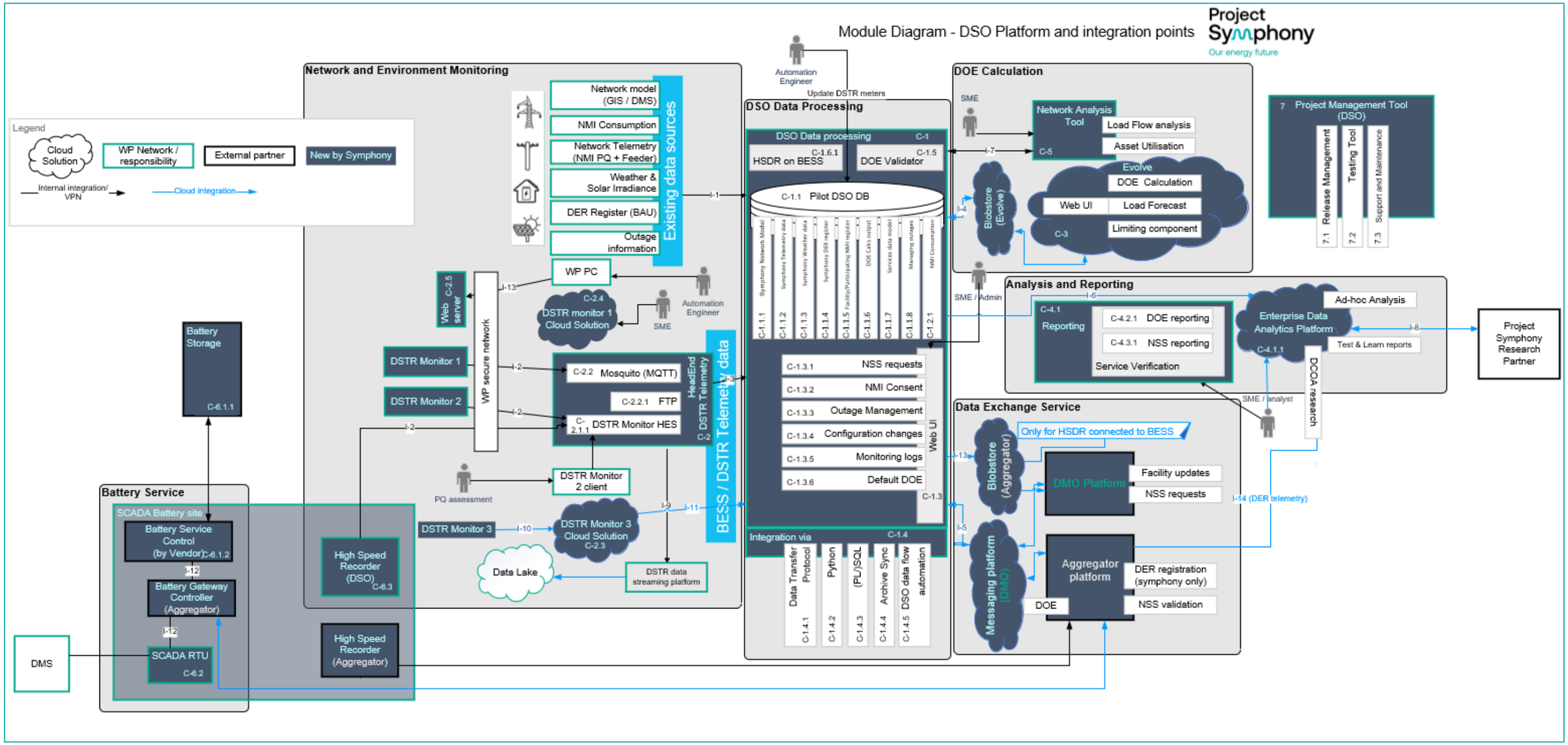

Table 7: DSO Module Diagram Table

Level 1 ID	Level 1 Module name	Level 2 ID	Level 2 Module name	Level 3 ID	Level 3 Module name	Description
0	DSO Data Processing	1.1	Pilot DSO DB	1.2.1	NMI Consumption	Uses the daily consumption data for each national metering identifier (NMI) from Western Powers BAU data warehouse. Based on underlying meter consumption data collected by Metering Business System (MBS). Source could be advance metering infrastructure (AMI) 30-minute consumption data (in which case the consumption is aggregated to a daily consumption value for the NMI) or basic bi-monthly consumption data (in which case the consumption is interpolated/estimated for each day based on an estimated load curve for that NMI)
1	DSO Data Processing	1.1	Pilot DSO DB	1.1	Pilot DSO DB	A central online transaction processing (OLTP) database for all of Symphony's operational processes which facilitates transaction processing. This database usually contains two weeks' worth of historical information as well as forecasts for the next three days (seven days for weather). This module holds a copy of the Network model relevant for Symphony that allows the DSO Platform to manipulate the model or other input data (such as, consumption/weather) for general operational testing and the testing of hypothesis test cases for Test & Learn. Long term historical data is kept in the Enterprise Data Analytics Platform (for analytical purposes).
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.1	Symphony Network Model	The Network Model focussed on specific Feeders for Project Symphony and derived from GIS/DMS/Weather data/Enterprise Asset Management Software/Datawarehouse/DER Register. It is used as input to the DOE Calculator Module and allows the DSO team to make changes to the model (to test scenarios) without impacting the DSO/Western Power network model. The DSO Platform can also accommodate the addition of new battery installations that have not yet been commissioned to evaluate them too. • GIS; Extract of the Western Power's (WP) Geographic Information System (GIS) Network model (medium voltage (MV) / low voltage (LV) level - "as-built") for specific feeders relevant for Symphony. Data has been cleaned up where necessary. • DMS; Network Model which is based on the Western Power GIS and adjusted for "as-switched" information from the Distribution Management System (DMS) to make sure distribution transformers (DSTRs) are connected to the correct Feeder. Only long-term switching is considered. Short-term switching (for planned work and outage management) is dealt with via the outage management processes.
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.2	Symphony Telemetry data	The following telemetry data is captured from the DSO/Western Power Network and used as an input into the DOE Calculation Module: - AMI PQ; (five-minute instantaneous power, current, voltage information per NMI from via the AMI Headend System (AMIHES); For Project Symphony, performance quality (PQ) data for all NMIs in Southern River (SNR) 540 as, well as participating NMI's (and some NMIs - 50% - from SNR 508) is recorded. - DSTR monitoring (for some DSTRs) - a common view of all DSTR monitoring data across all different devices. - Feeder data; (voltage, current, power, etc) collected for each feeder for every 5 minutes in Western Powers BAU Corporate plant information (PI) tables in the data warehouse. Project Symphony is only interested in SNR 540 and 508 for the Pilot. This data is also used for validating NSS deployments as well as DOE compliance.

Level 1 ID	Level 1 Module name	Level 2 ID	Level 2 Module name	Level 3 ID	Level 3 Module name	Description
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.3	Symphony Weather data	Symphony collects weather and solar irradiance data as input for the DOE Calculation Module. It also allows for making changes to these values without impacting DSO/Western Power data sources so the DSO Platform can test for specific scenarios (only available in the test environment). Solar Irradiance values (per postcode) for actuals and forecasts are kept in Western Power's data warehouse. Project Symphony only uses postcodes relevant for participating customers. Weather information provided by Weather zone is kept in Western Power's data warehouse. Project Symphony only uses weather data information for Jandakot Airport (most relevant for SNR 540 area)
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.4	Symphony DER register	A combined DER Register that looks at both BAU (Western Power) DER register as well as the new DERs that have been signed up by the Aggregator as part of Symphony project. When photovoltaic systems (PV's) and Batteries are installed by electrical contractors, the details are captured in the distributed energy resources (DER) Register in Western Power's data warehouse. This is mainly for understanding the generation capacity for existing DER (non-participating NMIs).
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.5	Facility/Participating NMI register	Record of all Facilities provided by DMO and which NMIs participate in those facilities. It keeps track of changes over time. There is also a record of which NMIs have given consent for the DSO Platform to share data for those NMIs.
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.6	DOE calcs output	Pilot DSO Data Base collects outputs from the DOE calculator. This includes: - DOEs for each of the participating NMIs, - Load Forecast for all NMIs in the network catchment areas; and - Limiting Module report (helps identifying the bottlenecks in the network at times of high load/generation) This is the main source for publishing DOEs to our partners (Aggregator/DMO)
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.7	Services data model	Information kept for managing services like: - Network Support Services requests (creation, changes, cancellations) - recording of Constraint To Zero notifications
1	DSO Data Processing	1.1	Pilot DSO DB	1.1.8	Managing outages	Both planned and unplanned outages are replicated to Western Power's data warehouse near Realtime (coming from the Distributed Management System). Significant outages impacting the Symphony's network model is used by the web user interface (ui) application to alert the subject matter experts (SMEs) of any significant outages that could impact the Dynamic Operating Envelopes (DOEs) that have been issued the day before.
1	DSO Data Processing	1.3	Web UI	1.3.1	NSS requests	User interface to allow Subject Matter Experts (SME) to issue and manage NSS requests with Aggregator (via DMO).
1	DSO Data Processing	1.3	Web UI	1.3.2	NMI Consent	User interface to manage NMI consent responses from customers to ensure the DSO Platform are not sharing data with third parties (DMO) related to the customer without their consent.
1	DSO Data Processing	1.3	Web UI	1.3.3	Outage Management	The Western Power Datawarehouse has Realtime feed of TCS (Trouble call system / Distributed Management System) incidents. This web applications looks at incidents impacting the feeders of interest to Project Symphony. This page allows an SME to react to incidents of interest and intervene with a DOE set already sent to the Aggregator by issuing emergency / default DOEs.
1	DSO Data Processing	1.3	Web UI	1.3.4	Configuration changes	Allows SME to modify some parameters used by DOE calculator (voltage limits etc)
1	DSO Data Processing	1.3	Web UI	1.3.5	Monitoring logs	Allows system administrator to monitor different parts of the DSO Platform.
1	DSO Data Processing	1.3	Web UI	1.3.6	Default DOE	Default" DOEs are a "static" version of a DOE used for Participating NMI's that have no Network model and in the event of a module and/or system failure.

Level 1 ID	Level 1 Module name	Level 2 ID	Level 2 Module name	Level 3 ID	Level 3 Module name	Description
1	DSO Data Processing	1.4	Integration	1.4.1	Data exchange layer	The Data exchange layer allows the DSO to communicate to the DMO and Aggregator platforms.
1	DSO Data Processing	1.4	Integration	1.4.2	Python	Light weight coding language and popular for writing "user exits" (extensions) in COTS (Commercial off the shelf) applications. For example, Network Analysis Tool allows for extensions and automations/macros to be coded in Python.
1	DSO Data Processing	1.4	Integration	1.4.3	PL/SQL	Structured Query Language is an industry standard for querying/updating both relational and non-relational databases. Typically, SQL is executed from a client that is separate from where the Database is hosted. PL/SQL allows for SQL to be executed by the Database server and has been used in Project Symphony to extract data from other sources, transform it and insert it into the DSO Pilot Database.
1	DSO Data Processing	1.4	Integration	1.4.4	Archive Synch	Integration platform as a service. Allows the DSO platform to integrate between cloud platforms as well as integrate internal data sources with cloud data storage (for example, pushing data to the Enterprise Data Analytics Platform). A variety of different protocols and standards are supported.
1	DSO Data Processing	1.4	Integration	1.4.5	DSO data flow automation	- DSTR telemetry data pulled into Symphony, - DOE / Data validation, - push/pull to Evolve via a Blobstore, - push/pull to partners via Data exchange layer, - Network Analysis Tool integration; and - loading of data into the DSO Pilot Database - mainly PL/SQL
1	DSO Data Processing	1.4	DOE Validator	1.5	DOE Validator	The DSO data flow automation runs several DOE checks to make sure the DOEs per NMI are correct and the aggregated values (e.g., all DOEs under a Transformer) are correct.
1	DSO Data Processing	1.4	BESS HSDR feed	1.6.1	HSDR on BESS	The High-Speed Data Recordings from the BESS that are sent via DSO data flow automation to the DMO (via the Aggregator's Blob store)
2	Network and Environment Monitoring	2.1	data feed	2.1.1	DSTR Monitor HES	Data coming from DSTR Monitor 2 and stored by the DSTR Monitor Headend System virtual machine server (also High-Speed Data Recorder (DSO) software). There is a vast number of data points collected (and stored in Western Power systems including the Enterprise Data Analytics Platform), but the ones that are of most interest to Project Symphony is Power, current and voltage.
2	Network and Environment Monitoring	2.1	data feed	2.1.2	FTP server	Web server that allows Automation engineer to remotely log in to monitoring device to access configuration settings as well as extract High Speed data records.
2	Network and Environment Monitoring	2.2	DSTR Monitor 1 data feed	2.2.1	DSTR Monitor 1 data feed	Data coming from DSTR Monitor 1 devices and stored via MQTT in the DSO/ Western Power corporate databases including the Enterprise Data Analytics Platform. Major data points that are being used to by Project Symphony is Power, current and voltage.
2	Network and Environment Monitoring	2.3	DSTR Monitor 3 data feed	2.3.1	DSTR Monitor 3 data feed	Data coming from DSTR Monitor 3 devices and stored via DSTR Monitor 3 Cloud Solution in our corporate databases incl Cloud computing–based data cloud. Major data points that are being used to by Project Symphony is Power, current and voltage.
2	Network and Environment Monitoring	2.4	DSTR monitor 1 Cloud Solution	2.4.1	DSTR monitor 1 Cloud Solution	DSTR monitor 1 Cloud Solution is the analysis platform for the data collected by the devices registered in the DSTR monitor 1 Cloud Solution. Although possible to also use this cloud platform to feed the data into DSO's corporate network, the Cloud Risk Assessment showed some vulnerabilities, and it has been decided to not further use DSTR monitor 1 Cloud Solution other than some basic analysis / verification. DSTR monitor 1 meter configuration as well as data extraction should not be done using DSTR monitor 1 Cloud Solution and the product has been contained within the limited scope of Project Symphony.
2	Network and Environment Monitoring	2.5	DSTR monitor 1 webserver	2.5.1	DSTR monitor 1 webserver	Web server that allows an Automation engineer to remotely log in to monitor devices to access configuration settings as well as extract High Speed data records.

Level 1 ID	Level 1 Module name	Level 2 ID	Level 2 Module name	Level 3 ID	Level 3 Module name	Description
3	Evolve Platform	3.1	Digester	3.1.1	ANU digester	This module takes Telemetry, Weather, and network model from the Pilot DSO DB for Load forecasting, as well as, for thermal limit calcs in DOE calculator
3	Evolve Platform	3.1	Digester	3.1.2	Zepben digester	Takes network model from Pilot DSO DB for voltage limit calcs in DOE calculator
3	Evolve Platform	3.2	Load Forecaster	3.2.1	Load Forecaster	Takes weather forecast and actuals as well as recent consumption/load and predicts the load for upcoming three days for every five-minute interval for each NMI on the network (SNR540).
3	Evolve Platform	3.3	DOE calculator	3.3.1	Thermal limit calculator	Takes the input from the ANU digester and calculates thermal limits for participating NMIs
3	Evolve Platform	3.3	DOE calculator	3.3.2	Voltage limit calculator	Takes the output from Thermal Limit DOE Calculation Module as well as output from Zapien digester and calculates Voltage limits for participating NMIs. The results from this calculation provides Project Symphony with the "raw" DOEs that will be validated by DSO platform before being publish to Aggregator/DMO.
3	Evolve Platform	3.4	Web UI	3.4.1	Web UI	Visual view of the Network model loaded.
4	Analysis and Reporting	4.1	Reporting	4.1.1	Enterprise Data Analytics Platform	Essentially a replica of the Pilot DSO DB but unlike Pilot DSO DB, this replica keeps track of all changes (no data is lost). The Pilot DSO DB is used for operational purposes and only keeps a data for a short amount of time to ensure performance criteria are met. The Enterprise Data Analytics Platform is for the analysis purposes to support the Test & Learn phase of Project Symphony. It is also used for sharing large data sets with other partners (like Project Symphony's Research Partner).
4	Analysis and Reporting	4.1	Reporting	4.2.1	DOE reporting	Operational reports related to DOEs (and load forecasts) service verification. For example: quality, compliance reports.
4	Analysis and Reporting	4.1	Reporting	4.3.1	NSS reporting	Operational reports related to NSS service verification. For example: NSS validation and verification.
5	Network Analysis Tool	5.1	Network Analysis Tool	5.1.1	Network Analysis Tool	The Network Analysis Tool automation work has been developed specifically to compare the load constraints calculated by the EVOLVE platform with the equivalent calculations done by The Network Analysis Tool.
6	Symphony BESS	6.1	Symphony BESS	6.1.1	Symphony BESS	1MW Battery Energy Storage System (BESS)
6	Symphony BESS	6.1	Symphony BESS	6.1.2	Battery Service Control	Battery Gateway Controller and Battery Service Control.
6	Symphony BESS	6.2	SCADA RTU	6.2.1	SCADA RTU	Standard RTU (typically used in RMU sites) but with a modified config to interact with BESS via Modbus.
6	Symphony BESS	6.3	High Speed Data Recorder (DSO)	6.3.1	High Speed Data Recorder (DSO)	High Speed Data Recorder used by the DSO Platform
7	Project Management Tool (DSO)					An issue and project tracking software. It is used by the DSO Platform team to plan, track, test, release, and report on software development activities.
7	Project Management Tool (DSO)	7.1	Release Management tool			Manages changes to the DSO Platforms modules that are used by the Pilot. This module supports the planning and implementation of changes, as well as the tracking and communication of those changes throughout the Pilot and associated Partners.
7	Project Management Tool (DSO)	7.2	Testing tool			Assists in the Development, System integration and user acceptance testing of the DSO Platform modules, including defect management.
7	Project Management Tool (DSO)	7.3	Support and Maintenance			Supports with managing technical assistance requests, troubleshooting issues, as well new feature requests/enhancements, in line with the DSO Platform's Service Level Agreements

Appendix C: DSO Platform Requirements Mapped to Modules

1. Introduction

The below tables include a detailed assessment on how well the DSO Platform Solution modules have met all the functional and non-function requirements, contained in the "Platform Functional and Non-Functional Requirements"[36]. The table headers include the same module identification numbers used in the as-built DSO Platform Module diagram, in Appendix B.

The colour code status RED ●, AMBER ●, and GREEN ● is used in this assessment correlate to what extent the modules cover the requirements.

2. Network and Environment Monitoring modules

2.1 Description

The Network monitoring module of the DSO Platform is comprised of several discrete solutions that support the collection and storage of telemetry data from different locations on the Pilot area network, as well as Pilot area environment/weather data. Collected data is forwarded on to the DSO Data Processing where it is organised, stored, and managed. The architecture for the Network and Environment Monitoring module is shown in Figure 2.

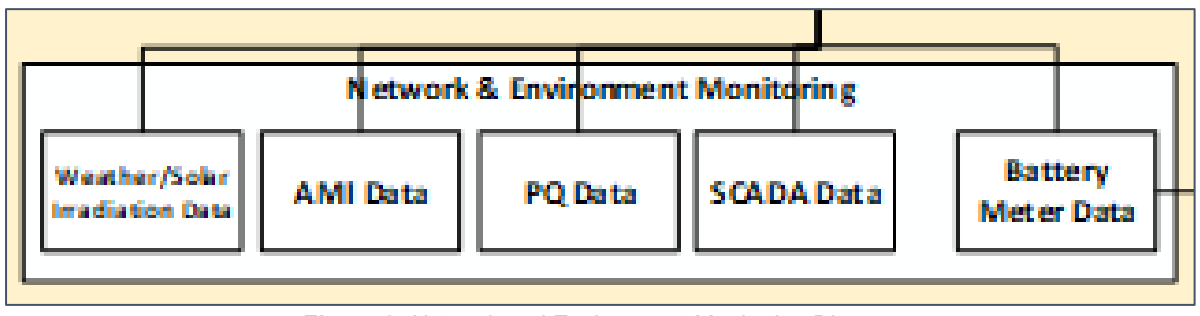

Figure 2: *Network and Environment Monitoring Diagram*

The data sources are:

- **Existing Data Sources (I-1):** Where available, the project has made use of existing network monitoring data. This includes supervisory control and data acquisition (SCADA), Advance Metering Infrastructure (AMI), weather, and solar irradiance data, Distributed Energy Resources (DER) Registrations, Network model, outage management. These datasets have been imported from existing DSO data collections into the Project Symphony database. In addition, the project has also supported roll-out of AMI metering in the Pilot area to ensure this existing data collection is comprehensive enough for the project,
- **Distribution Transformer Monitors:** Three separate types of distribution transformer monitor devices have been implemented in the project Pilot area to test the merits of the different devices. As the data collection mechanism/platform for each device is different, the DSO Platform has required three different solutions for directing and integrating distribution transformer data into the Project Symphony database: and,
- **BESS High Speed Data Collection (C6.3):** A high speed data recorder solution has been implemented at the BESS to support the collection of data, specifically to test the Essential System Services (ESS) scenario.

[36] project-symphony-platform-functional-and-non-functional-requirements-report.pdf (arena.gov.au)

2.2 DSO Requirements mapped to Network and Environment Monitoring modules

***Table 8**: DSO Requirements mapped to Network and Environment Monitoring Modules*

DSO Requirements mapped to Network and Environment Monitoring modules					Symphony Network Model	Symphony Telemetry data	Symphony Weather data	PL/SQL	IICS	DSO data flow automation	BESS HSDR Feed	DSTR Monitor HES	FTP server	DSTR Monitor 1 data feed	DSTR monitor 3 data feed	Enterprise Data Analytics Platform	High Speed Recorder (DSO)
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1.1	1.1.2	1.1.3	1.4.3	1.4.4	1.4.5	1.6.1	2.1.1	2.1.2	2.2.1	2.3.1	4.2.1	6.3.1
9	Feeder Data - History	Mandatory	GREEN			Y		Y									
10	DSTR Data - History	Mandatory	GREEN			Y			Y	Y		Y	Y	Y	Y	Y	
11	Service Connection (NMI) Data - History	Mandatory	GREEN			Y		Y									
13	Feeder Data - Granularity	Mandatory	GREEN			Y	Y	Y									
14	DSTR Data - Granularity	Mandatory	GREEN			Y				Y		Y	Y	Y	Y		
15	Service Connection Data - Granularity	Mandatory	GREEN	There are known small gaps in the AMI PQ data		Y		Y	Y							Y	
16	GRID Connected BESS - Granularity	Mandatory	GREEN			Y				Y	Y	Y	Y				Y
17	Telemetry Data - Availability	Mandatory	GREEN	There are some delays in the PQ data. The data will be available within four hours in the Data processing module, and within 24 hours in the Archiving module (for analysis and reporting).	Y			Y	Y	Y	Y					Y	Y
17A	High Speed Recording Data	Desirable (New)	GREEN	This requirement is a refinement of requirement 17 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "High Speed Recording (HSR) data is collected and stored for WP owned HSR's."						Y	Y	Y	Y				Y
18	Weather Data – History	Mandatory	GREEN						Y							Y	
19	Weather Observation Data – Granularity	Mandatory	GREEN				Y	Y	Y							Y	
20	Weather Observation Data – Availability	Mandatory	GREEN				Y	Y	Y							Y	
21	Weather Forecast Data – Forecast	Mandatory	GREEN				Y	Y									
22	Weather Forecast Data – Granularity	Mandatory	GREEN				Y	Y	Y							Y	
23	Weather Forecast Data – Availability	Mandatory	GREEN				Y	Y	Y							Y	

3. DSO Data Processing modules

3.1 Description

The DSO Data Processing module is used to organise, store, and manage DSO Platform data. This module includes:

- Network monitoring data collected from local distribution network monitoring Modules,
- The model that describes network Modules and how they relate to each other,
- Network Module details and operating constraints,
- Network configuration information required to support network load flow analysis and DOE calculations; and,
- DSO Platform inputs and outputs, including DOE publications and data received from partner platforms.

The architecture for the DSO Data Processing module is shown in Figure 3:

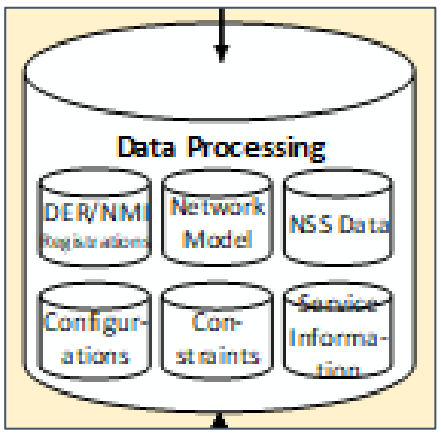

***Figure 3:** DSO Data Processing Diagram*

DSO Data Processing makes this data available to other DSO Platform modules, including the DOE Calculator and Analysis and Reporting modules, as well as partner platforms via integration with the Data Exchange Service module. To support these integrations, the DSO Data Processing module includes multiple integration points. The module is used store two weeks of monitoring and output data in the operational database, with data transferred to the Analysis and Reporting module (C-4) for longer term storage and analysis.

3.2 DSO Requirements mapped to DSO Data Processing modules

Table 9: *Requirements mapped to DSO Processing Modules*

DSO Requirements mapped to DSO Data Processing modules					Pilot DSO DB	Symphony Network Model	Symphony Telemetry data	Symphony DER register	Facility/Participating NMI register	DOE calcs output	Services data model	Managing outages	NSS reporting	managing NSS requests	Default DOE	DATA TRANSFER PROTOCOL	PL/SQL	IICS	DSO data flow automation	Thermal limit calculator	Voltage limit calculator	Enterprise Data Analytics Platform
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1.*	1.1.1	1.1.2	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	4.3.1	1.3.1	1.3.6	1.4.1	1.4.3	1.4.4	1.4.5	3.3.1	3.3.2	4.2.1
1	Network Components	Mandatory	GREEN ●			Y	Y									Y						
2	Network Connections	Mandatory	GREEN ●			Y											Y					
3	Network Component Constraints	Mandatory	GREEN ●			Y											Y					
4	Service Connections	Mandatory	GREEN ●	The DSO Platform does not store specifics on the customer service connections (for example if the customer has paid for an upgrade or not). However, the DSO Platform has the capability in the Symphony data model to apply a static value for single or three phase service connections.		Y			Y								Y					
5	Network Model Management	Mandatory	GREEN ●	Regarding Distribution Transformers (DSTR), switched into the pilot area, the DSO Platform only brings in the load of the additional DSTR via a "dummy" connection between the feeder and DSTR. The DSO Platform does not have the correct connection as the switching program of how the DSTR is switched into the Feeder is not easily derived from the data available and is not necessary for the purposes of the Project Symphony pilot phase.		Y											Y					
5A	Network Model Refresh	Mandatory (New)	GREEN ●	This requirement is a refinement of requirement 5. New requirement Description: "The Symphony Network Model must be refreshed nightly starting at 0:00am and be based on the "as-designed" model as well as the "as-switched" model."		Y											Y					
6	Network Model Changes	Mandatory	GREEN ●	Multiple changes made during the day are not stored in the archive. Only a single snapshot of the Symphony Model for a day is kept in the cloud computing software – based in the data cloud.				Y	Y									Y				Y
7	Network Outage Information	Desirable	GREEN ●			Y																
8	Future Planned Outage	Desirable	GREEN ●									Y					Y					
12	Network Model History	Desirable	GREEN ●	This requirement of providing two years of historical data has been descoped as there is no business need. The enterprise data analytics platform has the capability to store historical data.																		Y
24	Facility Registration Data	Desirable	GREEN ●						Y							Y			Y			
24A	Facility Registration Data	Desirable	GREEN ●	This requirement is a refinement of requirement 24 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall include data on registered Facilities. Facility information to include but not limited to: • Start and end date reflecting the trading date and intervals. • Array of NMI's participating in the market service the facility will provide (RID 24)."					Y							Y			Y			
25	Service Connection Participation	Mandatory	GREEN ●			Y			Y								Y					
26	DER Registration Data	Mandatory	GREEN ●					Y								Y			Y			
27	Facility Registration – Change History	Desirable	GREEN ●						Y							Y		Y	Y			Y
28	Service Connection Participation – Change History	Mandatory	GREEN ●						Y							Y		Y	Y			Y
29	DER Registration – Change History	Mandatory	GREEN ●	The DSO Platform is aware there are issues with the current productionised Distributed Energy Resources register (for example, service connection supply abolishment's/ demolitions are not recorded).				Y								Y	Y		Y			Y
30	Market Service Information	Mandatory	GREEN ●						Y		Y					Y		Y	Y			Y
31	Service Requests	Mandatory	GREEN ●						Y		Y		Y			Y		Y	Y			Y
32	Service Dispatch	Mandatory	GREEN ●						Y		Y		Y			Y		Y	Y			Y
32A	NSS Service Registration	Mandatory (New)	GREEN ●	This requirement is a refinement of requirement 32 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall support the registration of NSS Services, including: - Recording the service registration ID - Facility that will be used to deliver the service - Date/times service may be called - Amount of power that can be requested - Whether the service involves the provision of forward or reverse power"					Y		Y					Y		Y	Y			Y
32B	NSS Service Dispatch	Mandatory (New)	GREEN ●	This requirement is a refinement of requirement 32 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall support the requesting of the delivery of an NSS service, including: - Requesting the delivery of the service via the DMO platform - Providing all service information, including services ID, MW requirements, start time and delivery time (Req32A) - Provision of a NMI list"					Y		Y			Y		Y			Y			

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DSO Requirements mapped to DSO Data Processing modules					Pilot DSO DB	Symphony Network Model	Symphony Telemetry data	Symphony DER register	Facility/Participating NMI register	DOE calca output	Services data model	Managing outages	NSS reporting	managing NSS requests	Default DOE	DATA TRANSFER PROTOCOL	PL/SQL	IICS	DSO data flow automation	Thermal limit calculator	Voltage limit calculator	Enterprise Data Analytics Platform
32C	NSS Service Dispatch	Mandatory (New)	GREEN	This requirement is a refinement of requirement 32 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "A NMI list will be used to communicate the available NMIS that can be used to provide an NNS service. This list will essentially be a list of active NMIs on a section of the network and will allow for any network changes to be communicated to the Aggregator prior to service delivery. The DSO Platform shall support the maintenance of a NMI list, which can be sent to the DMO as part of a request for an NSS Service Dispatch (req. 32B)"		Y								Y									
32D	NSS Service Dispatch	Mandatory (New)	GREEN	This requirement is a refinement of requirement 32 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall support the requesting of the delivery of an NSS service to be registered without being tied to a specific asset, including: - Providing all service information, including services ID, MW requirements, start time and delivery time (Req32A) - Provision of a NMI list"					Y		Y		Y	Y		Y		Y	Y			Y
44	Grid Connected BESS	Mandatory	GREEN			Y				Y										Y	Y	
47	Service Dispatch Information	Desirable	AMBER	The Aggregator and the DSO created a process in the pilot which was enough to demonstrate if offering Network Support Service (NSS) with DER was viable. However, the DOE calculator does not consider data linked to Dispatch and/or intended Dispatch of a service (REQ, 33) when calculating and assigning DOEs. Services included, but are not restricted to, Network Support Service and Constraint to Zero.									Y									
55	Configurable Items	Desirable	GREEN	What has not been implemented is: - triggers for automatic calculation, instead the solution delivered only facilitates time/schedule based automated calculation). - location of input data can be changed for some input data (weather, telemetry, solar irradiance) for testing purposes only.	Y														Y			
64	DER Registration Data	Mandatory	GREEN					Y								Y			Y			
65	Facility Registration Data	Mandatory	GREEN						Y							Y			Y			
71	Identification of Grid Connected BESS	Mandatory	GREEN	The DSO Platform has met this requirement by specifying the National Metering Identifier (NMI) associated with the Batter Energy Storage System (BESS), the way it is connected into the DSOs/ Western Power network and the size of the Distributed Energy Resource (DER). In the future, BESS's owned by DSO will go into the Geographic Information System (GIS) and DSO/Western Power (Enterprise Resource Planning (ERP) solution. Further development is still in progress regarding what is needed to identify BESS's not owned by DSO/Western Power		Y	Y															
78	NSS Validation	Mandatory	GREEN				Y		Y		Y		Y				Y	Y				Y
107	Storage of DOE Calculator Inputs and Outputs	Desirable	GREEN		Y																	Y
108	Network Coverage	Desirable	AMBER	Some parts of the technical solution delivered are extensible to other parts of the network, for example, the Default DOE Module. In general, there are modules that require additional work to roll out to the next feeder. The known challenges are: - new asset types / configuration in network models, - The pilot is currently only dealing with "switch in and out". Additional feeders mean "swapping of load" between feeders (has been tested to a limited extent) - when considering multiple feeders, the DSO Platform will need to run Evolve calculations in parallel (one per feeder) to ensure throughput times stay the same. This requires more development time.											Y							
111	Increased DER – Volume	Desirable	GREEN	The current Distributed Energy Resources (DER) register already allows for multiple inverters DER connected to the grid per National Metering Identify (NMI). However, this is mainly used for Photovoltaic (PV) and Battery installations.				Y														
112	Increased DER – Scope	Desirable	AMBER	In principle, this requirement has been met (any type of Distributed Energy Resource (DER)) could be added to the DSO Platform. There is still further analysis required into whether Electric Vehicle Fast Chargers will modify the Network Model. Also, the current DSO technical rules only allow for certain types of DER to be registered (not any type of controllable load - only generation and storage). There is additional analysis required on how more controllable load will impact load forecasting module (for example, should the DSO Platform include planned dispatch schedules in the load forecast?). This requires further assessment before more types of DER are included. Also, further consideration is needed to test what the impact is to the load forecast if consumers (customers) were to change their controllable load assets.				Y														

4. DOE Calculator modules

4.1 Description

The DOE Calculator module incorporates capabilities to calculate and allocate DOEs to NMIs, participating in Project Symphony. The DOE Calculator also supports the identification of network constraints that cannot be managed using DOEs, requiring the deployment of NSS. As such, the DOE Calculator is fundamental to the process of identifying NSS requirements and triggering DSO, DMO and Aggregator processes that facilitate the provisioning and dispatch of NSS.

Dynamic Operating Envelope (DOE) calculator module is built around the Evolve Platform. The Evolve Platform was developed by the Australian National University (ANU) Battery Storage and Grid Integration Program[37]. Data is transferred from the DSO Data Processing area to the Evolve Platform via a data ingestor, where it is transformed into a format similar to the IEEE 2030.5 standard. The platform applies the Evolve methodology, which uses available data to forecast network loads, conduct a load flow analysis to identify network constraints, prior to calculating and allocating DOEs based on the results. The outputs are then published back to the DSO Data Processing module (C-1).

DOEs are calculated daily by the DOE Calculator module for the duration of the Pilot, with the DSO Data Processing module used to publish safe 'default' DOEs for each NMI at short notice in cases where the network changes between DOE calculation cycles, such as during outages and/or unplanned network switching.

The architecture for the DOE Calculator module is shown in Figure 4.

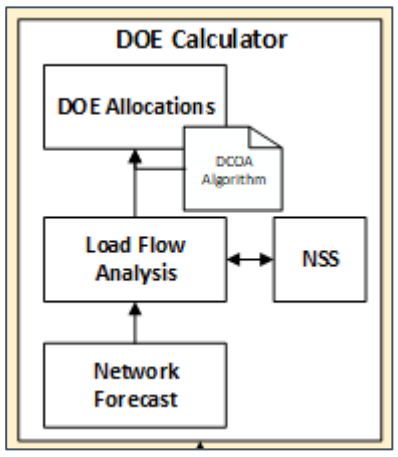

Figure 4: DOE Calculator Diagram

[37] ANU Battery Storage and Grid Integration Program

4.2 DSO Requirements mapped to DOE Calculator module

Table 10: *DSO Requirements mapped to DOE Calculator modules*

DSO Requirements mapped to DOE Calculator modules					Pilot DSO DB	Symphony Network Model	Symphony Telemetry data	Symphony Weather data	Facility/Participating NMI register	DOE calcs output	DOE reporting	managing NSS requests	managing NMI Consent	Outage management	Default DOE	DATA TRANSFER PROTOCOL	Python	PL/SQL	IICS	DSO data flow automation	DOE Validator	ANU digester	Evolve digester	Load Forecaster	Thermal limit calculator	Voltage limit calculator	Enterprise Data Analytics Platform	Network Analysis Tool
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1*	1.1.1	1.1.2	1.1.3	1.1.5	1.1.6	4.2.1	1.3.1	1.3.2	1.3.3	1.3.6	1.4.1	1.4.2	1.4.3	1.4.4	1.4.5	1.5	3.1.1	3.1.2	3.2.1	3.3.1	3.3.2	4.2.1	5.1.1
34	Forecast Against Available Data	Mandatory	AMBER	The forecasting module currently predicts solar outputs adequately however accuracy improvements are required to predict load spikes because of sudden temperature conditions. Load forecasting improvements has been committed to by Evolve. All data from the requirements are covered by the Pilot DSO DB, the gap is with the implementation of the load forecasting component.	Y															Y				Y				
35	Network Load Forecast Length	Mandatory	GREEN	The solution is capable to create a load forecast at five-minute intervals for the next three days, in-line with the Dynamic Operating Envelope Calculator forecasts. For all National Metering Identifiers in the Network Model.																Y				Y				
36	Load Flow Analysis	Mandatory	AMBER	The Dynamic Operating Envelope (DOE) Calculator undertakes load flow analysis as part of developing DOE results. The DOE Calculator module outputs to DSO include "limiting component" and DOEs. However, the output does not include the load flow analysis results. The DSO platform is yet to validate that the DOE calculator module applies voltage constraints correctly.													Y									Y	Y		Y
37	DOE Allocation Granularity	Mandatory	GREEN	The DSO Platform had a requirement that only changes if the value is over .5kW between intervals that were published. The DSO Platform also produces Operating Envelopes for national metering identifiers that have been recruited outside of pilot area.						Y										Y					Y	Y		
38	DOE Allocation to Alleviate Constraints	Mandatory	GREEN			Y	Y			Y	Y																	
39	DOE Allocation for Participating Service Connections	Mandatory	GREEN			Y			Y	Y										Y		Y	Y	Y	Y	Y		Y
40	Equal Allocation	Mandatory	GREEN							Y										Y					Y	Y		
41	Proportional Allocation	Mandatory	GREEN			Y				Y										Y					Y	Y		
42	Optimal Allocation	Mandatory	AMBER	The DOE calculator module calculates at National Metering Identifier (NMI) levels regarding voltage limits and then applies "equal allocation" for all NMIs on same distribution transformer (DSTR). Project Symphony's Research Partner Platform Distribution Constraint Optimisation Algorithm (DCOA) work has been de-scoped until further notice.						Y							Y								Y	Y		
43	Firm Capacity	Mandatory	GREEN		Y					Y										Y					Y	Y		
45	Transformer Level DOE Allocation	Desirable	GREEN		Y					Y										Y					Y	Y		
46	Default DOEs	Mandatory	GREEN	Default DOEs are stored in the Pilot DSO DB.	Y					Y										Y								
48	Load Flow Analysis - Output	Mandatory	AMBER	A separate network analysis tool was meant to be used only for validation. The load flow results analysis has been conducted using measured data from AMI instead of forecasting and early indications show minor differences between actuals, though the results are encouraging.													Y			Y								Y
51	DOE Allocations - Output	Mandatory	GREEN							Y						Y				Y								
52	Default DOEs - Output	Mandatory	GREEN	Requirement specific to "lack of sufficient ... component" is not implemented. Instead, the solution will always calculate a DOE (even if no recent telemetry data is coming in - which is monitored separately). Missing data is interpolated/estimated. To what extend this is impacting the quality of the DOE is still being analysed.					Y	Y			Y	Y		Y				Y	Y							
53	Manual DOE Calculation	Mandatory	GREEN																	Y		Y	Y	Y	Y	Y		
54	Automated DOE Calculation	Mandatory	GREEN	The DSO Platform implemented the scheduled based Dynamic Operating Envelope calculation as that is what the requirements for publishing to the Aggregator state. However, there is an option in non-Pilot environments to calculate DOEs more often (by manually trigging a re-calculation) if required for testing (when other data is available).																Y		Y	Y	Y	Y	Y		

DSO Requirements mapped to DOE Calculator modules					Pilot DSO DB	Symphony Network Model	Symphony Telemetry data	Symphony Weather data	Facility/Participating NMI register	DOE calcs output	DOE reporting	managing NSS requests	managing NMI Consent	Outage management	Default DOE	DATA TRANSFER PROTOCOL	Python	PL/SQL	IICS	DSO data flow automation	DOE validator	ANU digester	Zonkey digester	Load Forecaster	Thermal limit calculator	Voltage limit calculator	Enterprise Data Analytics Platform	Network Analysis Tool
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1.*	1.1.1	1.1.2	1.1.3	1.1.5	1.1.6	4.2.1	1.3.1	1.3.2	1.3.3	1.3.6	1.4.1	1.4.2	1.4.3	1.4.4	1.4.5	1.5	3.1.1	3.1.2	3.2.1	3.3.1	3.3.2	4.2.1	5.1.1
56	Default DOEs	Desirable	GREEN	This requirement has been refined, as below: "The DSO Platform shall allow for different default DOEs operating envelopes (OE's) to be defined, configurable to change the limiting values, calculated and allocated as followed: -Custom OE with a shaped profile, fixed based on the Embedded Generation Connection Agreement for a Grid Connected BESS (REQ. 71) "; and, -NMI's outside of SNR540 (excluding BESS) will have a Standard OE for an export limit of 5kW. -In the event of a component and/or system failure, issue a Default DOE with a shaped profile based on the Service Connection limit, Time of year, and -1.5kW export limit. "	Y										Y															
56A	Default DOE Changes	Desirable (New)	GREEN	This requirement is a refinement of requirement 56 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall allow for the recording of any changes to the operating envelopes values over time."	Y										Y														
56B	Default DOE Application	Desirable (New)	GREEN	This requirement is a refinement of requirement 56 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO Platform shall record all instances where the operating envelopes were used (in place of calculated DOEs)."	Y					Y					Y														
57	DOE Calculation in Response to Incidents and Outages	Desirable	AMBER	The DSO platform considered a different approach: rather than recalculating DOEs, the DSO platform detects any significant changes in the pilot area and then notifies the DSO Platform users to identify what the best response is. If required, the user can publish a short notice/ default operating envelope DOE for the required National Metering Identifier's.										Y	Y														
58	Failsafe Override	Mandatory	GREEN		Y									Y		Y				Y									
59	DOE Calculator Notification Configuration	Desirable	AMBER	The output of Evolves load flow analysis incorporates ratings of some components, which necessitates additional analysis and improvement to meet the criteria.																									
60	DOE Calculator Notification Channel	Desirable	GREEN																										
61	DOE Calculator Notification Preferences	Desirable	GREEN																										
62	DOE Calculator Notification History	Desirable	GREEN																										
63	DOE Publication	Mandatory	GREEN							Y					Y	Y		Y		Y									
79	DOE Calculator Performance Verification	Mandatory	GREEN				Y			Y	Y							Y	Y								Y		
80	Network Analysis	Desirable	AMBER	It was intended to use an alternate load flow solution for validation of results, however, challenges resulting from complexities with implementing the solution meant that this method of validation was not completed. The DSO Platform instead manipulates input data in our DSO platform and rerun's the DOE Calculator module.		Y	Y	Y		Y	Y									Y				Y	Y	Y		Y
105	Simulated Data	Mandatory	GREEN	Some conditions can only be simulated in non-Pilot environments (for example, electricity network outages, weather, solar irradiance). Changes to the network model (for example, Distribution Transformer ratings) can be done in the Pilot live environment.	Y																								

5. Analysis and Reporting modules

5.1 Analysis and Reporting

5.2 Description

The Analysis and Reporting module comprises of two main areas:

1. **Reporting and Service Verification:** Provide timely reports to support operational decision making, such as such as verifying the accuracy of DOE Calculator forecasts against actuals, validating compliance with DOEs and validating NSS delivery for settlement; and,
2. **Ad-hoc Analysis (Post-operations):** Provides analytical capabilities to validate hypotheses as part of Project Symphony's Test and Learn strategy, as well as analysis in support of longer-term planning.

The architecture for the Analysis and Reporting module is shown in Figure 5.

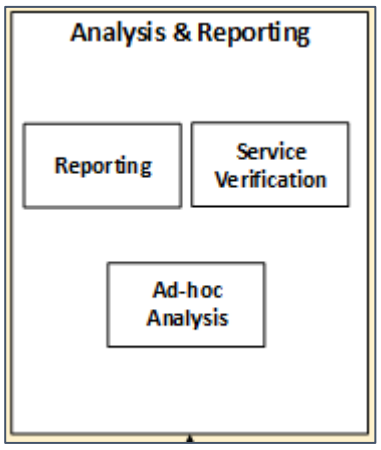

Figure 5: Analysis and Reporting Diagram

5.3 DSO Requirements mapped to Analysis and Reporting modules

Table 11: *3.5.4 Requirements mapped to Analysis and Reporting*

DSO Requirements mapped to Analysis and Reporting modules					Pilot DSO DB	Symphony Network Model	Symphony Telemetry data	DOE calcs output	DOE reporting	NSS reporting	monitoring logs	PL/SQL	IICS	DSO data flow automation	DOE Validator	Load Forecaster	Thermal limit calculator	Voltage limit calculator	Enterprise Data Analytics Platform
ID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1.*	1.1.1	1.1.2	1.1.6	4.2.1	4.3.1	1.3.5	1.4.3	1.4.4	1.4.5	1.5	3.2.1	3.3.1	3.3.2	4.2.1
49	Identified Constraints - Output	Mandatory	AMBER 🟡	There is a constraint report produced by the DOE Calculator module vendor, however, it is not in readable output. This part of the module is yet to be completed.				Y						Y			Y	Y	
50	Identified NSS Constraints - Output	Mandatory	GREEN 🟢	Instead of using the constraint report, The DSO platform uses the load forecast (in kW) and compares that to the kW ratings of the electrical network components.		Y		Y						Y		Y			
77	DOE Compliance	Mandatory	GREEN 🟢				Y	Y	Y			Y	Y						Y
81	Report Creation	Mandatory	GREEN 🟢	There has been a recent requirement to store all dispatch instructions from the DMO sent to the Aggregator for Test and learn purposes. The DSO Platform currently only store Network Support Services and Constraint To Zero information (not Balancing Market Offer or Essential System Services).	Y								Y						Y
82	Report Management	Mandatory	GREEN 🟢	The reports are written using the WESTERN POWER Business analytics platform environments underpinned by Data base / Cloud computing–based data cloud SQL. The DSO platform acknowledges that there are a few challenges with this environment: • slow process to change control • does not allow for input parameters (only to apply filters) • tagging/searching • not ideal for data analysis					Y	Y		Y							Y
83	Schedule Report Publication	Mandatory	GREEN 🟢	The DSO platform acknowledges that there are a few challenges with this environment • using the business analytics platform environment. • only time-based refreshes • reports are typically for a predefined period (time horizon) which can be shortened/zoomed in on by applying filters, but not broadened • The DSO platform is not sending emails, but there have been no requirements for this. • Business analytics platform reports can be exported to PDF and these can be sent to partners if required.					Y	Y										
84	Data Visualization	Mandatory	GREEN 🟢	The DSO platform have had issues with the business analytics platform displaying scatter plots (we found work arounds by using unique row numbers etc). However, in general the business analytics platform can display the required visualisations, but the experience is that it is not intuitive, and it has limitations.					Y	Y										
85	Standard Derivations and Measures	Mandatory	GREEN 🟢	There are options in both the Business analytics platform and The DSO platform Symphony Data Base Views to standardise certain measurements, and calculations, for example, with the purpose of reuse.					Y	Y		Y								
86	Data Quality Reports	Desirable	GREEN 🟢	The DSO platform has the following quality reports: • DOE quality • Load forecast quality • DSO operational / monitoring report, including data quality measures.					Y		Y				Y					
87	Ad-hoc Data Analysis	Mandatory	GREEN 🟢									Y	Y						Y
88	Ad-hoc Data Visualisation	Desirable	GREEN 🟢						Y	Y									Y
89	Additional Data	Desirable	GREEN 🟢	Manual uploads of Spreadsheets can be done either through the DSO Symphony Data base, the Enterprise Data Analytics Platform or directly into the Business analytics platform.	Y				Y	Y									Y
90	Logical Separation of Activities	Desirable	GREEN 🟢		Y				Y	Y		Y							Y
117	Data Retention	Mandatory	GREEN 🟢	All data and changes are archived in the Enterprise Data Analytics Platform.									Y						Y

6. Data Exchange Service

6.1 Description

The Data Exchange Service module provides the exchange of information between partner platforms required to execute the 'must-have' project scenarios. This includes:

- Exchange of data to support the identification and registration of participating NMIs,
- Information on VPP facility registrations,
- Publication of DOEs; and,
- Requests for the deployment of NSS.

Data is exchanged with partners through three main integration mechanisms:

1. Data exchange layer**:** It is an open-source solution used to pass data between partner platform using an agreed data model. Data Exchanged through this mechanism includes published facility registrations, Dynamic Operating Envelope files, and Network Support Services requests. The solution is provided via the DMO Platform Vendor.
2. **Data Transfer via Shared Storage:** A shared storage area is used to exchange data between partner organisations.
3. **Email:** Email integrations are used largely for Test and Learn data, not necessary for the operational end-to-end execution of the 'must-have' scenarios.

The architecture for the Data Exchange Service module is shown in Figure 6.

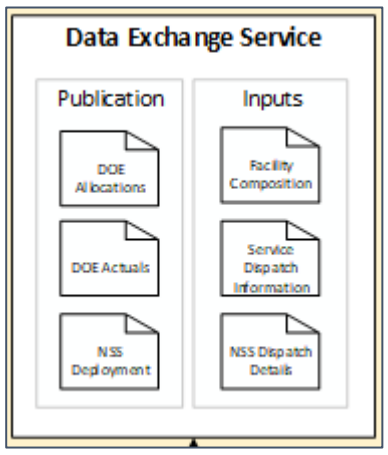

Figure 6: Data Exchange Service

6.2 DSO Requirements mapped to Data Exchange module

DSO Requirements mapped to Data Exchange modules					Pilot DSO DB	Symphony Telemetry data	Facility/Participating NMI register	Services data model	Managing outages	configuration changes	Voltage limit calculator
RID	Requirement Name	Priority	Total coverage	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1.1.*	1.1.2	1.1.5	1.1.7	1.1.8	1.3.4	3.3.2
66	Receive Additional Files	Desirable	AMBER	All necessary information on NSS dispatch, ESS, system integration testing and DER telemetry is collected. The only task left is to upload the DER telemetry data into the Enterprise Data Analytical Platform module.			Y				Y
67	Publish Additional Files	Desirable	GREEN					Y	Y		Y
68	DSO Platform Messages	Desirable	GREEN	The Data Transfer Protocol module covers this to a certain extent. However, the design of the integration could be improved for proper acknowledgement of requests.						Y	
69	DMO Platform Messages	Mandatory	GREEN	All the events received via email from the DMO platform, which is part of the Dispatch instructions, include Balancing Market Offer + Network Support Services + Constraint to Zero + Essential Support Services.			Y			Y	
70	Aggregator Platform Messages	Mandatory	GREEN		Y	Y	Y			Y	
120	Open Standards	Desirable	RED	The integration was done using a custom data modelling approach, instead of adhering to open standards to support compatibility with partners. Even though the module was designed to use the IEEE 2030.5 standard to standardise Dynamic Operating Envelope messages, the DMO, Aggregator, and DSO platforms decided to stay close to the standard instead of strictly following it due to the size of the application programming interface output, which would have caused performance and storage issues. Additionally, IEEE 2030.5 is not a required or regulated standard. There are other integrations that couldn't be covered with any standard, for example, issuing Network Support Service.							

6.3 Battery Service Module

6.3.1 Battery Service

6.3.2 Description

The Battery Service module is comprised of three main Modules:

1. Battery Service Control: Controls the battery and provides detailed data on BESS functions.
2. Gateway: Supports Aggregator control of the BESS, allowing the Aggregator to monitor and use the battery as part of a VPP, dispatching the BESS the same as other facility DER, including ensuring compliance with the DOE.
3. SCADA Remote Terminal Unit (RTU): Integrates the BESS with DSOs SCADA Distribution Management System and real-time data historian, allowing Network Operations to take control of the BESS in case of emergency.

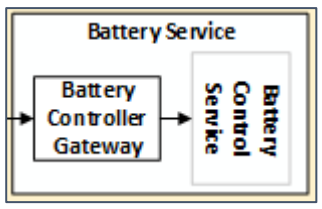

Figure 7: Battery Service

6.3.3 DSO Requirements mapped to Battery Service modules

Table 13: *Requirements mapped to Battery Service*

DSO Requirements mapped to Battery Service modules					Symphony BESS	Battery Service Control	SCADA RTU	High Speed Data Recorder (DSO)
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	6.1.1	6.1.2	6.2.1	6.3.1
72	Aggregator Control	Mandatory	GREEN	Aggregator has installed their own Distribution Transformer Monitor (DSTR Monitor 1) recorder installed at the Battery Energy Storage System (BESS)site for visibility/control	Y	Y		
73	Aggregator Visibility	Mandatory	GREEN	Aggregator has installed their own Distribution Transformer Monitor (DSTR Monitor 1) recorder installed at the site for visibility/control. In addition, Aggregators Energy Management System recorder installed at the Battery Energy Storage System (BESS) site for visibility and control.	Y	Y		
73A	DMO HSDR Visibility	Mandatory	GREEN	This requirement is a refinement of requirement 73 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO must log high-resolution time synchronised system disturbances and/or events and make the electronic information available to the DMO"				Y
73B	DMO BESS Visibility	Mandatory	GREEN	This requirement is a refinement of requirement 73 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The DSO must make the Symphony BESS recorded measuring information available to the DMO within 3 business days, or a timeframe otherwise agreed by the DMO, in the event of a system or network event, and/or, as requested by the DMO."				Y
73C	HSDR data sharing transactions	Desirable	GREEN	This requirement is a refinement of requirement 73 with consensus between the DMO, Aggregator, as well as the DSO. New requirement Description: "The solution should have a database /report on the successful/unsuccessful HSDR data sharing solution transaction"				Y
74	DSO Control	Mandatory	GREEN		Y	Y	Y	
75	Prioritisation of Control	Mandatory	GREEN	This requirement is not implemented by DSO and/or the DSO Platform. This has been delegated to the Aggregator, for example, the Aggregator's energy management system module has new firmware that will manage prioritisation between the Aggregator and DSO (DSO has higher priority). Actual prioritisation is implemented by the Aggregator and those two components allow for the priority control.	Y	Y		
76	End-of-Lease Disconnection	Desirable	GREEN		Y	Y	Y	

7. DSO Non-Functional Requirements mapped to modules

Table 14: *Non-Functional Requirements mapped to Modules*

DSO Non-functional Requirements mapped to modules					DSO Data Processing	Network and Environment	DOE Calculator	Analysis and Reporting	Project Management Tool (DSO)
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1	2	3	4	7
91	Useability	Desirable	AMBER	The Web User interface developed has a consistent user experience, however, the module has limited validation and needs to be operated by trained subject matter expert. See also R93. SQL Views could be improved to further standardise the ad-hoc analysis and data acquisition for reporting The created Business Analytics Platform reports needs extra effort to make them consistent and enhance the user experience.	Y			Y	
92	Branding	Desirable	GREEN		Y				
93	Consistent Error Messages	Desirable	AMBER	See also R 91 Very limited number of users. The few subject matter experts that are using the DSO Platform frontend web page user interface adequately understand the system. However, this needs more work. Also, consistency / wording / unit of measure in the business analytics platform reporting needs to be reviewed.	Y			Y	
94	WWW Access	Desirable	GREEN		Y			Y	
95	Single Portal	Desirable	AMBER	Reporting is available through Business analytics platform dashboard; Web User Interface is available through a separate portal.	Y			Y	
96	Single Sign-on	Desirable	AMBER	Most used modules are covered: - DSO Web User Interface - Cloud computing–based data cloud archive - Business analytics platform reporting Not covered: - Distribution monitoring device access - Network Analysis Tool environment - Evolve environment	Y	Y	Y	Y	Y
97	Role Based Access Control	Mandatory	GREEN		Y		Y	Y	Y
98	User Management	Mandatory	GREEN	See also R97 The intent of this requirement is delivered via Active directory and the Data base/Cloud computing–based data cloud roles.	Y		Y	Y	Y
99	Compliance with Australian Privacy Principles	Mandatory	GREEN	No personal / confidential data is kept within The DSO platform's Symphony Data Base.	Y		Y	Y	
100	Cloud Risk Assessment	Mandatory	GREEN			Y	Y		
101	Virus and Malware Detection	Mandatory	GREEN	Cloud software is assessed against these kinds of attack and on-premises Virtual Machines that are constantly checked for malware/virus attacks as part of DSOs infrastructure services.	Y	Y	Y	Y	Y
102	SSDLC	Mandatory	GREEN		Y	Y	Y	Y	Y
103	Environment Provisioning	Mandatory	GREEN	The DSO Platform has delivered the following environments: <u>Dev:</u> - Unit Tests <u>Internal Test</u> - System (Integration) test - internal User Acceptance Testing - performance / load testing <u>X-Platform Test</u> - cross partner testing - end-to-end testing - performance testing <u>Pilot live environment:</u> - T&L hypotheses testing <u>Tools:</u> - Joint partner test and defect management tool. - DSO Platform Software Development Tool (DSO) - bitbucket (version control) - platform management (business analytics platform version control) - direct SQL validation of data. <u>Improvement:</u> - change control of DB changes - automated test execution	Y				Y

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DSO Non-functional Requirements mapped to modules					DSO Data Processing	Network and Enviornment	DOE Calculator	Analysis and Reporting	Project Management Tool (DSO)
RID	Requirement Name	Priority	Rating	DSO Platform comments* **If the requirement was not fully met, is new, changed, or the DSO Platform delivered above and beyond the requirements intent.*	1	2	3	4	7
104	Test Environment Equivalence	Mandatory	GREEN	Test and the Pilot live environment will always be different. However, if required, the DSO Platform can make the Test environment look the same as the Pilot environment, both in terms of data input, as well as version of software to ensure problems can be replicated.	Y				Y
106	Software Version Control	Desirable	AMBER	The functionality of promoting new versions of modules is covered under the change and release management process. This is not at the module level, however. DSO's system used to manage version control is not able to use typical CI/CD practices due to DSO's restrictions on migrating Data Base changes. The DSO Platform does have a backup in bitbucket however and is relying on DSO's standard practices.	Y	Y	Y	Y	Y
110	Multiple Aggregators	Desirable	AMBER						
113	Software Licensing	Desirable	GREEN	Total number of end-users of the DSO platform is low (Web User Interface / DOE Calculator Module User Interface) Cloud computing–based data cloud archive is higher during Test & Learn but will be less after that and cost is mainly related to compute time (query complexity) which is monitored and training is provided where necessary. Data volumes on Data base Exadata (on prem) is expensive and kept at bay by archiving to Cloud computing–based data cloud for low cost storage.	Y	Y	Y	Y	Y
114	Modular Design	Desirable	AMBER	The DSO platform has not been completely designed modularly for reuse in mind. Instead, the focus has been on obtaining the learning outcomes and "design a solution" on the way in conjunction with the partners. When certain parts prove to be correct some redesign is required to make them more robust, scalable and extensible, as well as easier to interact with. Some parts are modular, for example, the DOE calculation module could be seen as reusable but does heavily rely on the data as presented by DSO - not having this data means that the DOE Calculator Module solution is difficult to reuse.					
115	Audit Trail	Desirable	GREEN		Y		Y		
116	Audit Retrieval	Desirable	GREEN	All updates on non-telemetry data can be queried in the archive. Changes are tracked daily. Changes to Network Support Services / Facilities are tracked in the operational Project Symphony Data Base	Y		Y	Y	
118	Data Provenance	Mandatory	GREEN	In the operational Project Symphony Data Base (DB): Network Model data is refreshed daily, but the time is not stored in the DB against the model. However, it is easily traceable from logs when the last successful run was. Other WESTERN POWER data is referenced (Performance Quality, supervisory control and data acquisition (SCADA)) Distribution Transformer (DSTR) telemetry is read: - DSTR monitor 2 every 60min (1min samples collected) - DSTR Monitor 1 near Realtime (10sec samples) - DSTR Monitor 3 every 10min (1min samples) Configuration tables and ratings that are managed manually are not tracked for changes except for daily changes that are recorded in the archive. In the archive: All data is synced with the archive on a daily basis and load times are captured for all tables.	Y		Y	Y	
119	Response Times	Desirable	GREEN	This is mainly related to Web user interface requests.			Y		
121	Support and Maintenance	Desirable	GREEN	100% covered by our Project's Service Level Agreements					Y
122	Service Request Process	Desirable	GREEN	100% covered by our Project's Service Level Agreements					Y
123	Problem and Incident Management Process	Desirable	GREEN	100% covered by our Project's Service Level Agreements					Y
124	Change Request Process	Desirable	GREEN	Intent of the requirements delivered via the change and release management process defined by the project, in conjunction with partners.					Y
125	Release Management Process	Desirable	GREEN	Intent of the requirements delivered via the change and release management process defined by the project, in conjunction with partners.					Y
126	Availability	Desirable	GREEN	100% covered by our Project's Service Level Agreements	Y		Y	Y	Y
127	Downtime	Desirable	GREEN	Intent of the requirements delivered via the change and release management process defined by the project, in conjunction with partners.					Y
129	Business Continuity and Disaster Recovery	Desirable	GREEN	The whole of Symphony is classified as a tier 4 (Pilot/non-business critical). Recovery Time Objective: up to 1 week (Tier 4 application) - This includes Service Level Agreements offered by the DSO Calculator module vendor. Recovery Point Objective: data is continuously replicated (near Realtime) to offsite location so there is minimal data loss.	Y	Y	Y	Y	Y

Appendix D: DMO Platform Requirements Mapped to Components

Section for DMO Platform. The Appendix will include a detailed mapping of all requirements contained in WP4.3 to the component that delivers the requirement.

10.1 Register Participant

Capability for the:

- DMO administrator to coordinate with the applicant to setup the technical and financial requirements in a multi-step process to complete the registration as a market participant. A registered user will be assigned a role, username and logon password to access the user interface.
- DMO Market Platform to receive and store NMI and aggregated DER facility level registration information from the Aggregator Platform to monitor the capability of the aggregated DER facility that can offer/bid and provide energy, ancillary and network services.

ID	Short Description	Capability Mapping	Integration Mapping	Component Mapping
REG1	Receive registration data from the Aggregator for registered services	F01, F02	IS0102	C01, C02, C03, C04
REG2	Descoped from the solution			Descoped
REG3	Store the registration data from the Aggregator	F03		C06
REG4	Record that the service requirements can be met by the aggregator	F03		C06, C08

Table 10. Register Participant

10.2 Process Facility and Constraint Data

Capability for the AEMO Market Platform to:

- receive, process and store data required to operate the market.
- construct and send data required to operate the market.
- receive, process and store data required to assess the performance of the DER market.

ID	Short Description	Capability Mapping	Integration Mapping	Component Mapping
PFC1	Receive facility constraint information from the DSO	F06	IS0105	C01, C02, C03, C04
PFC2	Receive aggregated facility capacity from the Aggregator	F11	IS0118	C01, C02, C03, C04
PFC3	Receive DER facility status from the Aggregator	F09	IS0108	C01, C02, C03, C04
PFC4	Receive AGC interface points from the Aggregator	Not Delivered		C01, C02, C03, C04
PFC5	Receive Active DER Forecast from the Aggregator	F11	IS0118	C01, C02, C03, C04
PFC6	Receive Telemetry Data (facility) - 4s resolution and frequency	F09 Partially delivered, 1 min resolution and 5 min frequency	IS0108	C01, C02, C03, C04
PFC8	Store facility constraint information from the DSO	F06		C06
PFC9	Store aggregated facility capacity from the Aggregator	F11		C06
PFC10	Store DER facility status from the Aggregator	F09		C06
PFC11	Store AGC interface points from the Aggregator	Not Delivered		C06
PFC12	Store Active DER Forecast from the Aggregator	F11		C06
PFC13	Store Telemetry Data (facility) - 4s resolution and frequency	F09		C06
PFC17	Receive NSS Contract Information	F04	IS0115	C01, C02, C03, C04
PFC18	Store NSS Contract Information	F04		C06

Table 11. Process facility and Constraint Data

11.1 Manage Bids/Offers

Capability for AEMO's Market Platform to:

- Receive bids and offers from the Aggregator to provide energy services to the DER market.
- Receive bids and offers from the Aggregator to provide ancillary services to the DER market.

ID	Short Description	Capability Mapping	Integration Mapping	Component Mapping
MBO1	Must receive and process offers for BMO	F07 F08 F12	IS0106 IS0112	C01, C02, C03, C04, C06, C08 C12
MBO3	Must receive and process offers for Frequency Regulation Up/Down	Not Delivered	Not Delivered	Not Delivered
MBO6	Must define and communicate Contingency Reserve Raise requirements to the market	F07	IS0112	C01, C02, C03, C04, C06, C08 C12
MBO7	Must receive and process offers for Contingency Reserve Raise	F12	IS0106	C01, C02, C03, C04, C06, C08
MBO11	Must receive and process deployment signal from the DSO platform for NSS	F05	IS0117	C01, C02, C03, C04, C06, C08
MBO13	Must receive and process offers for a bi-directional bid	F07 F08 F12	IS0106 IS0112	C01, C02, C03, C04, C06, C08 C12
MBO15	Must receive and process a dispatch acknowledgement from the aggregator for any DI or control signal sent by AEMO	F05	IS0117	C01, C02, C03, C04, C06, C08
MBO16	Must send a NSS DI acknowledgement to the DSO	Not Delivered		C01, C02, C03, C04, C06, C08

Table 12. Manage Bids/Offers

11.2 Manage Dispatch Instructions/Control Signals

Capability for the AEMO Market Platform to:

- Construct and send instructions to the Aggregator to provide energy services during specified time intervals.
- Construct and send instructions to the Aggregator to enable provision of Ancillary Services during specified time intervals and in response to observed network events.

ID	Short Description	Capability Mapping	Integration Mapping	Component Mapping
MDICS1	Send and manage a series of dispatch instructions to the aggregator for BMO	F08 F18		C01, C02, C03, C04, C06, C08 C12
MDICS2	Send and manage a series of dispatch instructions to the aggregator for BMO (marginal unit)	F13 F14		C01, C02, C03, C04, C06, C08 C12
MDICS3	Send and manage a series of control signals to the aggregator for ESS Regulation.	Not Delivered	Not Delivered	Not Delivered
MDICS4	Send and manage a series of dispatch signals to the aggregator for ESS Frequency Regulation Raise and Lower.	Not Delivered	Not Delivered	Not Delivered
MDICS7	Send a control signal to the aggregator for Contingency Raise	F16		C01, C02, C03, C04, C06, C08
MDICS9	Send a NSS DI to the aggregator for NSS	F05	IS0123	C01, C02, C03, C04, C06, C08
MDICS10	Send an instruction of constrain export to 0 MW	F15		C01, C02, C03, C04, C06, C08 C12

ID	Short Description	Capability Mapping	Integration Mapping	Component Mapping
MDICS12	Send and manage a series of dispatch instructions to the aggregator for a bi-directional offer/bid	F16 F17 F18	IS0107 IS0117	C01, C02, C03, C04, C06, C08 C12

Table 13. Manage Dispatch Instructions / Control Signals

11.3 Reporting and Performance Assessment

Provide capability for:

- The AEMO Market Platform to retrieve and configure the data required to assess the performance of the DER market.
- AEMO to present this information to both internal and external Project stakeholders.

ID	Short Description	Component Mapping	Integration Mapping	Component Mapping
REP1	Send registration data to the DSO	F03	IS0104	C01, C02, C03, C04, C05, C06
REP2	Send bid/offer data to the DSO	F19 F20		C01, C02, C03, C04, C06, C08 C12
REP3	Receive and store operational forecast data from the aggregator to allow AEMO to monitor the energy balance in the grid	F19 F20		C01, C02, C03, C04, C06, C08
REP4	Receive and store DER high-speed recorder data from a Pilot scenario.	F19 F20		C13
REP5	Receive and store distribution network constraints during test period from the DSO	F19 F20		C01, C02, C03, C04, C06, C08
REP6	Receive and store network outage information during test period from the DSO	Not Delivered	Not Delivered	Not Delivered
REP7	Receive and store Real-time Load Levels during test period from the DSO	Not Delivered	Not Delivered	Not Delivered
REP8	Receive and store Voltage / Frequency (telemetry - 4s freq) information during test period from the DSO	Not Delivered	Not Delivered	Not Delivered
REP9	Receive and store operating limits include thermal limits for network equipment from the DSO	Not Delivered	Not Delivered	Not Delivered
REP10	Allow analysts to retrieve and extract the test related data from the storage capability in a format that can be imported into an analysis platform	F20		C10, C13
REP11	Allow for an analyst to perform an assessment of the performance of the system and participants during the tests and overall Pilot	F20		C07, C09, C10,
REP12	Must record the energy dispatch, ESS & NSS of the aggregated DER facility in real time and display to control room user to monitor	F10		C07, C09, C11, C14

*Table. Reporting and Assessment P*erformance

11.4 User Modifiable Test Variables

Provide capability to:

- Configure system variables related to market timing, market price and network events.

Allow set up of testing market and operational scenarios through the configuration of variable data pre-test and during the test execution.

ID	Short Description	Component Mapping	Integration Mapping	Component Mapping
UM1	Must allow at time prior or during a test event, the ability to construct and input a dispatch schedule	F13 F14		C02, C03, C04, C06, C08
UM2	Must allow at time prior or during a test event, the ability to construct and input a set of control signals	F13		C02, C03, C04, C06, C08

ID	Short Description	Component Mapping	Integration Mapping	Component Mapping
		F14		
UM3	Must allow the analyst to modify the dispatch time interval testing parameters	Not Delivered	Not Delivered	Not Delivered
UM4	Must allow the analyst to modify the gate closure cut off time testing parameters	F13		C02, C03, C04, C06, C08
UM5	Must allow the analyst to modify the price ceiling/floor testing parameters	F13		C02, C03, C04, C06, C08
UM6	Must allow the analyst to modify the price/quantity tranche that will be settled testing parameters	Not Delivered	Not Delivered	Not Delivered
UM7	Must allow the analyst to simulate a frequency increase scenario	Not Delivered	Not Delivered	Not Delivered
UM8	Must allow the analyst to simulate a frequency decrease scenario	Not Delivered	Not Delivered	Not Delivered
UM9	Must allow the analyst to simulate a constrain to zero scenario	F13		C02, C03, C04, C06, C08

User Modifiable Test Variables

Appendix E: Aggregator Component Diagrams

Two views are provided to illustrate the platform components: firstly, from a business component perspective and, secondly, from a technical platform capability perspective.

The first view is intended to provide an insight into the extent to which current SaaS platforms support Project Symphony requirements more or less 'out of the box', and to what extent bespoke or custom development has been required to support requirements.

The second view provides insight into the technical capabilities required to support custom build components – primarily to support functional requirements not supported by SaaS solutions. This view also substantially aligns with and supports with the mapping of capabilities to the non-functional requirements detailed below in Section 0, '**Non-Functional Requirements**'.

10.1.1 Platform Functional Capability View

The following diagram maps the Project Symphony Aggregator capability model to the primary solution component that delivers each capability.

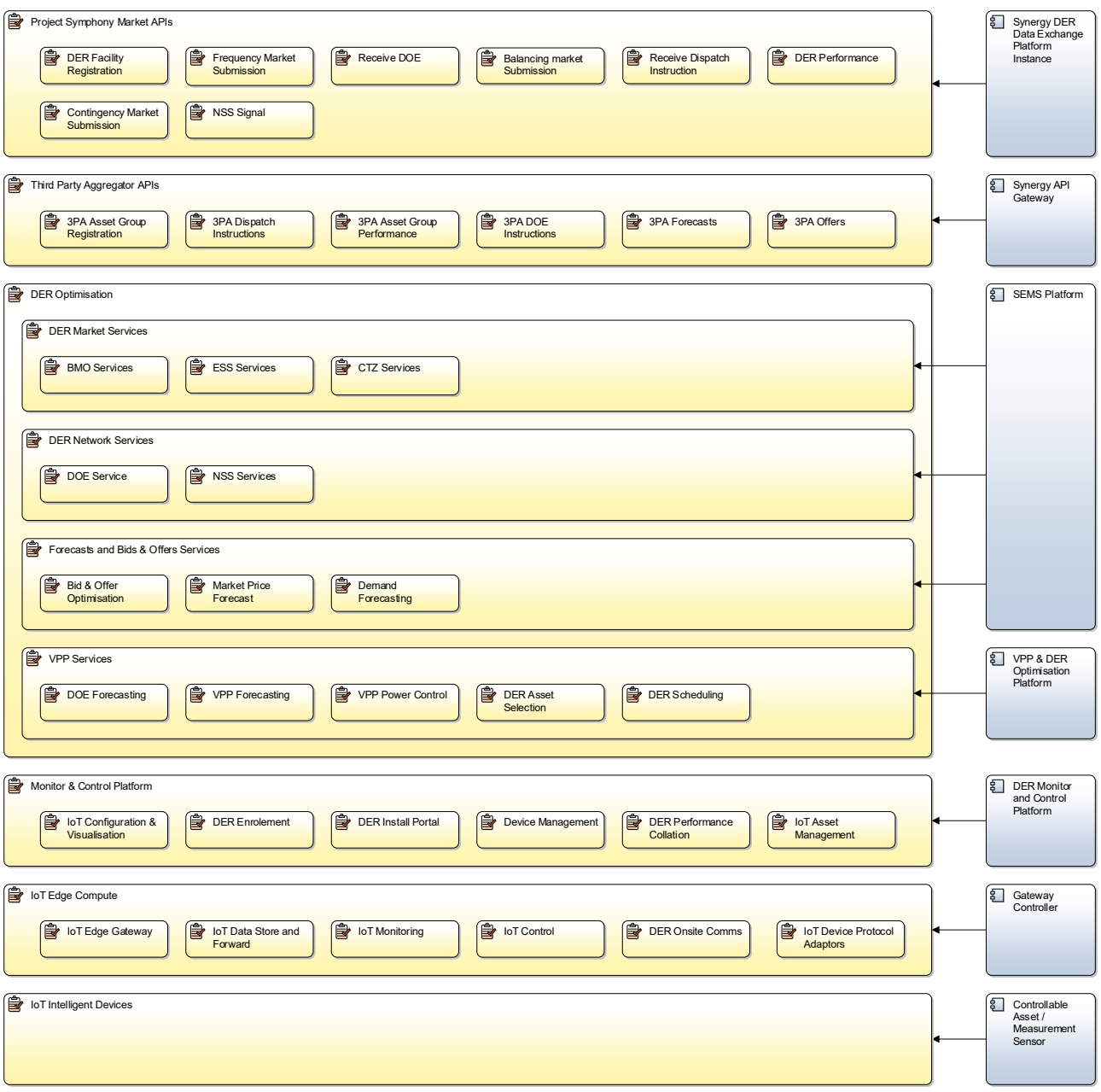


Figure 2 – Aggregator Solution: Platform Functionality View

10.1.2 Platform Technology Capability View

The following diagram maps the Aggregator solution to the primary technical platform capabilities required to deliver the solution. It should be noted that SaaS solutions are viewed in this report as technical "black boxes": their design and implementation details are the responsibility of the respective vendors and are opaque to Synergy.

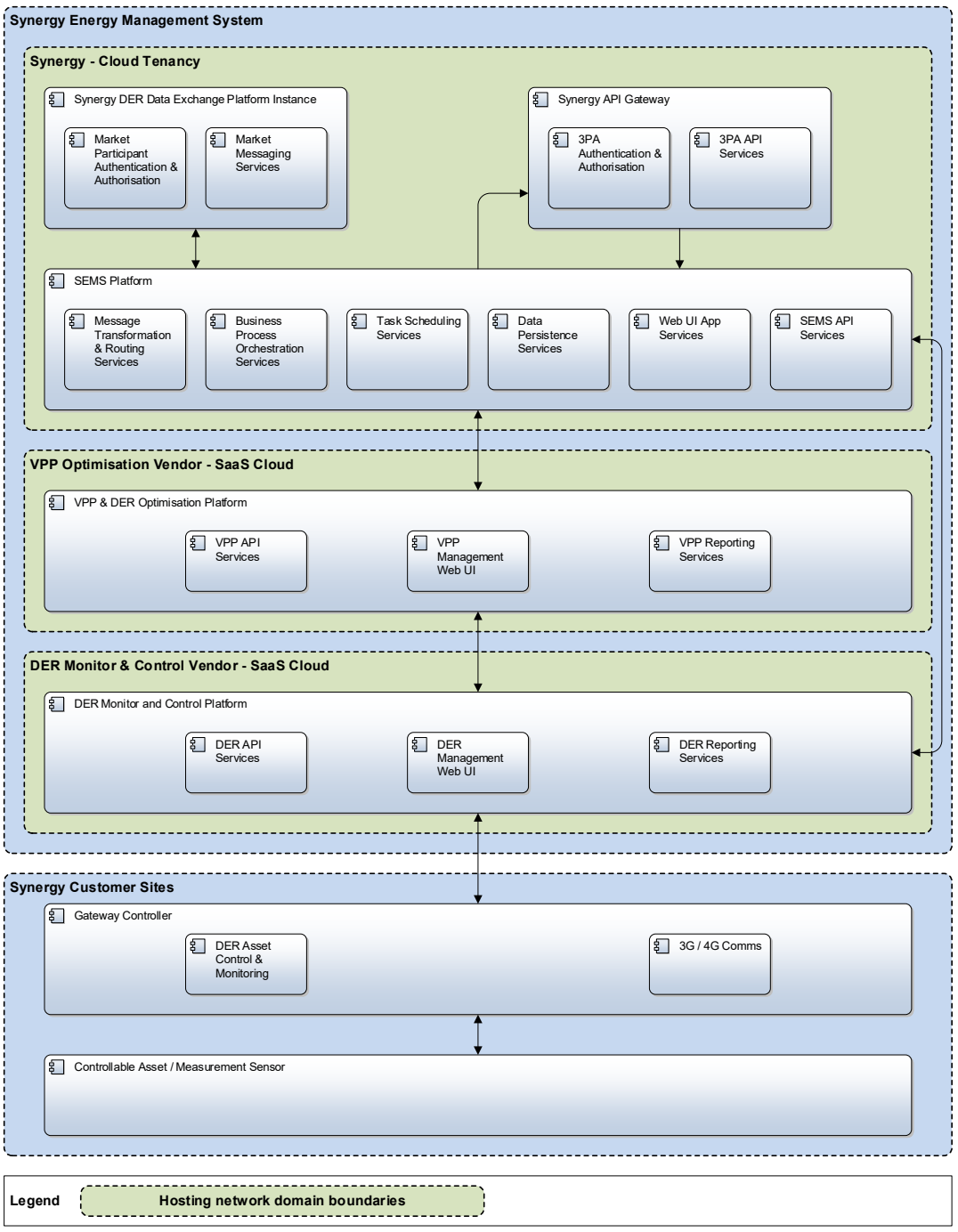


Figure 3 – Aggregator Solution: Platform Technology View

Appendix F: Aggregator Platform Requirements Mapped to Components

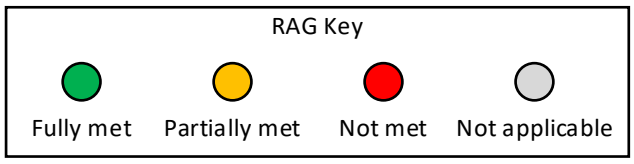
10.1.3 Functional Requirements

The 'ARENA Work Package 4.4 Report' documented the requirements for the Aggregator solution. This appendix maps those requirements to the major solution component(s) that implement them.

Since the 'ARENA Work Package 4.4 Report' was finalised, additional functional requirements for the Aggregator solution have been identified and agreed through the participant working groups. For clarity on how the scope has changed since that earlier document, the new and additional functional requirements have been documented and mapped separately in Section **Error! Reference source not found.** '**Error! Reference source not found.**'.

Note that due to the treatment of Third-Party Aggregator solutions as "black box" implementations, the solution component level mapping is only provided to components developed or implemented by Synergy: it does not map requirements to components of Third-Party Aggregator solutions other than to indicate a dependency on the Third-Party Aggregator solution *as a whole* to deliver part or all of a requirement.

The level of compliance of components against requirements is broadly assessed using a Red-Amber-Green (RAG) signage:



A small number of 'ARENA Work Package 4.4 Report' requirements have been de-scoped, and for completeness are tagged as "Not applicable", rather than as "Not met".

A 1.1 Bi-Directional Energy Services

Customer Recruitment

ID	Description	Priority	RAG	Notes
REC1	Store customer site information.	M		
REC2	Store network model information.	M		
REC3	Store DER asset information, including asset operating constraints.	M		Individual DER asset capabilities stored for Synergy managed DER assets only. Aggregated capabilities of 3PA DER assets provided to Synergy by 3PAs and represented in VPP & DER Optimisation Platform as Virtual Batteries.
REC4	Store IOT gateway information.	M		For Synergy managed DER assets only. Does not store details of 3PA IoT gateways.
REC5	Support automated and manual DER asset and IOT gateway commissioning information.	M		For Synergy managed DER assets only. Does not store details of 3PA DER assets or IoT gateways.
REC6	Store commissioning results.	M		For Synergy managed DER assets only. Does not store details of 3PA DER assets.

Structure Facility

ID	Description	Priority	RAG	Notes
FAC1	Define a DER facility as a logical grouping of NMI connection points.	M		
FAC2	Capture and store DER facility information required for registration and orchestration.	M		

FAC3	Update of registered facility standing information, including NMIs contained.	M		
FAC4	Extract of new structured facility information into a file format as required by the DMO.	M		
FAC5	Structure of any facility registered with DMO will ensure 1 NMI will be part of only 1 registered facility.	M		A NMI may be associated with different facilities over time, but only one facility at a point in time.
FAC6	Ability to optimise NMIs into discrete facilities.	D		

Facility Capacity

ID	Description	Priority	RAG	Notes
CAP1	Ingestion of Dynamic Operating Envelope data received from the DSO.	M		
CAP2	Application of Dynamic Operating Envelope to the required NMI for operational control of the assets attached to the NMI.	M		DOE instructions for NMIs under the control and management of Third-Party Aggregators are passed through to the Third-Party Aggregator for actioning.
CAP3	Calculation of the available flexible energy capacity for a facility, incorporating Dynamic Operating Envelope constraints for all NMIs within the facility and the DER asset operating or opt-out constraints.	M		

Dispatch Planning

ID	Description	Priority	RAG	Notes
OPT1	View current state of DER assets – availability and performance.	M		Current state of DER assets under the control and management of Third-Party Aggregators is not immediately visible to Synergy. Virtual Battery level telemetry reporting may lag by a number of minutes.
OPT2	Provision of behind-the-meter demand and generation forecasts.	M		
OPT3	Provision of generation, load and flexible energy capacity forecasts.	M		
OPT4	Provision of optimised control event schedule for each enrolled DER asset that will ensure fulfilment of market bids.	M		Schedules for Third-Party Aggregators are issued by Synergy at the level of Third-Party Aggregator nominated Asset Groups. It is the responsibility of the Third-Party Aggregator to optimise their DER assets to meet the Synergy scheduled Asset Group objectives.

Balancing Market Submission

ID	Description	Priority	RAG	Notes
SUB1	Generation of optimised proposed bids/offer for a facility and service, considering balancing market price forecast and VPP operational costs.	M		
SUB2	Ability to send optimised bids/offers for energy services to the DMO in compliance with RTMS specification using EnergyWeb.	M		

SUB3	Ability to manually construct bids and offers for energy services compliant with the DMO RTMS specification and submit them to the DMO.	M		

Create Dispatch Instructions

ID	Description	Priority	RAG	Notes
CON1	Ability to receive dispatch instructions from the DMO for dispatch of energy services.	M		Synergy has decided to use Pre-Dispatch schedule to dispatch energy
CON2	Ability to send a dispatch instruction receipt acknowledgement to the DMO.	M		
CON3	Create and send disaggregated (from facility level dispatch instructions) control instructions to DER assets for a specified or unspecified duration.	M	1.	2. For Synergy managed and controlled DER assets only. 3. Instructions to 3PAs proved at Asset Group level, and 3PAs responsible for further disaggregation to individual DER assets.
CON4	Ability to monitor and control the following asset types (various makes and models): • PV inverters • Battery inverters • Hot water systems • Air conditioning units	M	4.	5. For Synergy controlled DER assets only. 6. Synergy does not have access to 3PA controlled DER assets. 3PAs provide Asset Group (i.e., Virtual Battery) level telemetry to Synergy for after-the-event monitoring.
CON5	Ability to monitor and control pool pump assets.	D		Pool pumps removed from project scope. Capability not implemented.
CON6	DER asset control instructions to respect the individual asset control operating requirements/constraints as specified by the original equipment manufacturer.	M	7.	8. For Synergy controlled DER assets only. 9. Synergy does not have DER asset level control for 3PAs.
CON7	Ability to return DER asset to default mode of operation when control event completed.	M	10.	11. For Synergy controlled DER assets only. 12. Synergy does not have DER asset level control for 3PAs.
CON8	Ability to execute DER asset control to a specified setpoint, expressed as a % of maximum consumption/generation or kW/W value.	D	13.	14. For Synergy controlled DER assets only. 15. Synergy does not have DER asset level control for 3PAs.
CON9	Ability to execute DER asset control on/off via a relay contact.	D	16.	17. For Synergy controlled DER assets only. 18. Synergy does not have DER asset level control for 3PAs.
CON10	Ability to monitor and control grid-connected (FoM) battery.	M		
CON11	Ability to execute DER asset control via demand response management (DRM) control.	M	19.	20. For Synergy controlled DER assets only. Synergy does not have DER asset level control for 3PAs.
CON12	Ability for the gateway device to operate on a configurable default operating mode in the event of a communications failure.	M	21.	22. For Synergy controlled DER assets only. 23. Synergy does not have control of 3PA gateway devices.

Monitoring and Maintenance

ID	Description	Priority	RAG	Notes
MON1	Storing of high resolution telemetry timeseries data for all necessary parameters for each DER asset.	M		Third-Party Aggregators provide telemetry at Asset Group (i.e., Virtual Battery) level, rather than the individual DER assets under their control.
MON2	Ability to monitor DER asset performance metrics specific and appropriate to the asset type.	M		For Synergy controlled DER assets only. Third-Party Aggregators provide telemetry at Asset Group (i.e., Virtual Battery) level.
MON3	Ability to monitor DER asset availability and status.	M		For Synergy controlled DER assets only. Synergy does not have DER asset level control for 3PAs.
MON4	Ability to monitor IOT gateway device availability and status.	M		For Synergy controlled DER assets only. Synergy does not have IoT gateway level control for 3PAs.
MON5	Ability to monitor DER asset, site and facility performance during and post control event execution in order to validate service delivery.	M		DER asset level performance monitoring only available for Synergy controlled DER assets. 3PAs provide after the event telemetry at Asset Group (i.e., Virtual Battery) level.
MON6	Ability to monitor connections and communications between: • DER assets and IOT gateway device; and • IOT gateway and optimisation layer.	M		For Synergy controlled DER assets only. Synergy does not have DER asset or IoT gateway level control for 3PAs.
MON7	Ability to execute firmware and software maintenance remotely on IOT gateway device.	D		For Synergy controlled DER assets only. Synergy does not have IoT gateway level control for 3PAs.
MON8	Ability to log, action and track system issues to resolution.	M		Synergy and each of its solution platform partners maintain their own issue tracking solutions.

Reporting

ID	Description	Priority	RAG	Notes
REP1	Provision of NMI and DER asset master data once per week during customer and DER asset recruitment via file upload.	M		
REP2	Provision of aggregated facility telemetry data once per day for all registered and active DER facilities.	M		
REP3	Provision of facility forecast data once per day for all registered and active DER facilities.	M		

Customer Information

ID	Description	Priority	RAG	Notes

CUS1	Provision of data about control events executed for a customer site (NMI connection point) and customer DER assets for billing and customer communication purposes.	M		For Synergy controlled DER assets only.
CUS2	Availability of customer facing application containing information and functionality such as: • Energy consumption and generation at site; • Real time energy flows – household load, PV generation, battery charge/discharge, grid import/export; • Historical and upcoming scheduled control events; and • DER asset opt out.	D		Descoped

3rd Party Aggregators

ID	Description	Priority	RAG	Notes
3PA1	Ability to receive dispatch instructions from Synergy for dispatch of energy services.	M		
3PA2	Ability to send a dispatch instruction acknowledgement / commitment to Synergy.	M		
3PA3	Ability to provide energy capacity forecasts for the VPP to Synergy.	M		
3PA4	Ability to provide performance of service provision aggregated to the VPP.	M		
3PA5	Ability to receive DOE constraints from Synergy and respect these constraints in both forecasts and execution of instructions to DER assets.	M		
3PA6	Ability to manually provide the NMI and asset details for the VPP, including when changes occur.	M		
3PA7	Ability to provide payment invoices for services provided.	O		
3PA8	Ability to provide asset standing data and NMI details.	O		
3PA9	Ability to provide telemetry data at high level of resolution and latency for purposes of Synergy aggregation control.	O		Third-Party Aggregators provide telemetry for nominated Asset Groups, rather than individual DER assets under their control. Telemetry reporting from 3PAs may lag by a number of minutes.
3PA10	Ability to receive asset control commands as pass through to the assets.	O		Descoped.

Network Support Services

ID	Description	Priority	RAG	Notes
NSS1	Ability to structure a facility to provide network support services.	M		

NSS2	Receive pre-dispatch notification of NSS requirement for a facility from the DMO.	M		
NSS3	Allocate DER asset capacity within a facility to meet NSS requirement, within DOE constraints.	M		
NSS4	Respect both DOE and NSS commitments of a facility and DER asset in determining operational capacity forecasts.	M		
NSS5	Respect both DOE and NSS commitments of a facility in proposed bids and offers for energy services.	M		
NSS6	Receive NSS operating instruction from DMO to dispatch NSS services for particular date/time intervals.	M		
NSS7	Disaggregation of NSS operating instructions from DMO for a facility into individual DER asset control events.	M		
NSS8	Provision of facility and/or DER asset performance data post network support service provision to enable NSS settlement.	M		

Constrain to Zero

ID	Description	Priority	RAG	Notes
CTZ1	Receive constrain to zero dispatch instructions for a facility from the DMO for specified date/time intervals.	M		
CTZ2	Disaggregation of constrain to zero dispatch instructions from the DMO for a facility into individual NMI and DER asset control events.	M		
CTZ3	On conclusion of constrain to zero event, ability to control DER asset resumption of net export or gross generation to meet ramp up requirements.	M		
CTZ4	Provision of facility and/or DER asset performance data post constrain to zero service provision to enable settlement.	M		

Essential System Services – Contingency Raise

ID	Description	Priority	RAG	Notes
ESS1	Ability to register a facility for the provision of essential system services, including Contingency Raise.	M		These services were out of scope.
ESS2	Respect the DOE, NSS and ESS commitments of a facility and DER assets in determining operational capacity forecasts.	M		
ESS3	Generation of optimised proposed bids/offer for a facility for provision of essential system services taking into account the DOE, NSS and ESS commitments of a facility.	M		

ESS4	Sending of optimised bids/offers for ESS to the DMO in compliance with RTMS specification.	M		
ESS5	Ability to receive dispatch instructions from the DMO for dispatch of ESS.	M		Synergy has decided to use the Pre-dispatch schedule to dispatch energy through DER
ESS6	Create and send disaggregated (from facility level dispatch instructions) control instructions to DER assets for a specified or unspecified duration for the provision of ESS.	M		
ESS7	Provision of facility and/or DER asset performance data to enable settlement of ESS service provision.	M		

Additional Functional Requirements

Since the publication of the 'ARENA Work Package 4.4 Report', further functional requirements have been discussed and agreed between the Project Symphony participants. This subsection documents the additional Aggregator-specific requirements and maps them to the relevant delivery component.

DOE Handling

ID	Description	Priority	RAG	Notes
DOE1	Support the specification of a default DOE export value at each site as a fall-back where DOE instructions are not received (e.g., due to communications failure).	M		For Synergy controlled DER assets only.
DOE2	Support short interval DOE instructions for emergency constraint of export electricity.	M		
DOE3	Validate received DOE instructions and ensure any omitted intervals are completed (based on the relevant default DOE value for the site) to provide a complete schedule.	M		
DOE4	Accommodate DOE schedules based on a midnight-to-midnight operational day (as distinct from WEM market rules based on a trading day commencing at 8:00 AM WST) when preparing market transactions such as forecasts, bids and offers.	M		

Front of Meter Battery

ID	Description	Priority	RAG	Notes
FOM1	Provide the ability for Western Power's SCADA system to override Synergy and take control of a FoM Battery in case of emergency.	M		Once Western Power takes control of the FoM Battery, any further instructions from Synergy are ignored until control is returned to Synergy.

Absolute vs Relative Support

ID	Description	Priority	RAG	Notes
AVR1	Provide support for VPP generation objectives based on either including uncontrolled load (absolute power) or excluding uncontrolled load (relative power).	M		

Virtual Facilities

ID	Description	Priority	RAG	Notes
VRF1	Provide the ability to associate NMIs with different Facilities to support different VPP objectives (e.g., based on DER asset type, location or service objective).	M		
VFR2	Provide support for time-range specific configurations of Facilities for different objectives, including the adjustment of associated NMIs or capacity settings.	M		

ESS Frequency Injection

ID	Description	Priority	RAG	Notes
EFI1	Provide the ability to simulate a frequency disturbance at site using the IoT Edge Device and an injected frequency profile, to support ESS Test and Learn activities.	M		
EFI2	Install 100 High Speed Data Recorders and supporting secure communications infrastructure at a sub-set of Project Symphony sites to report on ESS Test and Learn activities.	M		
EFI3	Ensure the High Speed Data Recorders are able to measure 50ms frequency response at either the NMI or DER asset.	M		

Telemetry

ID	Description	Priority	RAG	Notes
TLM1	Provide operational telemetry to AEMO every 5 minutes for the immediate previous 5 minute interval, aggregated at 1 minute granularity.	M	24.	25. Requirement supported for Synergy managed and controlled DER assets. 26. Reporting of 3PA telemetry to Synergy may lag.

Hybrid DC-Coupled Battery Control

ID	Description	Priority	RAG	Notes
HBC1	Provide the ability to control hybrid DC-coupled batteries within a VPP scenario, as distinct from AC-coupled batteries	M		Asset specific: Inclusion of hybrid DC-coupled batteries only allows control at the hybrid inverter – not charge/discharge behaviour between PV and Battery.

Third-Party Aggregators

ID	Description	Priority	RAG	Notes
3PA1	Develop a bidding model for 3PAs to inform 3PAs when to optimally bid their capacity into the market.	M		Synergy developed stand-alone utility tool. Not hosted in, or integrated with, the core solution components.

Non-Functional Requirements

Accessibility

ID	Description	Priority	RAG	Notes
NFR1	The solution shall be accessible through the most commonly used web browsers.	M		The SEMS platform is only intended for internal use by Synergy staff, and is compatible with Synergy's SOE web browsers.
NFR2	The solution shall be designed to display on the most commonly used device types (smartphone, tablet, laptop).	D		The SEMS platform has been designed to operate on Synergy supported devices.

Security

ID	Description	Priority	RAG	Notes
NFR3	The solution shall provide secured and controlled user access to the platform resources through authentication and secured access.	M		
NFR4	The solution APIs shall authenticate and provide secured access to resources. All data in transit shall be encrypted.	M		
NFR5	The data residing in the cloud will remain within Australia.	M		
NFR6	All data at rest will be securely stored.	M		
NFR7	All customer identifiable data will be encrypted at rest and secured access will be provisioned.	M		
NFR8	The cloud platform will be audited and audit records will be maintained.	M		
NFR9	Logs will be kept of all key transactions conducted within the platform. User access and activity shall be logged.	M		
NFR10	The solution shall be resilient to cyber-attacks such as distributed denial of service, viruses and malicious software.	M		The SEMS Platform is hosted within Synergy's corporate cloud tenancy, and subject to the same cyber-security controls as other Synergy applications hosted in that environment. Cloud vendors are responsible for maintaining equivalent levels of cyber-security controls.
NFR11	The solution will be designed to support the availability of the Service Level Agreements within the contract.	M		
NFR12	All Synergy data shall remain the property of Synergy and not be disclosed without authorisation.	M		
NFR13	The solution shall secure the communications and isolate access to the distributed controller gateway.	M		For Synergy managed and controlled IoT gateways.
NFR14	The solution controller gateway shall be installed with adequate physical security access such as enclosure and tamper provisions.	M		For Synergy managed and controlled IoT gateways.
NFR15	Passwords for IoT devices will be securely stored on the device.	M		For Synergy managed and controlled IoT gateways.

Business Continuity

ID	Description	Priority	Delivered By	RAG	Notes

NFR16	The solution vendor shall have provision for adequate backup and disaster recovery aligned to the contracted service levels.	M	• Synergy Cloud tenancy		Components developed by Synergy reside in Synergy's Cloud Tenancy, which provides for DR failover between regions. 3rd party SaaS providers are contracted to SLAs covering back-up and DR.
NFR17	The business continuity plans shall be periodically tested.	M	• Operational Support		BCP plans have not been developed while the solution platform is still under development. BCP are expected to be reviewed once all components have been developed and deployed to production.
NFR18	The solution vendor shall provide notice of changes to the core product that may affect business continuity for Synergy.	M	• Vendor support team		
NFR19	Following the conclusion of the contracted period, all Synergy data shall be available for extraction by Synergy.	M	• VPP & DER Optimisation Platform • DER Monitor & Control Platform		'Delivered By' identifies 3rd party SaaS solutions that need to provide data extraction capabilities at the conclusion of Project Symphony. Data held in SEMS Platform is already under the control of Synergy.
NFR20	The solution shall retain backward compatibility when new features are released.	D	• Synergy software development processes and governance		To the extent that new features are consistent or compatible with existing features.

Change Control

ID	Description	Priority	Delivered By	RAG	Notes
NFR21	Software updates shall follow the agreed deployment lifecycle process through, as a minimum, a non-production environment.	M	• Synergy change control processes • Development, QA and Production environments		3rd party SaaS providers provide equivalent environments aligned with Synergy's environments.
NFR22	The solution vendor shall provide release notes for software changes ahead of the release of the software into the non-production environment.	M	• Vendor support team		

Maintainability

ID	Description	Priority	Delivered By	RAG	Notes
NFR23	As built technical design documentation shall be provided.	D	• Project team		

Data retention

ID	Description	Priority	Delivered By	RAG	Notes
NFR24	The vendor shall ensure all non-transitory data is retained for the duration of the Pilot.	M	• SEMS Platform		

Scalability

ID	Description	Priority	RAG	Notes
NFR25	The solution shall be able to scale to 900 assets being monitored, controlled and optimised.	M		
NFR26	The solution shall have the capability to scale to 10,000 assets under control.	D		Descoped. There is no hard limit on the number of assets that can be supported by the solution design, but the performance implications beyond supporting the Project's target recruitment sites have not been tested or assessed.
NFR27	The solution shall be able to scale to 500 customers as users concurrently using the user portal.	D		There is no customer facing user portal.

Performance

ID	Description	Priority	RAG	Notes
NFR28	Availability uptime of the platform shall be 99% (excluding scheduled maintenance).	M		All solution components are hosted in major cloud vendor environments. All cloud vendor environments provide up-time guarantees that exceed 99%. Gateway Controller provides some level of site autonomy (i.e., default behaviours) in the event of loss of communications with up-stream platforms.
NFR29	Asset performance shall be captured to understand the maximum throughput of command execution for each device.	M		For Synergy controlled DER assets.
NFR30	Overall system response time shall be within 30 seconds from command to response (excluding any device specific reaction time).	M		For Synergy controlled DER assets.

Incident management

ID	Description	Priority	Delivered By	RAG	Notes
NFR31	The vendor shall notify Synergy of all data breaches as soon as practical.	M	• Vendor support team		
NFR32	The vendor shall notify Synergy of all unplanned outages as soon as practical.	M	• Vendor support team		
NFR33	The vendor shall comply with SLAs for response time and resolved time as detailed in the contract.	M	• Vendor support team		

Usability

ID	Description	Priority	RAG	Notes
NFR34	The solution shall meet the branding, look and feel as defined in the Synergy user interface guidelines for all customer facing user access interfaces.	D		There is no customer or public facing solution component. SEMS Platform provides a web interface for authorised Synergy staff, which is only available to staff on the corporate network. The user interface is consistent with other Synergy web applications developed for internal staff use.

NFR35	The solution shall allow an efficient user interface to enable the user to conduct common tasks efficiently.	D		The user interface has been developed iteratively with input from key internal users.

Incident management

ID	Description	Priority	Delivered By	RAG	Notes
NFR31	The vendor shall notify Synergy of all data breaches as soon as practical.	M	• Vendor support team		
NFR32	The vendor shall notify Synergy of all unplanned outages as soon as practical.	M	• Vendor support team		
NFR33	The vendor shall comply with SLAs for response time and resolved time as detailed in the contract.	M	• Vendor support team		

Usability

NFR34	The solution shall meet the branding, look and feel as defined in the Synergy user interface guidelines for all customer facing user access interfaces.	D	• SEMS Platform		There is no customer or public facing solution component. SEMS Platform provides a web interface for authorised Synergy staff, which is only available to staff on the corporate network. The user interface is consistent with other Synergy web applications developed for internal staff use.
NFR35	The solution shall allow an efficient user interface to enable the user to conduct common tasks efficiently.	D	• SEMS Platform		The user interface has been developed iteratively with input from key internal users.