DER Integration and Automation Project

Final Report and Knowledge Sharing

PURPOSE

This document is the final Knowledge Sharing Report for Evoenergy's DER Integration and Automation Project. This report provides an overview of the project, the method and simulation exercises undertaken, outcomes achieved, and key lessons learnt.

ARENA ACKNOWLEDGEMENT AND DISCLAIMER

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

PROJECT OVERVIEW

The DER Integration and Automation Project received funding from ARENA as part of ARENA's Advancing Renewables Program. The goal of the DER Integration and Automation project is to simulate the utilisation and control of DER to ensure that the network is maintained within technical limits. This allows for deferral of the need for grid augmentation investment and at the same time increase network capacity to host more DERs. To achieve this Evoenergy is using the existing Schneider Electric EcoStruxture Advanced Distribution Management System (ADMS), a new instance of the Schneider Electric Distributed Energy Resource Management System (DERMS), the Evoenergy IoT Hub and the Greensync deX system.

PROJECT CONTACT

The project was led by Evoenergy, in collaboration with Schneider Electric and Greensync, with Withywindle as the knowledge sharing partner. The project contact is Eddie Thanavelil, Future Network Portfolio Lead at Eddie.Thanavelil@evoenergy.com.au.

Table of Contents

Table of Figures

1. ABBREVIATIONS AND GLOSSARY

Abbreviation	Description
ADMS	Advanced Distribution Management System
AEMO	Australian Energy Market Operator
DER	Distributed Energy Resource
DERMS	Distributed Energy Resources Management System
DNSP	Distribution Network Service Provider
deX	Decentralised Energy Exchange
ENA	Energy Network Australia
EPRI	Electric Power Research Institute
ESB	Energy Security Board
HC	Hosting Capacity
HV	High Voltage
IEC	International Electrotechnical Commission
IoT hub	Internet of Things Hubs
LACM	Look Ahead Constraint Management
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaic
VPP	Virtual Power Plant

2. EXECUTIVE SUMMARY

The DER Integration and Automation project is to utilise control of DER to ensure that the network is maintained within technical limits. This allows for deferral of the need for grid augmentation investment and at the same time increase network capacity to host more DERs. To achieve this Evoenergy is using the existing Schneider Electric EcoStruxture Advanced Distribution Management System (ADMS), a new instance of the Schneider Electric Distributed Energy Resource Management System (DERMS), the Evoenergy IOT Hub and the Greensync deX system.

The SE DERMS platform defines what DER groups are to be despatched subject to constraints and sequencing, it then communicates with these DER groups through integration to the IoT Hub that communicates to the deX platform.

The main task of the DERMS module is to create, validate and adjust the schedule of operating envelopes for DERs that are aggregated into DER groups /virtual power plants (VPP) along with validation with the network ADMS in accordance with network constraints, and to resolve predicted violations of network constraints utilising power flexibility of DER groups/VPPs.

The IoT Hub communicates to the GreenSync's deX platform, that is responsible for receiving and disseminating messages between integration to network systems, the platform used by VPP operators, and the end devices; which are both simulated for the purposes of this project.

For this project, Evoenergy selected the Woden Zone Substation and the downstream HV feeder called 'Streeton' for the simulation. The Streeton feeder incorporates greenfield and brownfield areas which has one of the highest penetrations of DER within the ACT. The feeder also supplies parts of greenfield estate called Denman Prospect which has mandatory solar PV on each detached dwelling thereby making it an ideal selection for this project.

The DER Integration and Automation Project set out to achieve a specific set of outcomes under the agreement with ARENA and the project partners through the demonstration of the use cases and simulation exercises.

a. The project successfully integrated the IoT Hub and EcoStruxure ADMS v3.9 which included the enhanced DERMS module platforms to understand the impact of high penetration of DER and the possible constraints that would be caused by such DER uptake. It demonstrated that EcoStruxure DERMS can provide preventive grid constraint management in order to improve hosting capacity.

b. The project demonstrated that market operators can be given visibility over distribution level impacts of their intended calls on the DER within a specific geographical location to ensure that market calls by retailers or aggregators in response to spot price hedging or VPP calls do not cause network constraints in the distribution network. This in turn maintains reliability in the electricity network and protects system security.
c. The project confirmed that DNSPs can showcase optimising the operations from DERs through increasing the visibility and intended operations from DERs via planned schedules and proposed dynamic limits through the integration of deX platform through the IoT Hub and the DERMS platforms.
d. The project successfully showcased that flexibility of DER exports can be coordinated and actioned by network management platforms and DER market and aggregator platforms.
e. The project API interface now enables DNSPs not on the Schneider ADMS platform to access GreenSync deX functionality. The API integration provides a pathway and capability of ingesting network limits from network management systems via an IoT Hub integration. By making the API document public, third parties can better understand the interactions between deX and network systems.
f. The project verified that NSPs now have a viable alternative to investment in the low voltage and medium voltage network in comparison to the traditional network asset option. If the project is implemented in a production environment, DER operators will be able to invest and deploy DER with greater confidence with the knowledge of network limitations being applied in uniform and appropriate manner without holistic changes in their operations and capabilities.

3. OVERVIEW OF THE PROJECT

According to the Energy Security Board (ESB) DER Integration roadmap and Workplan released in September 2020, technical integration of DER is 'fundamental and foundational'. Electricity systems were not designed with DER in mind and there are increasing technical challenges and opportunities arising as infrastructure adapts to multi-way flows of energy. Increased visibility is needed by both DNSPs and AEMO to support management and planning of the system. AEMO especially has a major focus on technical aspects of DER operations and management.

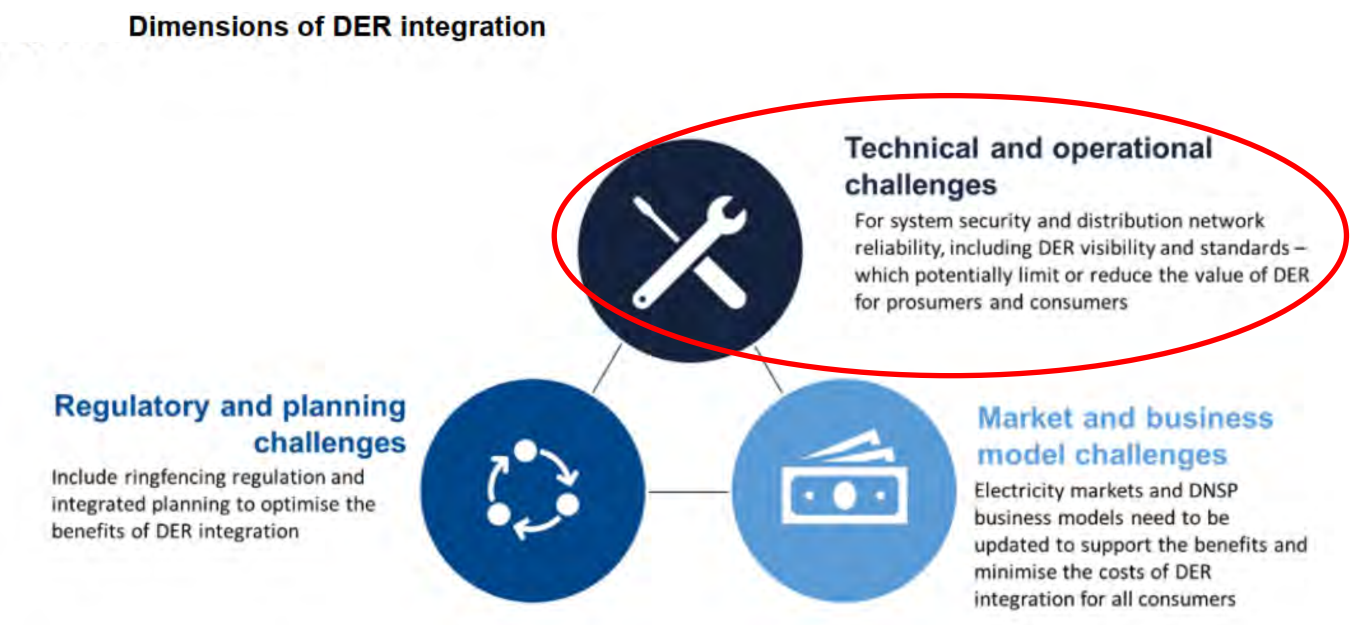

Figure 3-1 – DER Integration Challenges (Courtesy of AEMC/ESB)

The scope of technical integration includes device, interoperability, communication and cybersecurity standards, the governance of DER technical of standards and enabling changes to DNSP systems such as the development of standardised approaches to dynamic operating envelopes (which will expand DER exports by time of day and location within the technical limits of distribution networks).

Distribution businesses such as Evoenergy will in turn need to manage their networks more dynamically to understand, manage for and optimise the network use of DER. This means developing systems to provide visibility, communication and interoperability standards and protocols, together with the development of dynamic 'operating envelopes' to expand the access of DER to the grid. Required capabilities identified by the Open Energy Networks project jointly undertaken by the ENA and AEMO under these topics are:

- DNSPs defining network visibility requirements and network export constraints:

    - Define DNSP requirements for increased network visibility and development of more accurate LV models
    - Identify and communicate network constraints to maintain network operations within required parameters (operating envelopes)
- Establish an iterative and targeted approach for the timing of investments required to provide network visibility to support the optimal levels of safe, secure and reliable access for DER.
    - Defining common communication requirements for operating envelopes:
    - Define common protocols for operating envelope communication
- Establish Australian standards and guidelines to support the establishment of operating envelopes by defining common data access permissions
- Supporting development of an industry guideline for operating envelopes.

These activities are largely underway through numerous projects and trials, and energy market institutions are looking to assist with these processes where appropriate.

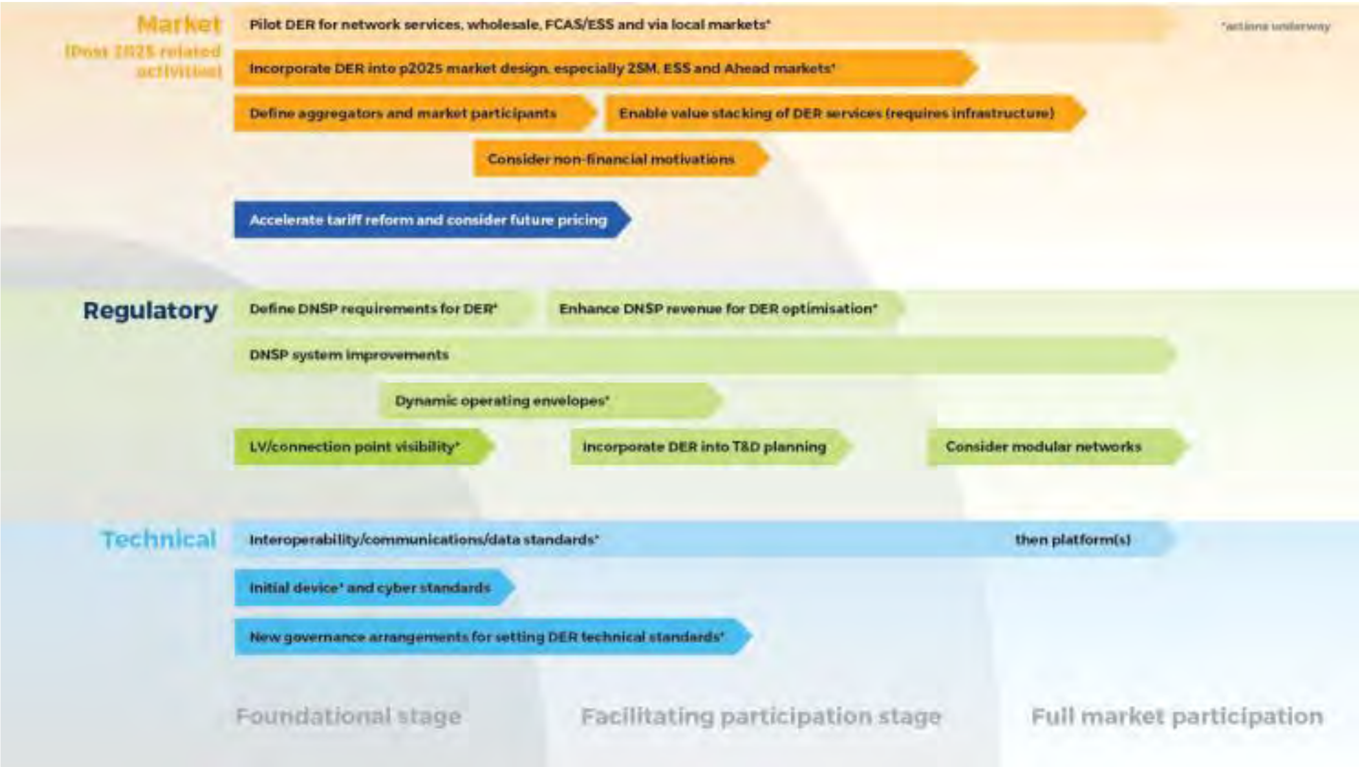

Figure 3-2 – Post 2025 activities related to DER (Courtesy: ESB)

Improving LV network visibility is a critical path action being progressed by DNSPs and investigated in the ESB's energy data strategy. DNSPs are undertaking different approaches to improving visibility of their LV networks depending on their circumstances. For example, in Victoria all DNSPs have visibility through smart meter data. In South

Australia, SAPN has modelled its network by feeder type and hosting capacity based on 14 standard types and is also purchasing data from third party providers.

Communication and interoperability standards and protocols will enable aggregators and retailers (and in some cases DNSPs and AEMO) to communicate with DER devices. The standardisation of architecture for this communication is a complex task. Dynamic operating envelopes are already being trialled. SAPN's trial system sends signals about the forecast availability of the network for DER exports with 5 minutes 'operating envelopes' to DER 24 hours in advance. This could beneficial to DER owners than static limits or constraints because it enables greater optimisation of DER services. The ESB is working with ARENA on how to support the nationally consistent uptake of operating envelopes across DNSPs and further work on this will emerge over the coming years

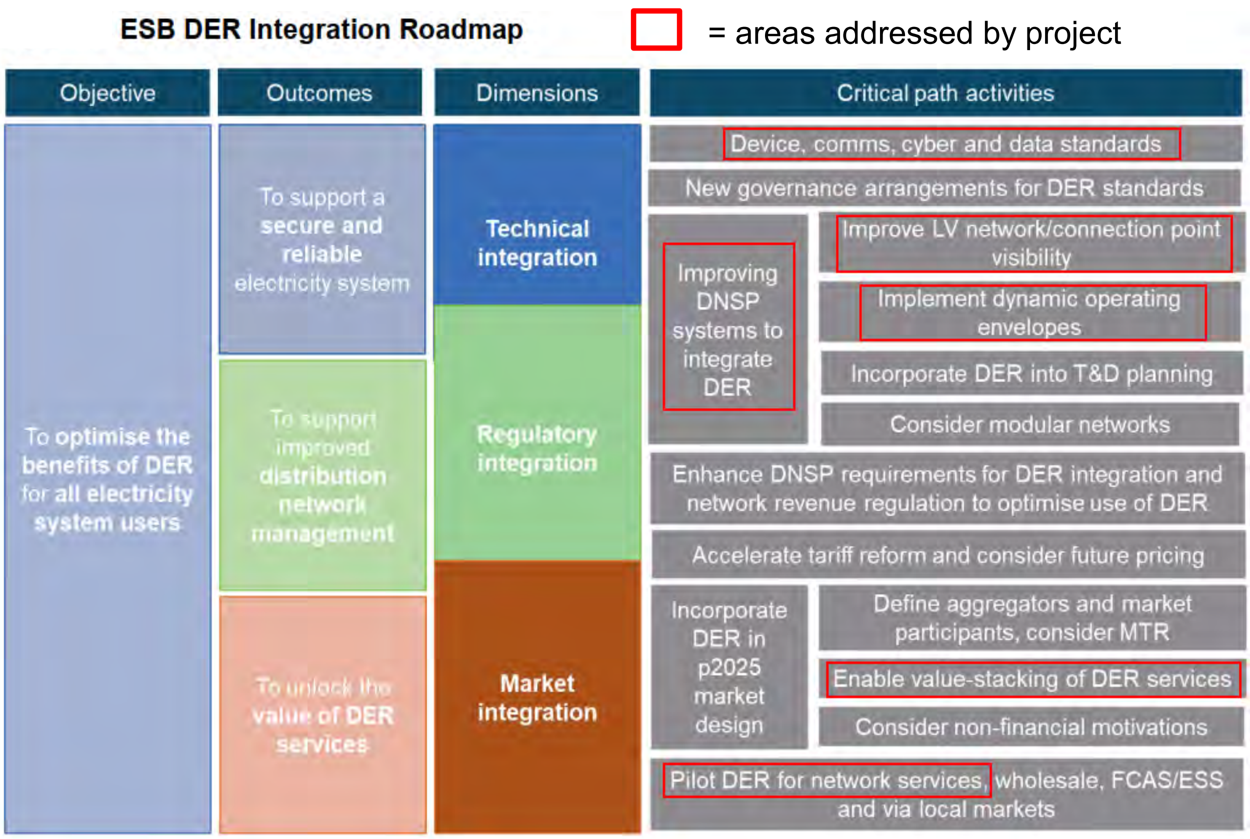

Figure 3-3 – DER Integration Roadmap (Courtesy: ESB)

The basic characteristics of a traditional distribution network are passive and predictable consumption as well as power flows from the supply point to the consumers. Problems occurring in such a network are related to overloads on various sections of the distribution grid, as well as the occurrence of low voltage in the connection points of consumers. With the increase of DER, the range of working states in which a distribution network can be found is significantly higher. Local generation from DERs can lead to the high voltages and reverse power flows in a distribution grid. However, DERs can also be considered as resources for improving the state of the grid.

The number of DERs in the distribution network can be very large. Because of this, grouping is often utilised, and this is why DER groups are created in the ADMS. DER groups represent a set of DERs whereby all functionalities are managed as a group, while the task of the DER groups is to distribute the corresponding control signals to the individual DERs. DER groups can be used to abstract the complexity of interacting with individual DER, to ensure that the network is maintained within technical limits in a particular network area.

As aggregators are free to recruit customers across multiple network areas, there are many relationships between aggregators and DER groups that includes the following cases:

- It is possible for one aggregator to be spanned across multiple DER groups.
- It is possible that one DER group includes DERs under the control of multiple aggregators.

4. ARCHITECTURE

The overall architecture of the analysed system is shown in Figure 4-1. It is a system consisting of 5 layers:

- Layer 1: EcoStruxure DERMS – centralised system that utilises DERs to optimise the distribution grid and provide operating envelopes,
- Layer 2: IoT Hub – a platform that enables communications between multiple systems
- Layer 3: deX – a DER Registration platform
- Layer 4: VPP – DER aggregator
- Layer 5: DERs

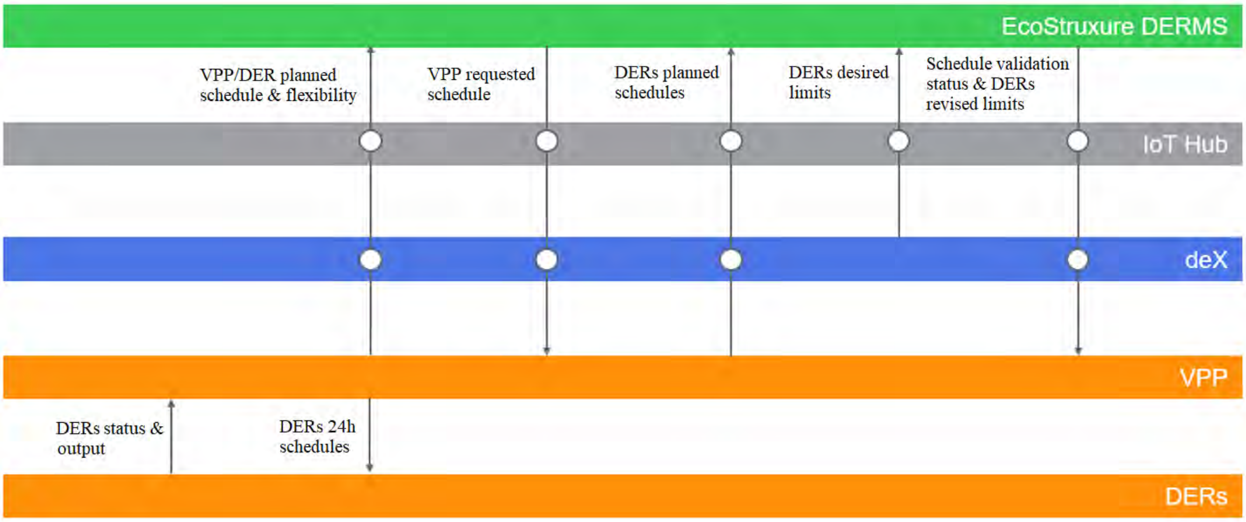

Figure 4-1 High level architecture

The EcoStruxure DERMS is a package within the EcoStruxure ADMS that provides awareness of DER behaviour, utilises DERs and VPPs to resolve violations and optimise the distribution grid. DERMS is a centralised system, aware of network topology, network parameters and weather forecast that is used to forecast the state of the system. Using forecast results, the DERMS utilises power flexibility of DERs and DER groups/VPPs to satisfy user defined objectives.

5. PROJECT USE CASES

The solution functionality is demonstrated through three use cases:

1. Testing the capability and outcomes of dispatching DER to avoid upstream capacity constraints with the benefit of deferring the need for network augmentation investment. This will demonstrate an increase in the value of energy available from DER by enabling DER to be automatically leveraged by a Distribution Network Service Provider (DNSP) to avoid network overloads, utilising the energy available.

2. Validating VPP dispatch requests (e.g., from energy retailers or energy service companies) against known network hosting capacities mapped in the DERMS in order to maximise exports of DER energy in response to market signals. This aims to increase the value of DER energy by enabling DNSPs to effectively evaluate and approve more frequent and larger VPP calls without fear of resultant network constraint violations.

3. Analysing at the degree to which network violation from natural DER behaviour is avoided if dispatched through this system so that dynamic controls can be deployed in place of more conservative and static limits. This will be achieved through simulating the application of dynamic control and limiting on existing level of penetration and analysing the network effects.

6. ECOSTRUXTURE DERMS INTRODUCTION

Utilities are facing substantial changes as the distribution network is shifting toward a future with much higher penetrations of DERs. This shift is driven by the changes in customer choices around energy; technological development leading to lower costs and better performance of DERs; and policies and regulatory proceedings requiring utilities to reliably integrate DERs to meet the renewable energy targets.

Schneider Electric's EcoStruxure DERMS is a platform specifically tailored for utilities to support them in overcoming this challenge, and leverage DERs to plan and operate the grid in the most economical way, including creation and publishing of granular operating envelopes at a NMI / meter level. DERMS is a platform and part of the EcoStruxure suite, often coupled with the ADMS, it is independently deployable across any Distribution Management System. For Schneider Electric's customers it is often an integrated part of the ADMS that leverages the common platform and provides services to other modules, thus seamlessly enhancing the overall DSO ADMS functionality with DER awareness and efficient DER utilisation. It also extends in to the AutoGrid capability for orchestration and VPPs.

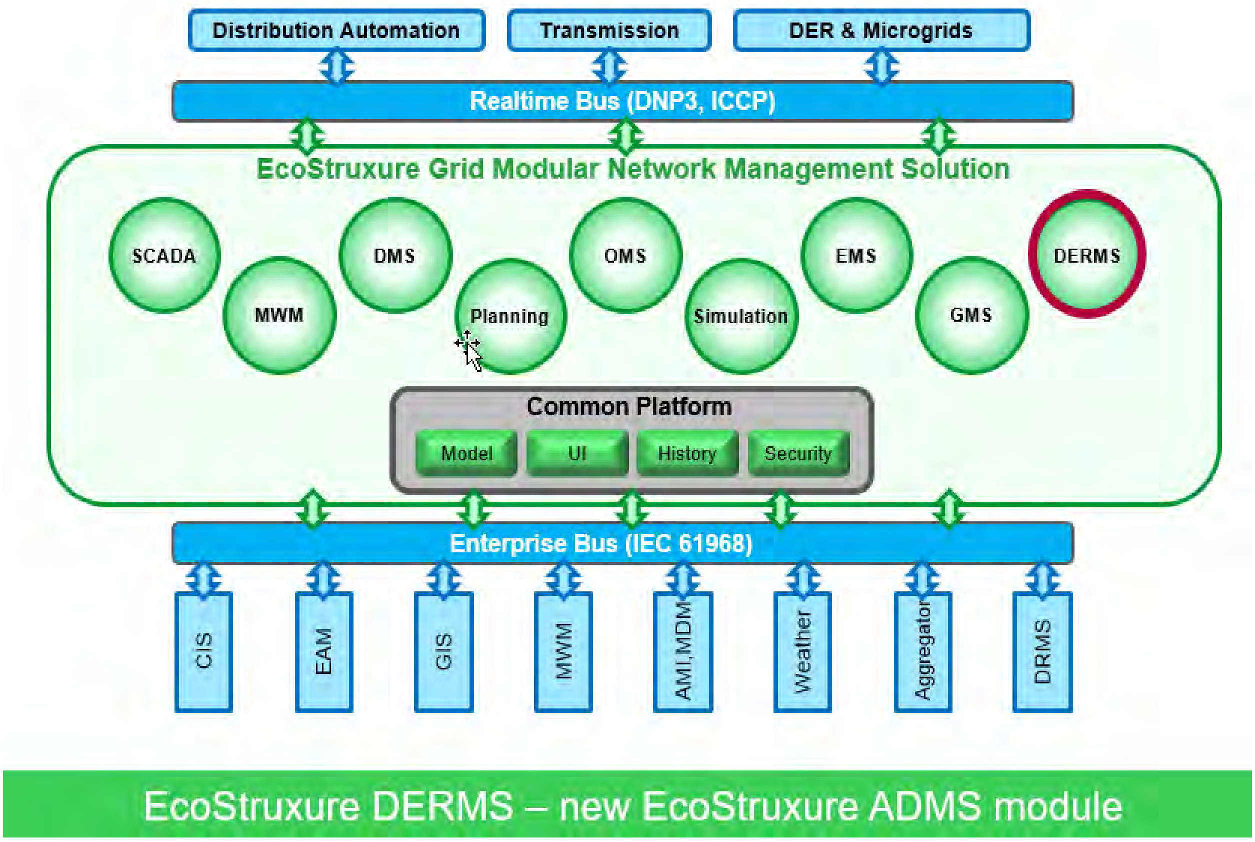

Figure 6-1 EcoStruxure ADMS with DERMS module

The Figure 6-2 shows the EcoStruxure DERMS applications that are used for DERMS Operations, Planning, Optimisation and Constraint Management.

Figure 6-2 EcoStruxure DERMS Functionalities

To achieve the objectives of this project, the following DERMS applications are used:

1. **Situational Awareness**

    - Look Ahead: The Look Ahead application provides insight to the future network state and warns or predicted grid constraint violations and power quality issues.

2. **Preventive Constraint Management**

    - Look Ahead Constraint Management: The DERMS application Look Ahead Constraint Management (LACM) resolves predicted violations of grid constraints through adjusting the operation schedules of DER groups. LACM utilises DER groups (VPP, microgrid, etc.) to mitigate grid issues detected by Look Ahead. Based on the Look Ahead results, LACM analyses the locations where violations are expected and identifies available DER groups who's near future behaviour can be altered, and sends dispatch request.

- Dynamic Capacity Conservation: The DERMS application Dynamic Capacity Conservation verifies whether desired DER export/import limits (Dynamic Operating Envelopes) will cause grid constraint violations. If violation is detected, the application modifies desired dynamic operation envelopes for all the requested DER(s) to mitigate possible grid constraint violation issues (overloads, low/high voltages, reverse flows), and sends revised dynamic operating envelopes of DERs.

3. VPP and aggregator management

- Aggregation of DERs is a core functionality of the DERMS. This provides the ability to monitor in real-time and forecast behaviour of aggregated DERs, obtaining an insight into their real-time and forecast capability (flexibility) and then triggering an optimal dispatch.

- Through integration with 3rd party systems, the DERMS receives and is aware of the group's:
    - Real-time and forecast output,
    - Flexibility in near real-time and forecast period.

- DERMS provides CIM compliant integration with 3rd party systems for DER groups provided through the IEC 61968-5 standard.

7. DEX INTRODUCTION

deX is a digital DER registration platform which allows retailers, aggregators, installers and networks to register customer DER devices, in the process enabling them to gain visibility, control and verification of DER performance so they can deliver benefit while also meeting network compliance obligations.

To deliver the solution for the DER Integration and Automation project, in addition to deX, five key sub-systems were employed, namely, deX DNSP Bridge, deX Evaluation Engine, deX Command, deX Vision and deX Lyrebird. Each system performed a specific set of roles and responsibilities and was required to interact with other systems as well as the IoT Hub to provide the full solution.

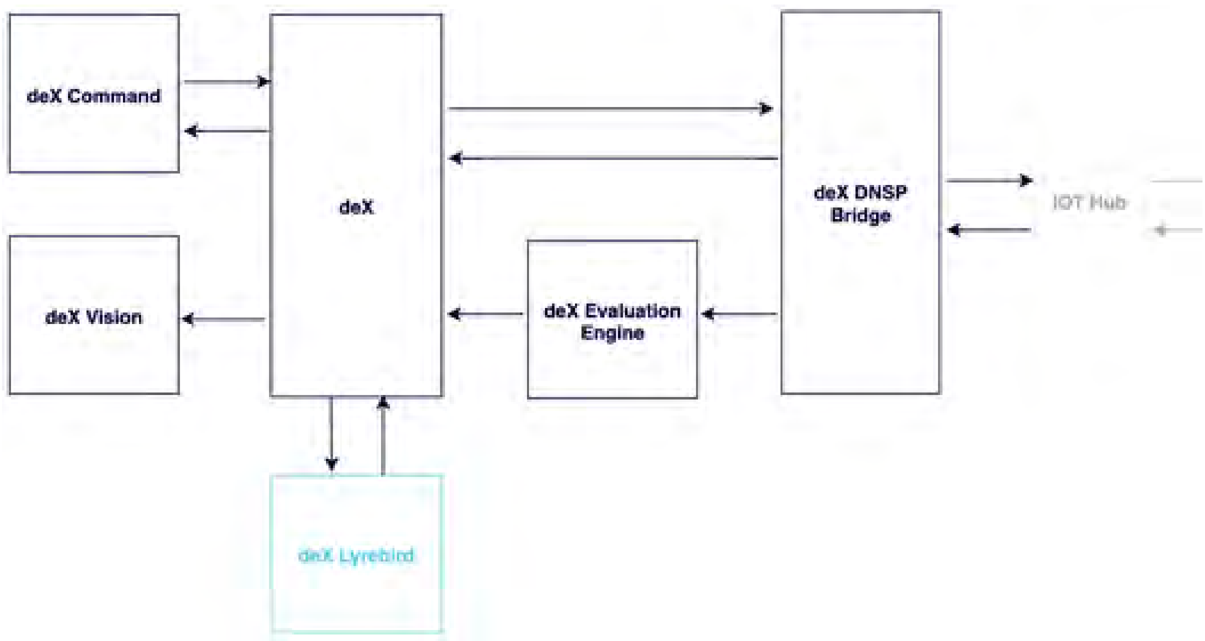

Figure 7-3 deX Systems

deX DNSP Bridge

The deX DNSP Bridge is the backend system that translates messages between deX and the IoT Hub and ensures that both systems are aligned and share the same understanding. The Bridge exposes information from deX to the IoT Hub to provide visibility of planned and forecast DER/VPP (Virtual Power Plant) behaviour. In return the Bridge also receives information from the IoT hub, namely limits and requested behaviour from any network management systems, and ensures that network requirements from DER are received and communicated to end devices in a timely manner.

deX Evaluation Engine

The deX Evaluation Engine was developed specifically for this project. The purpose of an evaluation engine is to take a set of inputs and perform a set of operations to determine a set of outputs that meet a specified criterion. For this project, the inputs relate to information about what participants (*aggregators*) are capable of doing at what price, and a required response from the network.

The output of the evaluation engine is a set of service contract calls to meet the required network response. In this instance, the internal operation of the evaluation engine is a set of mathematical operations that determine which combinations of service contract calls provides the required response at the lowest cost.

deX Command

deX Command is a deX native VPP platform that enables retailers and other parties to manage portfolios of DER. The functionality of this system includes:

- Scheduled group dispatching
- Triggered dispatch on wholesale price
- Portfolio and telemetry view and reporting.
- Acquire and contract DER to a portfolio.
- DER type and vendor agnostic.
- Can be contracted in near real time.
- Contract and provide services to 3rd parties (networks)

deX Vision

deX Vision provides foundational visibility and control functions for network operators. In this project it is being used to provide visibility of the outcomes of the dispatch optimisation performed by the Evaluation Engine.

deX Lyrebird

deX Lyrebird is a DER simulation engine which allows the impact of DER to be demonstrated without requiring real world DER and testing. To deX, deX Lyrebird is indistinguishable from any integration to an OEM’s platform - it receives and prioritises dispatch instructions and network limits and provides visibility of simulated device behaviour. Lyrebird is the only non-production system being used as part of this project.

8. HIGH LEVEL SOLUTION WORKFLOWS

8.1. Use Case 1 – DERMS initiates dispatch request (via IoT Hub to deX) to DERs to avoid upstream capacity constraint

8.1.1. Purpose

The purpose of this use case is to use the DERMS for avoiding a predicted grid thermal constraint (overload) on a feeder head section and HV/MV supply transformer.

The main task of the DERMS is to predict an overload and to utilise DERs to resolve the detected issues. When the DERMS predicts an overload on the feeder head section(s) and/or the HV/MV supply transformer, it sends a request through the IoT hub to deX for additional engagement of DERs in order to resolve the predicted problem. The IoT Hub receives the request from the DERMS via the IoT hub, which passes this onto deX. This process forms the market through which VPPs can bid their services. Using economic optimisation, deX determines the new schedules for the DERs. Finally, deX provides the planned schedules of each individual DER to the IoT Hub which communicates to the DERMS as well as the new DER group flexibility schedules.

This Use Case includes the following DERMS functionalities:

- Look Ahead calculation of network states for the next 24 hours, and detection of upcoming violations (overload, reverse flow) on the feeder head section and the HV/MV supply transformer
- Look Ahead Constraint Management application utilises DER groups to resolve detected issues.

High level illustration of Use Case 1 is shown on Figure 8-1.

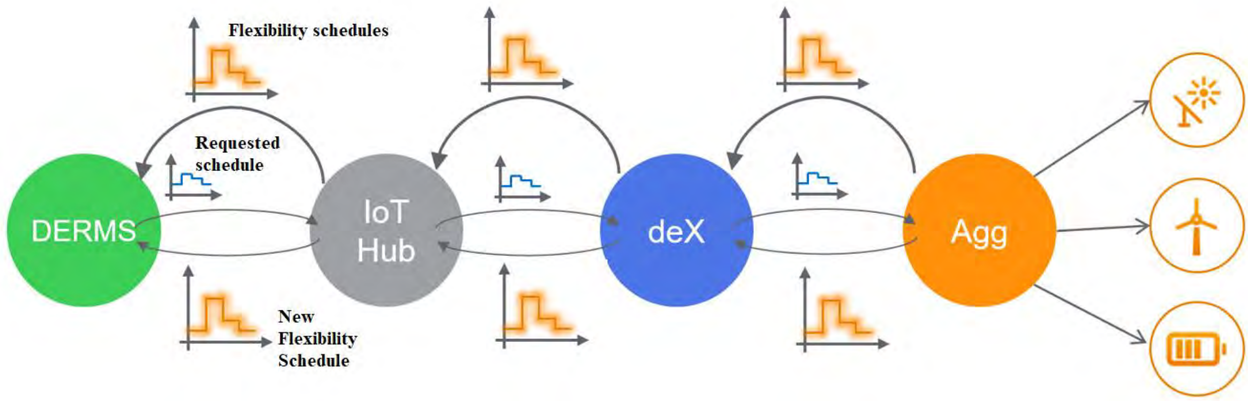

Figure 8-1 Use Case 1

8.1.2. Use Case 1 description

Step	Actor	Description
1.	deX	deX provides DER group flexibility schedule (minimum, maximum and planned schedules) of all DER groups. Each feeder has one DER group that aggregates all DERs controlled by aggregators on that feeder.
2.	DERMS	DERMS receives DER group flexibility schedule from the IoT Hub and incorporates them in its calculation.
3.	DERMS	Look Ahead (LA) forecasts network thermal constraints. Constraints in scope are: HV/MV supply transformer overload or the first section(s) downstream of a feeder head breaker.
4.	DERMS	Look Ahead Constraint Management (LACM), based on DER group flexibility schedules, determines the new output of DER groups that will resolve detected problem. In the case of a violation on the feeder head, LACM engages a DER group on that feeder. In the case of a violation on the transformer level, LACM engages one or more DER groups located on feeders.
5.	DERMS	DERMS sends requested schedules of DER groups that will resolve the detected problem to IoT Hub.
6.	deX	deX Evaluation Engine determines the combination of dispatches that meet the service requirement at the lowest cost.
7.	deX	Each VPP operators receive individual service requirements and enact control of individual DER to meet/exceed the required value.
8.	deX	deX sends the new flexibility schedules of DER groups as well as planned schedules of individual DERs.
9.	DERMS	DERMS forecasts that there will be no violation in the system.

8.1.3. Use Case 1 Outcomes

For the testing of Use Case 1, the violation is created on Bunbury feeder. This is conducted in the following way:

- Current limit on the feeder head is set to be equal to 90 A.
- With original forecast, relative load of the feeder head was 92%.
- Load forecast is increased for the whole analysed period for 10%.

- As result of load forecast increase, overload of 2% is detected on the feeder.
- LACM is automatically executed on detected violation. It used DER group on the feeder as resource and information about DER group flexibility to resolve the issue.
- The new schedule of DER group is sent to the IoT hub
- deX provided new schedules of DER group.
- After execution of look ahead application, the previous detected violation was not detected, so it was confirmed that the violation is resolved.

The Table 8-1 shows initial schedule of DER group on Bunbury feeder when violation is detected (Initial Forecast), requested schedule by DERMS (LACM Request) to resolve detected violation and final schedule received by deX (received Final Forecast).

Table 8-1– Results of Use Case 1

LACM			Difference	
Timestamp	Initial [kW]	Final (LACM request) [kW]	Forecast received (hourly) [kW]	LACM request - Forecast [kW]
26/2/2021 2:00:00 AM	-19	-19	-19	0
26/2/2021 3:00:00 AM	-19	-19	-19	0
26/2/2021 4:00:00 AM	-21	-21	-21	0
26/2/2021 5:00:00 AM	-21	-21	-21	0
26/2/2021 6:00:00 AM	-21	-21	-21	0
26/2/2021 7:00:00 AM	-21	-21	-21	0
26/2/2021 8:00:00 AM	39	39	39	0
26/2/2021 9:00:00 AM	26	26	26	0
26/2/2021 10:00:00 AM	13	13	13	0
26/2/2021 11:00:00 AM	171	171	171	0
26/2/2021 12:00:00 PM	169	169	169	0
26/2/2021 1:00:00 PM	144	144	144	0
26/2/2021 2:00:00 PM	9	9	9	0
26/2/2021 3:00:00 PM	19	19	19	0
26/2/2021 4:00:00 PM	9	9	9	0
26/2/2021 5:00:00 PM	19	19	19	0
26/2/2021 6:00:00 PM	7	7	7	0
26/2/2021 7:00:00 PM	-17	-17	-16	-1
26/2/2021 8:00:00 PM	-52	-52	-51	-1
26/2/2021 9:00:00 PM	-154	-154	-151	-3
26/2/2021 10:00:00 PM	-24	13	13	0
26/2/2021 11:00:00 PM	-41	-41	-41	0
26/2/2021 12:00:00 AM	-188	-188	-188	0
26/2/2021 1:00:00 AM	-21	-21	-21	0
26/2/2021 2:00:00 AM	-21	-21	-21	0

The Figure 8-2 shows the graph of initial forecast, requested schedule and final schedule.

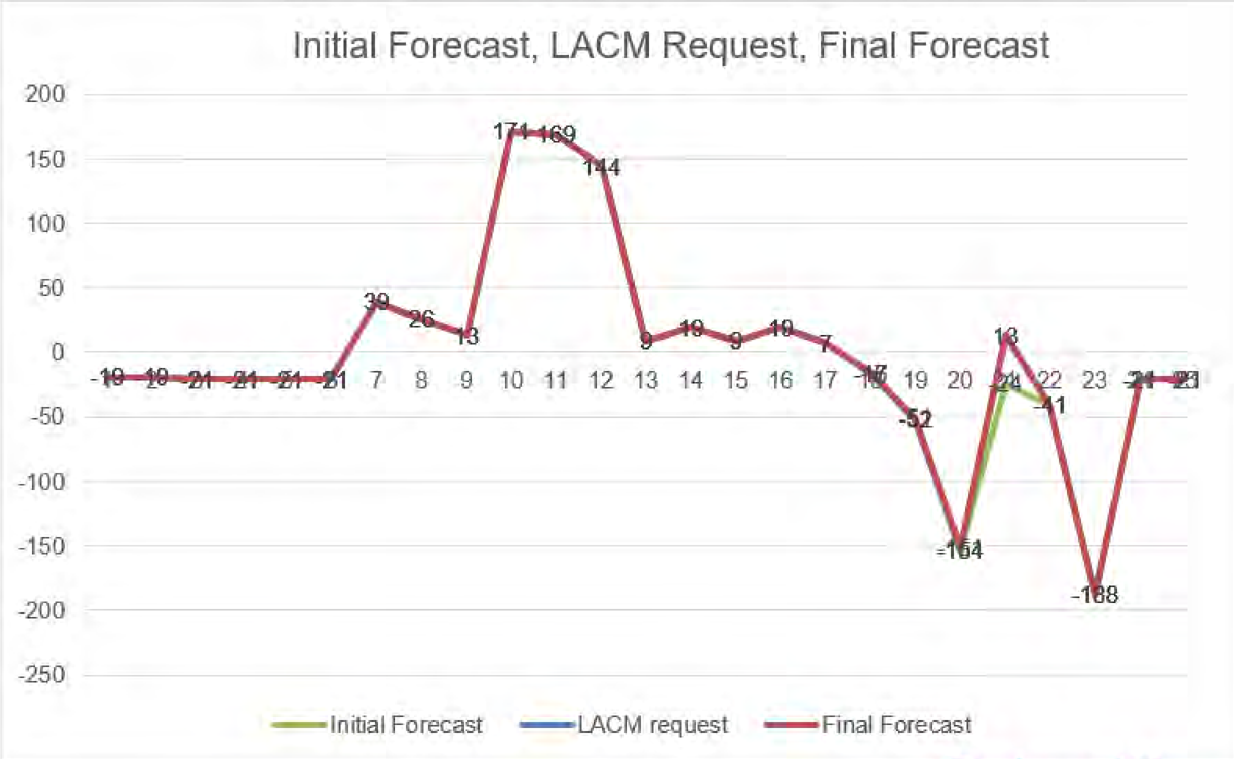

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Figure 8-2 Results of Use Case 1

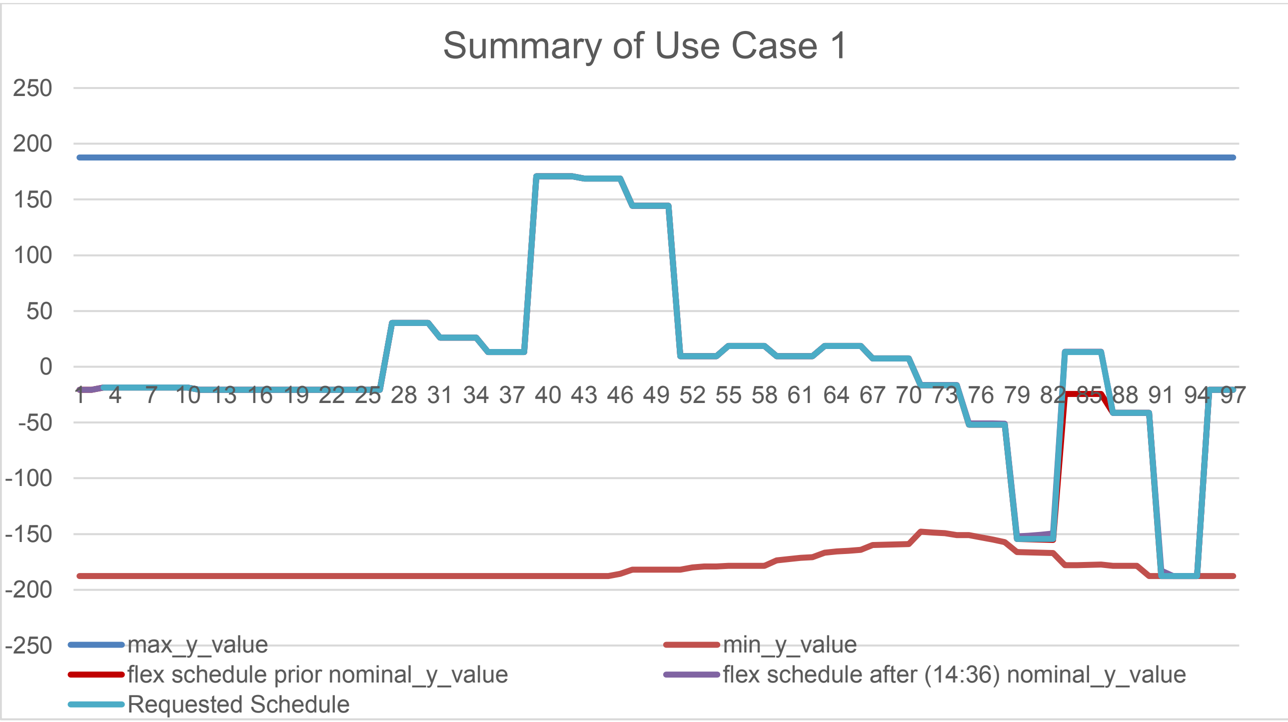

Figure 8-3 – deX platform – Summary of Use Case 1

The image below shows the deX Evaluation engine outputs in a typical workflow for Use Case 1.

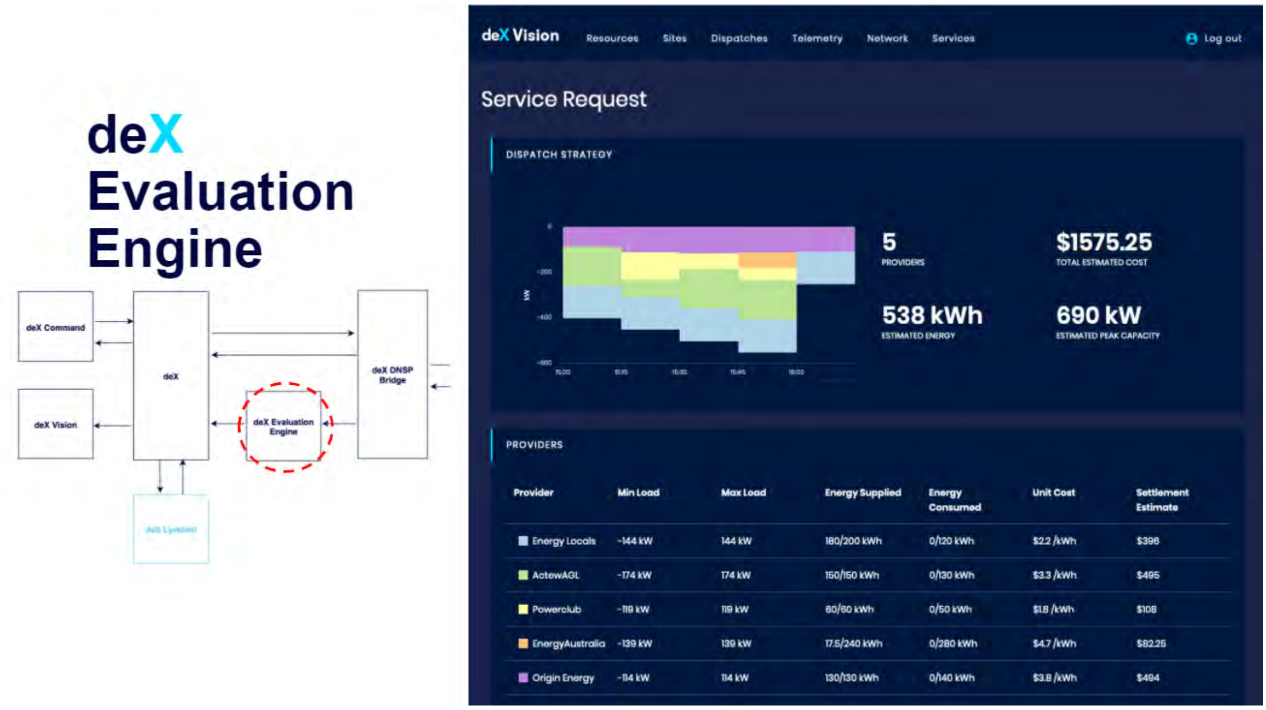

Figure 8-4 – deX platform – Evaluation engine

8.2. Use Case 2 – Appraisal of VPP call by third party - Individual DER dispatch and constraint identification

8.2.1. Purpose

The purpose of this use case is to use DERMS for validation of planned VPP behaviour as response to call by 3rd party (e.g., Retailer, or AEMO) in order to maintain grid reliability and power quality. The new DERMS application Dynamic Capacity Conversation (DCC) shall support this use case. DCC shall check whether DER can work within the desired limits without creating constraint violations. This Use Case is illustrated in Figure 8-5.

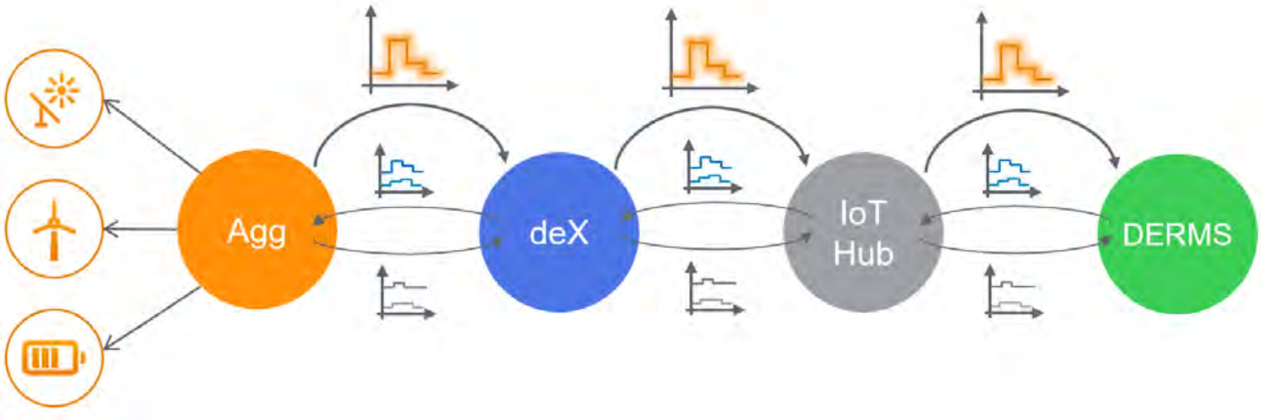

Figure 8-5 Use Case 2

Every *x* minutes (default 60 minutes), deX requests the service via the IoT hub from DERMS to validate DERs limits. DERMS receives the request through IoT hub and validates the limits. The result of schedule verification can be:

- Pass – there is no limits that need to be changed, DERMS sends 'Pass' status to IoT Hub
- Conditionally pass – some limits need to be changed, DERMS sends 'Conditionally Pass' status to IoT Hub, which communicates to deX the revised limits for the DERs that will resolve the problem,
- Warning – all schedules need to be changed, DERMS sends status 'Warning' to IoT hub, which communicates to deX and limits equal to zero for all DERs.
- Fail – there was a problem during the function execution. DERMS sends status 'Fail' and limits for DERs for which the verification has been executed successfully. For DERs for which the verification was unsuccessful, NaN values will be sent instead of limits.

deX sends DER limits to Aggregator.

Any changes in the DER behaviour as a result of imposed limits are reflected in future iterations of individual DER planned schedules and DER group flexibility schedules as a part of Use Case 1. Before market formation, Aggregator defines DER schedules in accordance with the last received DER limits and sends VPP output and DER schedules to deX.

8.2.2. Use Case description

Step	Actor	Description
1.	deX	VPP Operators schedule dispatches via deX (e.g., Retailer operating for Spot Price benefit). This is simulated in this project.
2.	deX	Every *x* minutes (default 60) deX sends desired schedule of DER limits to the DERMS for verification.
3.	DERMS	DERMS validates desired limits, specifically evaluates if any network constraints will be violated by desired individual DER limits. This calculation has four possible outcomes: - Pass: ADMS indicates the limits of all DERs can proceed without restraint. No limits are sent to deX - Conditional Pass: Specific DERs limits are changed and send to IoT hub to communicate to deX. Limits that are not changed will not be sent - Warning: All revised limits are equal to 0 and sent to IoT hub to communicate to deX, probably DERs are not the source of the problem. - Fail: the function is not executed on some part of the grid. Changed verified schedules are sent via the IoT hub to deX. Not changed schedules are not sent. Schedules that are not verified are populated with NaN values and sent.
4.	deX	Revised schedules received by deX, describing limits for individual resources
5.	deX	Limits communicated to end resources.
6.	deX	Limited behaviour incorporated into future schedules.
7.	DeX	deX sends the new flexibility schedules of DER groups as well as planned schedules of individual DERs.
8.	DERMS	DERMS uses obtained schedules to determine the state of the system in the future.

8.2.3. Use Case 2 Outcomes

Four possible results of the DCC application are possible:

- Pass
- Conditional Pass
- Warning
- Failed

The share of different statuses depends on the conditions in the system. During testing, the following share of different statuses was obtained (Figure 8-6).

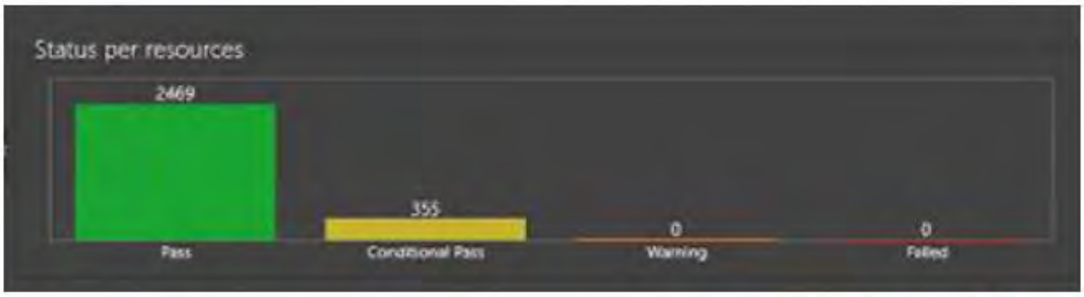

Figure 8-6 – DCC report – Share of different statuses of DERs

The following figure shows desired and revised (proposed) limits for DER with Pass status (DCC proposes revised limits that are equal to desired limits).

Figure 8-7 Results of Use Case 2 – DCC report – Pass status

The following figure shows desired and revised limits for DER with Conditional Pass status (desired limits must be modified to follow revised limits proposed by DCC).

Figure 8-8 Results of Use Case 2 – Conditional Pass status

The warning status is obtained when violation in the system is not created because of DER. The reason for warning status is usually related to the network model quality and it is needed to conduct additional tuning of the network model in that case. The following figure shows the example of Warning status.

Figure 8-9 Results of Use Case 2 – DCC report – Warning status

Screenshots from the deX platform for Use Case 2:

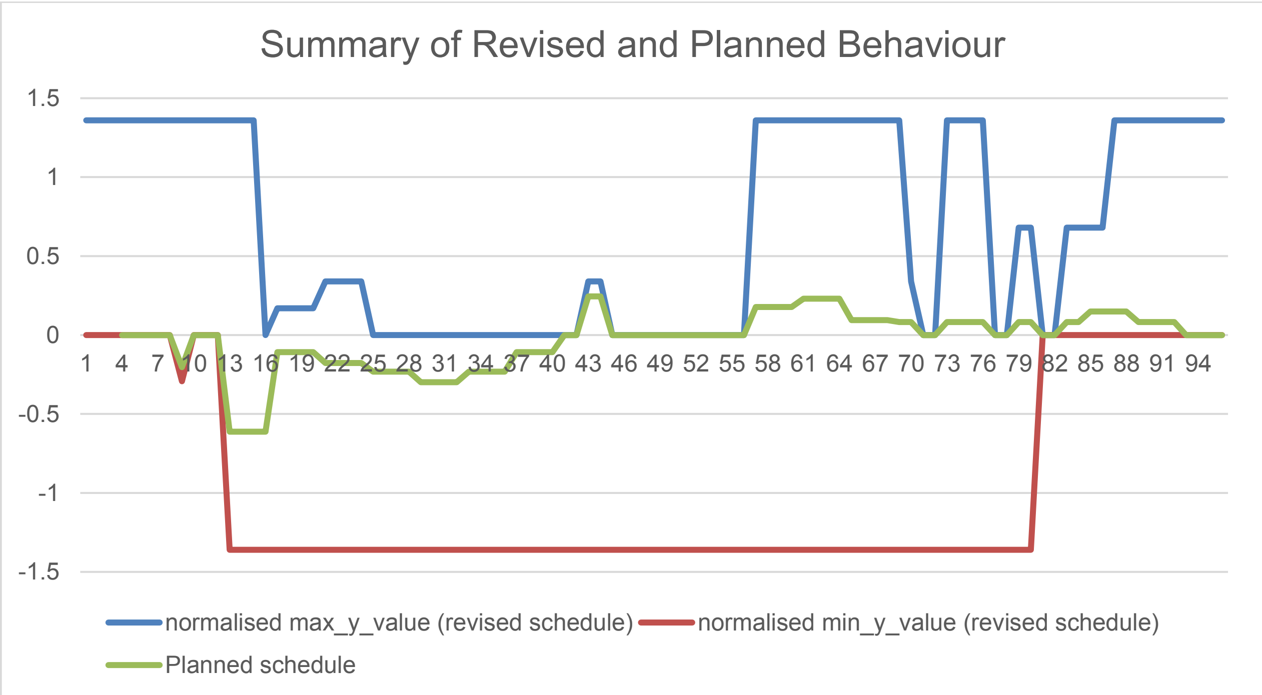

Figure 8-10 – deX platform – Summary of Use Case 2

8.3. Use Case 3 – Avoidance of Network Violation from Natural DER Behaviour - Individual DER dispatch and constraint identification

8.3.1. Purpose

The purpose of this use case is to use DERMS to adjust DERs natural behaviour and avoid local grid issues caused by high DER penetration.

The main task of DERMS in this Use Case is to validate desired natural limits of DERs and to correct them in case that natural behaviour of DERs will create violation in the future. This can happen for several reason: the network is reconfigured, there is planned or unplanned outage, etc. deX will send each hour the request for schedule verification to the IoT Hub.

This Use Case is illustrated in Figure 8-11.

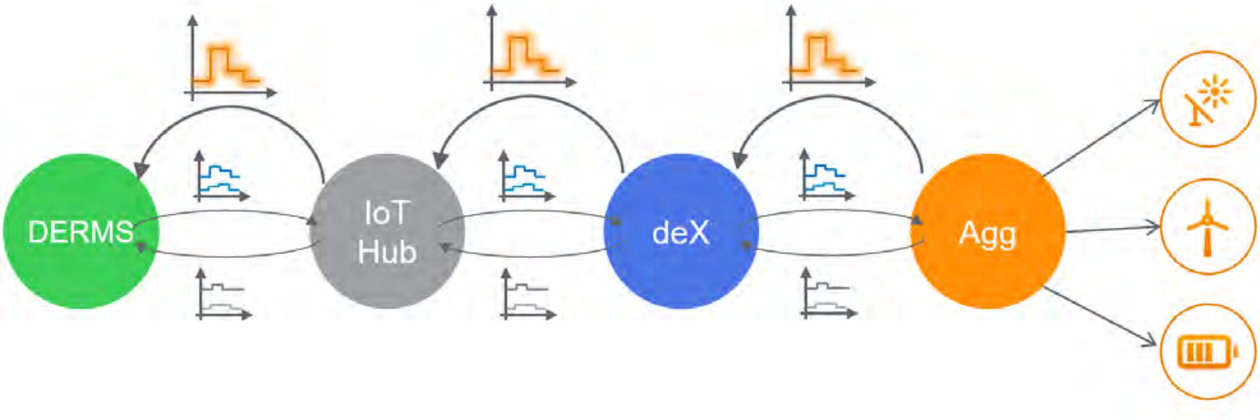

Figure 8-11 Use Case 3

8.3.2. Use Case description

Step	Actor	Description
1.	deX	Every *x* minutes (default 60) deX sends the desired limits of DERs to IoT Hub, which DERMS collects them from. Those limits represent natural behaviour of DERs.
2.	DERMS	DERMS validates desired limits, specifically evaluates if any network constraints will be violated by desired individual DER limits. This calculation has four possible outcomes: - Pass: ADMS indicates the limits of all DERs can proceed without restraint. No limits are sent - Conditional Pass: Specific DERs limits are changed and send to IoT Hub for collection by deX. Limits that are not changed will not be sent. - Warning: All revised limits are equal to 0 and sent to IoT Hub for communication to deX, probably DERs are not the source of the problem. - Fail: the function is not executed on some part of the grid. Changed verified schedules are sent. Not changed verified schedules are not

		sent. Schedules that are not verified are populated with NaN values and sent to IoT Hub for communication to deX.
3.	deX	Pass, conditional pass, warning or fail notification of validation request is received by deX with schedule of revised limits for individual DERs.
4.	deX	Limits communicated to end resources.
5.	deX	Limited behaviour incorporated into future schedules.
6.	deX	deX sends the new flexibility schedules of DER groups as well as planned schedules of individual DERs.
7.	DERMS	DERMS uses obtained schedules to determine the state of the system in the future.

8.3.3. Use Case 3 Outcomes

The outcomes were as expected.

From DERMS perspective, the results are similar to the results obtained in Use Case 2.

Screenshot from the deX platform

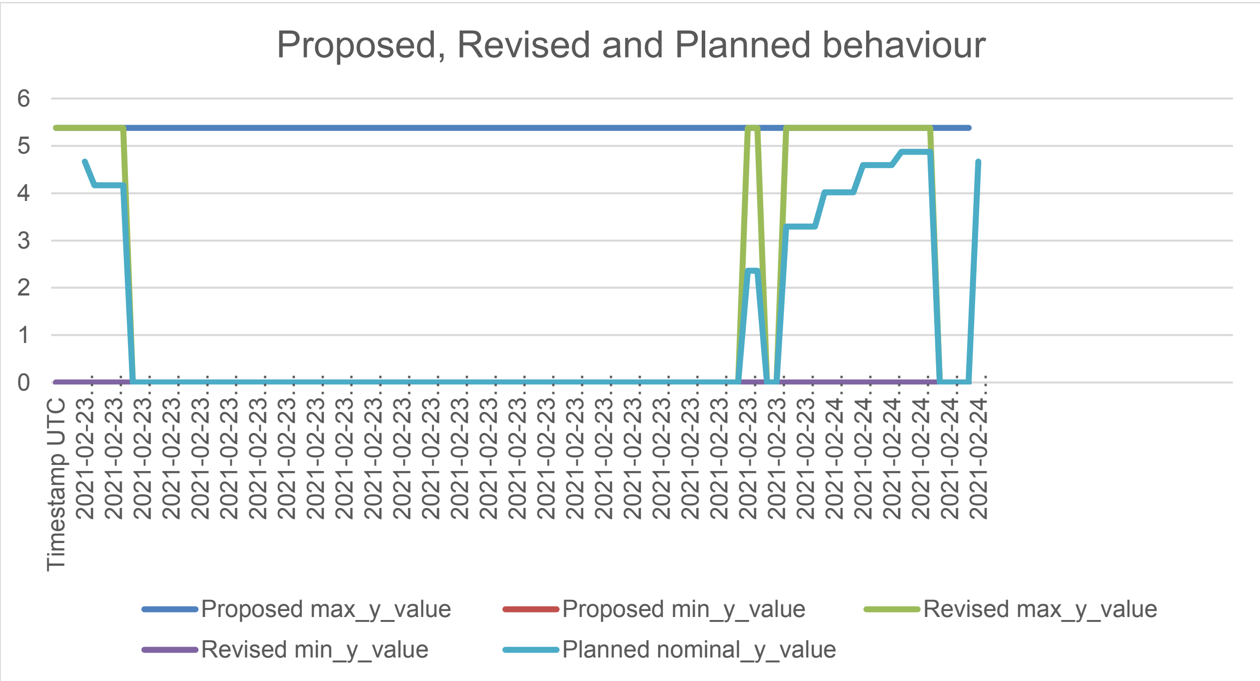

Figure 8-12 – deX platform – Summary of Use Case 3

8.4. Overall Observations from the Use Case simulations

The testing was completed over a period of few weeks where different bugs and issues were identified and resolved with the allowable time within these days. The overall functional aspects of the three use cases were tested and these have been tabulated in the Site acceptance testing report. A short overall summary is described below.

Number	Objectives	Execution Method	Challenges/Learnings	DERMS	IoT Hub	deX
1	DER group flexibility sent from deX to DERMS	DER group flexibility is passed from deX to IoT hub and from IoT hub to DERMS every 15 minutes	DER group flexibility is sent through many messages instead of a single packet due to the large size from deX. IoT hub is merging those messages into a single message and forwarding to DERMS, and splitting the message received from DERMS and sending them to deX	✓	✓	✓
2	DERMS runs the forecast and detects a violation	Violation is simulated by increasing the load forecast by 2% on a feeder	Started with simulating 10% violation but deX enrolled DER were unable to resolve the constraint. Iterative processes lead to a relatively small constraint being managed and resolve proving the use case for minimum viable product. Learnings: Lack of inter-visibility between the platforms on the total suppliable and consumable energy restricted larger constraint simulation.	✓	N/A	N/A

Number	Objectives	Execution Method	Challenges/Learnings	DERMS	IoT Hub	deX
3	DERMS identifies the DER group that will resolve the detected violation and send the requested schedule to deX through IoT hub	Requested schedule is sent through IoT hub and deX receives the request		✓	✓	✓
4	DERMS expects the updated schedule from deX in the next poll cycle	deX updates the schedules and sends the new flexibility schedules of DER groups to DERMS through IoT hub	In some circumstances, schedules retrieved after the publication of a requested scheduled may not have been updated to reflect the requirements from that requested schedule. deX does not have visibility of when the requested schedule may arrive may be in the process of generating, as a new requested schedule is received. As the round-trip time for flexibility schedule generation is much less than the poll frequency, the new flexibility will be reflected in the next flexibility schedule. Further details are mentioned in section 11.4	N/A	N/A	✓[1]
5	deX sends the updated schedule to DERMS	An updated schedule is sent to DERMS through IoT Hub		✓	✓	✓

[1] See Section 12.4 for further details

Number	Objectives	Execution Method	Challenges/Learnings	DERMS	IoT Hub	deX
6	DERMS runs the fore-cast using the new schedules and verifies that the violation is re-solved	DERMS uses the sec-ond message received from deX with updated schedules and verifies that the violation is re-solved		✓	N/A	N/A
7	Regression Testing for scenarios	MVP was considered to prove the scenarios	Further details in sections below	N/A	N/A	N/A
8	deX sends schedule of desired limits of DER to DERMS	Desired limits are sent to DERMS through IoT hub every 60 minutes	IoT hub is merging and splitting the messages	✓	✓	✓
9	DERMS validates these limits by verify-ing if any network vio-lations are caused by using these limits and adjust those limits so that network violation is resolved	DERMS verifies the limits using DCC (Dy-namic Capacity Con-servation) application		✓	N/A	N/A

Number	Objectives	Execution Method	Challenges/Learnings	DERMS	IoT Hub	deX
10	DERMS sends the validation result and adjusted limits	The result is sent to deX through IoT Hub	IoT Hub splits the message into multiple for deX. See Section 10.6 for further details	✓	✓	✓
11	DERMS expects that next DER planned schedule is aligned with the revised limits of the DER	deX sends planned schedules to DERMS through IoT Hub in the next polling cycle	Planned schedules are sent only for some DERs in the network.	✓	✓	✓[2]
12	DERMS expects the updated flexibility schedule from deX in the next 15-minute poll cycle	An updated schedule is sent to DERMS through IoT Hub		✓	✓	✓

[2] See Section 12.5 and 12.7 for further details

9. ECOSTRUXURE DERMS ARCHITECTURE

The architecture for the DERMS platform is shown in Figure 9-1.

The entire product suite is deployed onto a single virtual machine which is located at Evoenergy's site and has a connection to the IoT Hub.

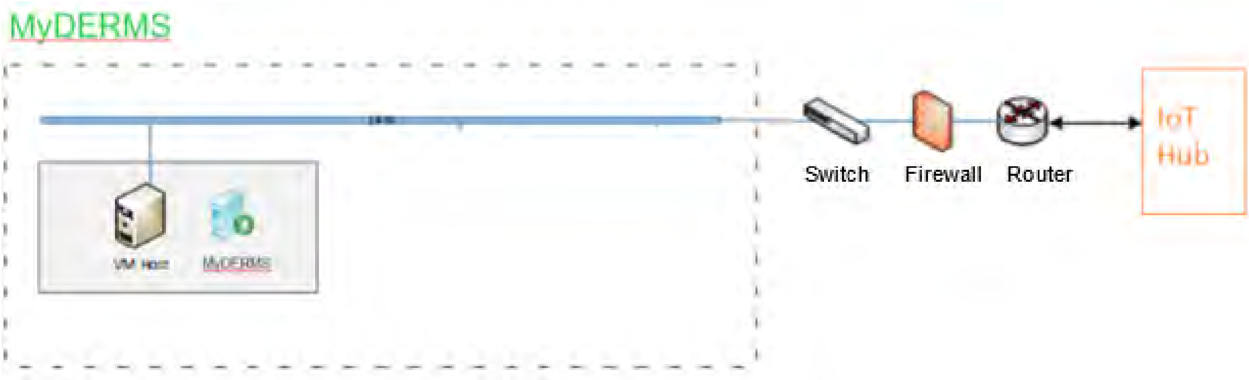

Figure 9-1 Network Architecture

10. NETWORK MODELING ON DERMS

The model that is currently existing on the Evoenergy's production system is considered. A part of the network is selected which consists of all the required components to suit our objectives of this project. For this project, Evoenergy selected the Woden Zone Substation and the downstream HV feeder called 'Streeton' for the simulation. The Streeton feeder incorporates greenfield and brownfield areas which has one of the highest penetrations of DER within the ACT. The feeder also supplies parts of greenfield estate called Denman Prospect which has mandatory solar PV on each detached dwelling thereby making it an ideal selection for this project.

Woden Zone Substation consists of 25000 customers. In total 5200 DERs are modelled for the purpose of the project, out of which 2824 are deX controlled. Some of them already exist in the network model and some of them were added for the purpose of the project. DERMS used PV system and batteries as resources to resolve violations in the system, however electrical vehicles were also modelled for the situational awareness and the analysis of their impact on the grid.

All DERs and DER groups are modelled on DERMS. All controllable (VPP and autonomous) DERs are simulated by deX. All DERs that are not controlled are represented on DERMS.

The historical data for this part of the network is obtained and integrated to predict their behaviours, calculate consumption forecast and generate battery profiles.

10.1. Network Model Preparation

The DERMS functionalities used in this project belong to the group of model-based functionalities. Model-based functionalities use the network model, load and generation forecast, and load flow calculation to obtain network state (active and reactive power flows, currents, voltages, etc.). The quality of calculated state is directly dependent on the quality of the data used in calculation. In order to enable high quality performance of DERMS functionalities, it is necessary to invest an effort to ensure high quality of data used in the system.

As part of this job, fine tuning process of the network model comes is the first task that needs to be executed. GIS data must reflect what is actually in the field, including all system parameters and information about customers. In the case when the quality of GIS data is not high enough, the quality of calculated state and results of model-based functionalities will be lower. The tuning process can be performed in cooperation between the vendor and the utility, with the vendor drawing the utility's attention to non-logical results obtained on using data from GIS, while the utility is responsible for making the maximum effort to correct these data. In order to enable the execution of EcoStruxure DERMS functionality, a fine-tuning process was performed by Schneider Electric, with minimal changes that will provide logical and expected results. These changes are not tracked back in the GIS so there are slightly differences between the model used in the pilot project and Evoenergy GIS data.

In addition to model correction, it is necessary to provide all the necessary historical data that will be used by the Artificial Intelligence engine that performs the forecast calculation. The following historical data are required:

- Hourly consumption for each feeder
- Hourly production of DGs (photovoltaic and/or wind turbines)
- Hourly battery power (charge/discharge)
- Historical hourly weather data

All data needs to be provided in expected format of EcoStruxure DERMS tools that are used to import these data. Battery data and weather data were obtained from Evoenergy. In terms of power consumption, only hourly current data were available for each feeder. Due to the high penetration of distributed energy resources, these data were not sufficient for quality forecast execution. Therefore, a simplified algorithm was used in which load curves that already exist in the obtained Evoenergy scheme are used to derive load forecast. Load curves are formed based on the historical data from smart meters, so the assumption is that this procedure will provide a better forecast results than in case when consumption power is derived using hourly current data and making assumptions about production from DERs and power factor.

Finally, to execute use cases it was necessary to add additional DERs into the network model. These devices do not exist in the GIS and were added additionally by Schneider Electric. This work was done using EcoStruxure DERMS planning application Customer Connection.

11. EXCHANGED INFORMATION BETWEEN DERMS AND IOT HUB

The exchange of data is via web services designed and implemented in accordance with IEC 61968-5 and 61968-100 standards whereas EcoStruxure DERMS interface for exchanging data for DER groups are certified as CIM compliant.

11.1. DER group flexibility schedules

For each DER group, deX provides information via IoT hub about minimal, maximal and planned schedule (three schedules) of the DER group. Using those data, DERMS can have insight into the flexibility of DER group. Figure 11-1 shows minimal, maximal and planned schedule of DER group.

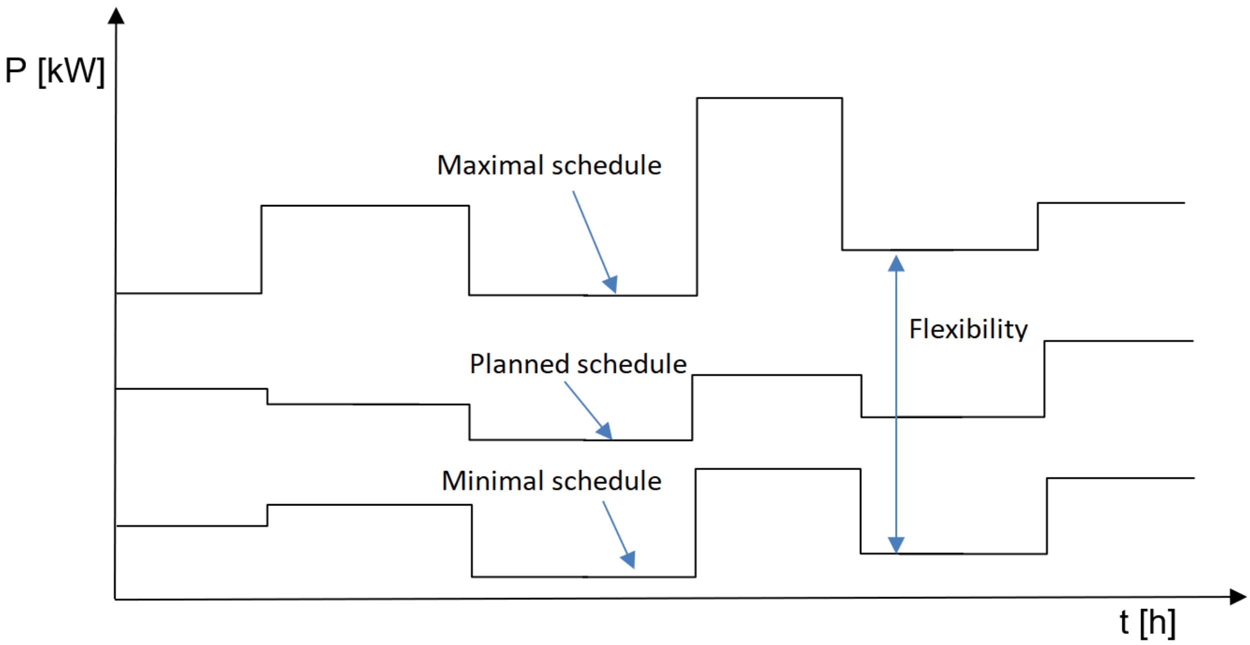

Figure 11-1 DER group flexibility schedule

Details:

- The schedules provided by deX contain values for the next 30 hours.
- Beside the values, deX provides appropriate timestamp values.
- The schedules are provided by deX on each change of DERs expected behaviour. In case that no change is detected, deX will update schedule after 6 hours.
- The schedule provided by deX represents active power in kW. Positive sign means that DER group in total exports active power (e.g., production from PVs is high). Negative sign means that DER group in total imports active power (e.g., batteries are charged with high active power).

- Schedule can be provided with configurable timestamp (15min, 30min, 1 hour). All values must be equidistant (difference between any two neighbouring values is equal).
- All three schedules are provided at the same time and all values have the same timestamp. For example, in case there is a change of minimal schedule, all three schedules will be updated. Also, for one timestamp there are values from all three schedules.

11.2. DERMS requested schedule of DER group

When DERMS detects overload or reverse power flow constraint violation on feeder head or on supply transformer in near future (the next 24 hours), it determines the new requested schedule(s) of DER group(s) which can resolve the upcoming issue. The requested schedules are sent to IoT hub and then to deX. Figure 11-2 shows diagram of DERMS requested schedule of DER group.

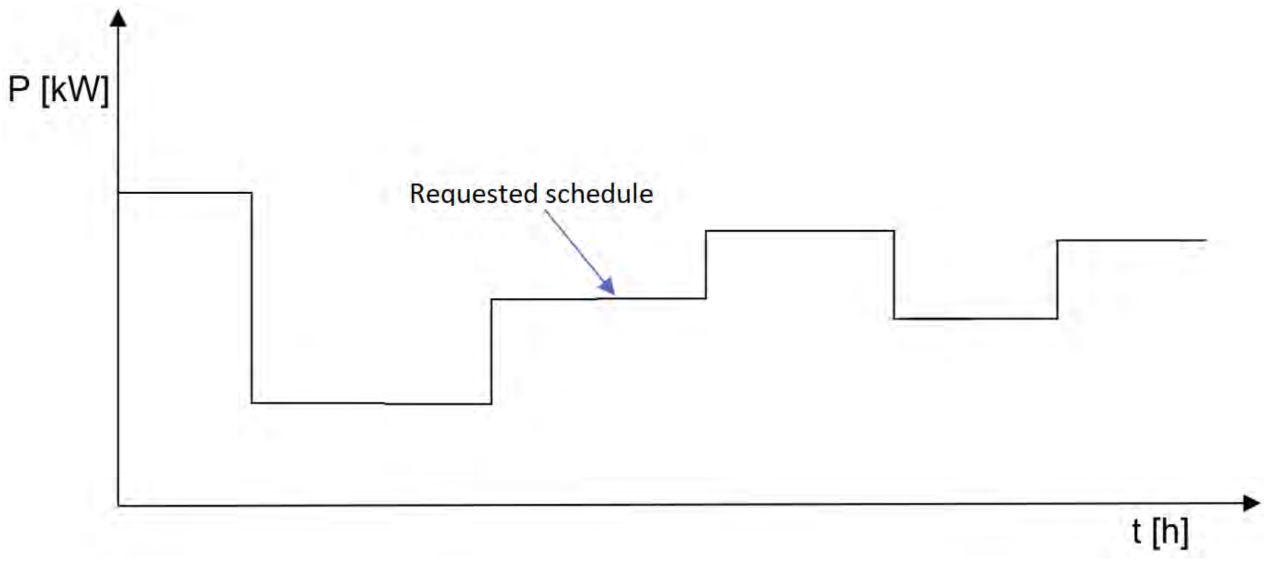

Figure 11-2 DERMS requested schedule of DER group

Details:

- The schedule sent by DERMS contains values for the next 24 hours.
- Beside the values, DERMS also provides appropriate timestamp values.
- The schedule is provided by DERMS when the violation is detected in the next 24 hours.
- The schedule provided by DERMS represents active power in kW. Positive sign means that DER group should export active power. Negative sign means that DER group should import active power.

- Schedule can be provided with configurable timestamp (15min, 30min, 1 hour). All values must be equidistant (difference between any two neighbouring values is equal).

11.3. Planned schedule for individual DERs

For each DER, deX provides the IoT Hub information about planned schedule. Figure 11-3 shows planned schedule of a DER.

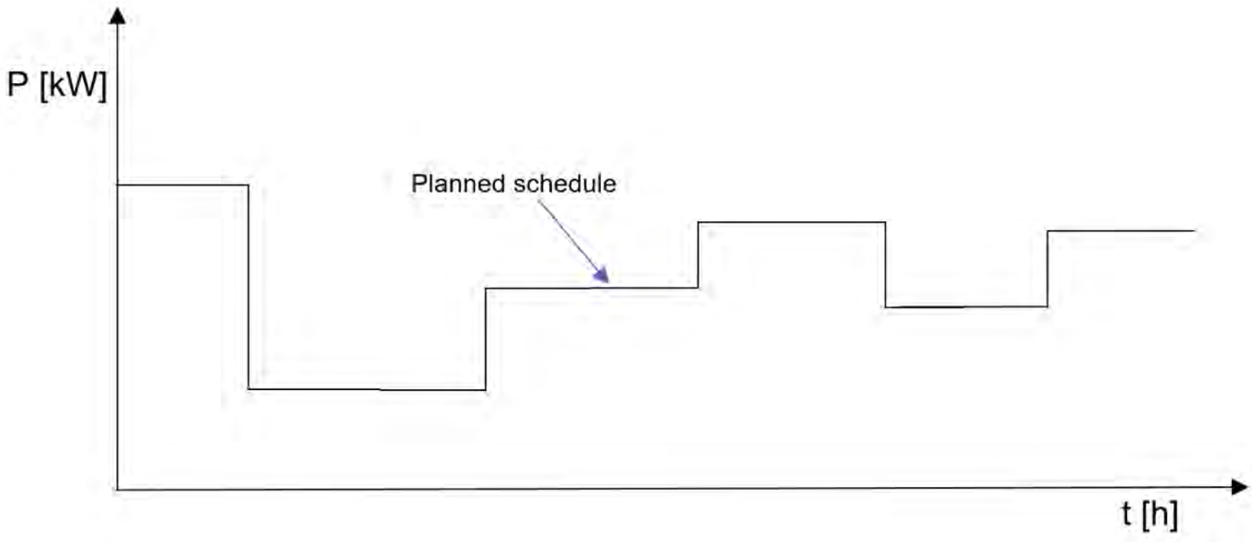

Figure 11-3: Planned schedule of DERs

Details:

- The schedule provided from deX contains values for the next 30 hours.
- Beside the values, deX provides appropriate timestamp values.
- The schedule is provided by deX on each change of DER expected behaviour. In case that no change is detected, deX will update schedule after 6 hours.
- The schedule provided by deX represents active power in kW. Positive sign means that DER produces energy. Negative sign means that DER consumes energy.
- Schedule can be provided with configurable timestamp (15min, 30min, 1 hour). All values must be equidistant (difference between any two neighbouring values is equal).

11.4. Desired limits for verification of individual DERs

deX sends the request to DERMS for verification of maximum export/import schedules (desired limits) of each individual DER. Desired limits for a DER are shown in Figure 11-4.

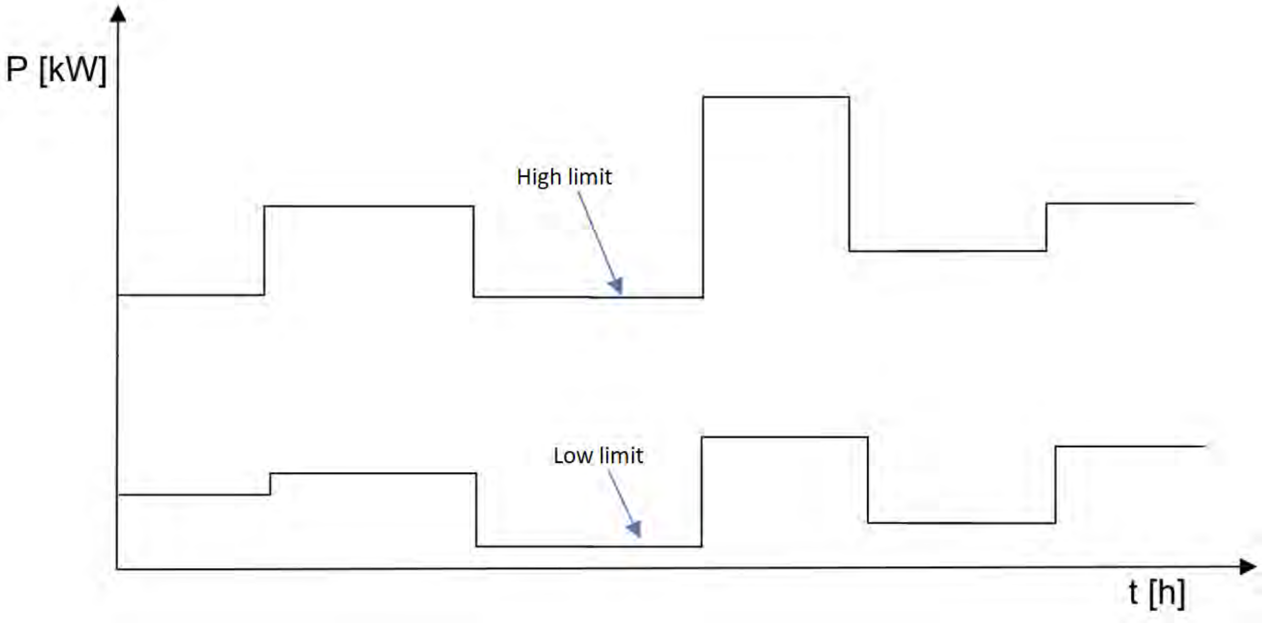

Figure 11-4 Desired high and low DER limits

Details:

- The desired limits for verification are provided from deX and they contain values for the next 24 hours.
- The limits provided by deX represent active power in kW. Positive sign means that DER produces energy. Negative sign means that DER consumes energy.
- Limits can be provided with configurable timestamp (15min, 30min, 1 hour). All values must be equidistant (difference between any two neighbouring values is equal).
- Beside the value, deX provides information about timestamp.
- deX will provide the request ID of the schedules. These request ids are unique. All DERs whose limits needs to be validated in one cycle of validation must be sent as part of one request.

11.5. Revised limits of individual DERs

DERMS sends revised DER limits to IoT Hub. DERMS sends only changed DER limits. In case that for some DERs the limits are not received by DERMS via the IoT Hub, deX should be aware that it means those limits are not changed. DERMS will also provide indication about the status of requested verification process:

- Passed – all DER desired limits are ok, DERMS does not send revised limits (there is no received new limits),
- Conditionally passed – some desired DER limits should be changed; DERMS sends revised limits (the new limits that need to be changed are provided),
- Warning – all limits need to be changed to 0 kW, there is probably the problem in the grid that is not associated with DERs. DERMS sends revised limits,
- Failed – some of the calculation failed.

Details:

- The revised limits are provided from DERMS and they contain values for the next 24 hours. They will be in the same form as the desired limits.
- DERMS will provide the request ID to IoT Hub so that deX can make the connection between the request and the response from DERMS.

11.6. Data exchange packets

During the testing it was observed that IoT Hub and deX platform were rejecting message packets. This was put down to the file size of the packets. The schedules from IoT Hub were not sent in one message to deX. They are split into many messages due to the message size. IoT Hub merged the packets before sending them to DERMS.

11.7. Minimum Viable Product

The DER Integration and Automation project had varying weather profiles and DER uptake scenarios that had been shortlisted for the regression testing phase of the project. With increasing project management delays for the project, the project consortium agreed with not completing the full-scale testing for this simulation project. The scenarios in consideration included increasing the solar and battery capacities along with a range of temperature profiles to showcase increasing DER output, associated constraint management and resulting DER manipulation from the DERMS and deX platform. While completing the use case testing, it was observed that the correlation IDs and the timing challenges within the project would lead to extensive testing and re-working of the schedules and profiles. Functionally, the project has demonstrated the viability and validity of the use cases that the project had set out to complete. The remaining scenarios that were originally in consideration was a further simulated exercise to understand the impacts of different weather scenarios and DER penetration levels, but would not test any system functionality that had not already been tested. Additionally, with increasing solar uptake scenarios, only the rated power of existing resources was to be changed and the DERMS platform was not adding more DER assets as agreed during the design. As a result, the minimum viable product (MVP) for the simulation project was established as the final deliverable showcasing the completing and success of the three Use Cases while proving that further scaling of the DER scenarios can be completed and showcased in further extensions of the project. Throughout the project testing phase, the logs of the project platforms from deX, IoT Hub and DERMS showcased that the systems were running unassisted for multiple weeks, while completing various DER schedules and automated constraint management exercises without any human intervention. As such the project consortium is confident that with further time allocation and DER resource visibility across the multiple platforms, further scenarios can be developed and tested. For this final milestone, the minimum viable product is showcased to prove the functional outcomes of the project.

12. LESSONS LEARNT

During design phase several constraints and limitations of final solution are recognised that are less important for major use cases that prove concept of the pilot project. Limitations of the final solution are agreed to be transparent and communicated as lessons learnt.

12.1. Race condition

Every 6 hours EcoStruxure DERMS receives from IoT Hub flexibility schedules of DER group: planned behaviour, as well as maximum and minimum possible behaviours for the next 30 hours. Also, if in the meanwhile flexibility schedules are changed, EcoStruxure DERMS will receive updated flexibility schedules.

In case of detected upcoming grid constraint issue (e.g., overload of feeder head section), EcoStruxure DERMS utilizes available flexibility of DER group(s) to resolve the issue and sends IoT Hub requested DER group(s) behaviour for the next 24 hours. Based on received requested DER group behaviour and planned schedule, deX determines the service requirement (change in behaviour – power delta) of DER group.

When in the meantime planned schedule of DER group is not changed, deX will derive exact power change of DER group that will resolve upcoming grid constraint violation, based on DERMs calculations communicated to the IoT Hub. Otherwise, deX may request power change from DER group that will not resolve completely upcoming grid issue, and more than one iteration and exchange of DER group flexibility and requested schedules will be needed, or race condition can happen.

The race condition can be prevented if the IoT hub communicates to deX knows which planned schedule is considered by EcoStruxure DERMS for resolving detected problem. To use adequate planned schedule of DER group, deX needs additional information, e.g., correlation Id of exchanged messages (schedules) and will request via the IoT Hub.

All schedules received from deX and IoT Hub are obtained with time resolution of one hour. Therefore, the race condition is not expected to occur within the scope of this project. However, it is recognized to be one of the lessons learned, and can be resolved in possible next phase of the project. In order to simulate and test race conditions, it would be needed that schedules are published from deX through IoT hub to DERMS on any change of these schedules and it would be needed to develop correlation ID between exchanged messages.

12.2. DER limits validation before energy market participation

Every 60 minutes EcoStruxure DERMS receives from IoT Hub desired maximum of DER export/import power for the next 24 hours, per individual DER. Based on load and generation forecast, and actual network topology, EcoStruxure DERMS validates desired DER export/import power against grid constraints. Thus, EcoStruxure DERMS derives DER dynamic export/import limits (DER limits) for which DER will not jeopardize grid reliability and power quality in near future. Finally, EcoStruxure DERMS sends new DER limits to the IoT Hub for the next 24 hours which is passed to deX which then incorporates these limits in case of VPP participation in energy market.

In the instance of any change to network topology, the current solution does not provide a mechanism for deX to be notified of these changes. Any changes to individual limits as a result topology changes will be reflected in revised schedules from the ADMS, the next time a desired schedule is passed through.

The major impact to DER limits modification will be in case of change of network topology in low voltage (LV) grid. However, the change of LV grid topology is not expected to occur often, and it is not recognized as significant issue to satisfy the requested use cases. Therefore, this situation is presented as one of the lessons learned which can be supported in possible next phase of the project. However, any changes to network topology will not be reflected in the DER groups for resolution of network issues for Use Case 1.

12.3. DER market evaluation

In the initial project proposal, a merit order approach to DER curtailment had been proposed. This would have resulted in customers being curtailed in sequence according to a price that they were willing to pay for curtailment. This approach may not be palatable when the equity of customer access to network capacity is being considered. In detailed design, this approach was revisited, and the curtailment approach was adjusted to a “pain sharing” approach, which curtails across all customers equally. This means that when EcoStruxure DERMS detects a grid constraint, it will equally reduce the limits on all DERs that can resolve grid issue.

All LV DER customers are equally treated when a grid problem has to be resolved. The merit order list for DER curtailment was not implemented for this project which is technically also another alternative methodology to evaluate the DERs that need to be ramped down to alleviate the constraint.

12.4. Alignment of Planned schedules and poll sequencing

When DERMS forecasts a constraint and requests for a new schedule from deX, it can happen that the first message DERMS receives from deX through IoT hub does not contain the requested change. This happens because of two reasons:

- There is some time delay between requesting schedules and obtaining the response due to the calculation time, communication with DERs and obtaining expected response. This is real life scenario that cannot be avoided.
- The current configuration has the IoT Hub polling deX each 15 minutes, and passes everything through to DERMS, regardless of whether the schedules have changed. So, in case that the schedules are still not changed, IoT Hub will collect old results and send them to DERMS. In this situation, DERMS will try again to resolve the issue and it will send the same request again, so deX may understand that additional request is sent. A possible way to resolve this is that the for the IoT Hub to only retrieve and pass through a new schedule if the ID has incremented since the last schedule. The deX bridge API provides a mechanism for the client to provide the last ID and will return any subsequent schedules, if any have been generated. This would mean that the data is not polled from deX with a fixed timestamp or interval, but that data is published only once they are changed. With this logic, DERMS will wait for the response for some maximum predefined time and it would be aware that obtained response is aligned with the requested changes.

12.5. Visibility of available energy per DER group

During execution of the use cases, it was noticed that sometimes even the requested schedules are within provided flexibility limits, the service could not be provided since the requested energy was larger than the available energy that can be used during a day, and DERMS received schedules that were not changed. This situation can be resolved by providing information to DERMS what is the available energy per DER group that can be used to resolve violations in the system. At this moment, most standards only support providing flexibility limits without energy. Also, this situation can be resolved if the obtained schedules are changed at least for the available energy. At this moment, when there is not enough energy, the schedules will not change at all and the old values would be received.

12.6. Non-exclusivity

To allow DER to provide the greatest possible value, it should be possible for DER to be used in resolution of more than one network issue. To achieve this, it is necessary for DER to be capable of belonging to multiple DER groups in network systems.

For example, a DER may be simultaneously capable of solving:

- Thermal overload on a zone substation;
- Thermal overload on feeder section;
- Overvoltage on a distribution substation.

Non-exclusivity would allow for resources to be members of groups to solve each of these network issues simultaneously.

12.7. Contract capacities

Use case 1 relates to the ability of the DERMS to utilise DER groups to resolve network issues by sending a Requested Schedule and receiving back a Flexibility Schedule. For a given Requested Schedule, based on the set of available contracts, the Evaluation Engine determines a dispatch strategy that meets the service requirement at the lowest cost.

In a real-world context, it is extremely unlikely that the capacity of all contracts would represent the flexibility of DER groups. That is because not all DER will be members of VPP portfolios available for providing network services, and a VPP operator is unlikely to agree to provide services that would be equal to the sum of all DER that comprise the portfolio.

In the implementation of this solution, network systems have not been provided with visibility over the capacities of the contracts available to resolve the network issue. This means that when a network issue arises, network systems may request a service response that exceeds the capacities of the contracts. This would result in a refusal of the requested schedule by the Evaluation Engine, which would be communicated back to network systems as unchanged DER flexibility schedule.

The solution needs to be designed such that the rejection of requested schedule is a possible outcome and is handled sensibly by all systems. However, unnecessary requests for services that are outside the capabilities of available contracts could be avoided by providing network systems with visibility of the contract capacities.

12.8. Project Observations

The overall project showcases the MVP for the project and the use cases that were considered at the initiation of the project. Since early 2018 when the project was first initiated with ARENA, the industry landscape has moved in relation to DER. The multiple projects and standards that have become the norm for DER orchestration are valid but were not considered for this project. This project highlights the opportunities in utilising dynamic control to maximise a customer's access to, and utilisation of, existing network capacity. For the benefits identified in this project to be realised in a real-life context, the percentage of DER that is able to provide these functions should be maximised. This could be achieved through a number of mechanisms including regulatory obligations, incentives (e.g., export limits, or tariffs) or others.

A short summary of some of the observations and future scope of works are detailed below:

- Platforms in DER orchestration will require the ability to correlate schedules and timings for DER limits (dynamic operating envelops) being passed between systems
- All systems will need visibility of suppliable and consumable limits of DER system capability.
- In order to reduce confusion, specific messages for accepting or rejecting a service request will be needed between platforms.
- A Polling/Publishing method is required, where the data is exchanged between Network Management System and a Market platform, when data is ready to be sent instead of a set time cycle.
- The DER integrations will require the ability to provide scheduled behaviour and flexibility (upper and lower bounds) for consumption by network management systems.
- Network Management systems should be able to target DER output to a setpoint value (not in scope for this project, possibility for a next phase)
- DER aggregators and platform will require the ability to revert to a default safe behaviour in event of loss of communications (not in scope for this project, possibility for a next phase).
- The platforms could be required to aggregate and record/report the total energy constrained and the devices list that are being engaged. This is to verify from a DNSP point of view, the value of the generation/restriction being applied. This will assist in comparing against the network vs customer benefit in terms of investment

(i.e., cheaper to pay through DER contracts or better to invest and remove the constraint causing issue)

- To reflect the dynamic nature of the distribution network configuration, it is essential that DER group membership can be updated over time. Dynamic membership complements the non-exclusivity functionality, by ensuring that the membership of DER to DER group(s), reflects the capability of those resources to address network issues associated with that group. For example, a resource that moves from one feeder to another as a result of network reconfiguration, should be removed from any groups of network areas that it no longer belongs to added to any new groups for network areas that it is now connected to. The membership of resource to DER groups should be updated and provided by network systems on a periodic basis.

13. CONCLUSION

The DER Integration and Automation Project set out to achieve a specific set of outcomes under the agreement with ARENA and the project partners. The list below describes how the project went about in achieving these outcomes.

Outcomes:

a. **Improve the capability of distribution networks to host DER at higher levels of penetration through the integration of DER into IoT and ADMS platforms via an enhanced DERMS module**

   The project successfully integrated the IoT Hub and EcoStruxure ADMS v3.9 which included the enhanced DERMS module platforms to understand the impact of high penetration of DER and the possible constraints that would be caused by such DER uptake. The simulation exercises proved that Evoenergy would be well placed to improve its capability to host DER as the IoT Hub in its integration with DER aggregators or registration platforms such as deX, would allow for schedule verification and validation for hosting capacity in near real time. The project showcased that EcoStruxure DERMS can provide preventive grid constraint management in order to improve hosting capacity.

b. **Enable market operators to manage the power system with a high share of DER while maintaining reliability and system security.**

   The project showcased that market operators who are largely concerned with energy supply and demand balancing within the electricity network can be given visibility over the distribution level impacts of their intended calls on the DER within a specific geographical location. This will ensure that market calls by retailers or aggregators in response to spot price hedging or VPP calls do not cause network constraints in the distribution network. When implemented in production settings, the project will be able to signal and notify networks, market operators and DER operators that any intended action to consume or dispatch energy could cause downstream or upstream issues in the network. This in turn protects the system security and reliability in the electricity network and ensure DNSPs can fulfil their obligations as a network service provider.

c. **Increase the visibility, predictability and control of DER for networks service providers (NSPs) and other relevant entities to optimise power system operation within secure technical limits.**

The project demonstrated that DNSPs are best placed to understand the technical limitations of their network assets which in turn host increasing levels of DER in areas. The DNSPs in conjunction with network management platforms that cater for DER management such as DERMS module, can adequately predict and notify operators of DERs when considering near-term weather forecast (temperature, irradiation, wind speed, etc.) and other network conditions. The project confirmed that networks can showcase optimising the operations from DERs through increasing the visibility and intended operations from DERs via planned schedules and proposed dynamic limits through the integration of deX platform through the IoT Hub and the DERMS platforms.

d. **Increase the visibility, predictability and control of network characteristics and behaviour to improve the efficiency of distribution network connection processes for DER to optimise investment.**

The project successfully showcased flexibility of DER exports can be coordinated and actioned by network management platforms and DER market and aggregator platforms. The use cases demonstrated that by allowing DERs to cycle their generation and consumption depending on network limitations and requirements, allows for DERs to be part of the solution for future network operations.

e. **Increase deX functionality by facilitating the integration of deX with Distribution Management Systems (DMS) of NSPs not using the Schneider ADMS.**

The project knowledge sharing deliverables successfully shows the API integration for the deX platform with the IoT Hub to deliver a pathway to increase the functionality of the deX platform to provide capability of ingesting network limits from network management systems via an IoT Hub integration. The API integration provides a pathway and capability of ingesting network limits from network management systems via an IoT Hub integration. By making the API document public, third parties can better understand the interactions between deX and network systems. For this project there was no integration into the Distribution

Management System, only APIs from deX into the IoT Hub which can be replicated for further use by different DNSPs.

f. **Increase hosting capacity on the network and improve business cases through enabling a commercial market for VPPs and DER services.**

The DER Integration and Automation Project showcased through the demonstration of the use cases that network service providers have a viable alternative to investment in the low voltage and medium voltage network in comparison to the traditional network asset option. The network constraints that are caused due to operations from DER or increased consumption from customers due to weather or temperature can be alleviated through network management systems signalling the relevant DERs and their operators through the appropriate market platforms. This will verify the value of the generation/restriction being applied and assist in comparing against the network vs customer benefit in terms of investment to alleviate constraints. Additionally, if the project is implemented in a production environment, DER operators will be able to invest and deploy DER with greater confidence with the knowledge of network limitations being applied in uniform and appropriate manner without holistic changes in their operations and capabilities.

Effectively, this project investigated, tested and verified the integration and automation in high DER penetration areas to enable greater dispatch and unlock existing network hosting capacity. This provides a pathway to effectively integrate and manage DER assets into an existing energy network which will enable Evoenergy other network businesses to continue to plan, build, operate, and maintain networks in compliance with regulatory standards and ensure reliable and safe supply of electricity to customers. Further work could include standardisation and interoperability pathways to establish a common network management and aggregator/OEM requirements that would enable network operators and customers to utilise DER in a simple and cost-effective way.