Project Journey Report

PROJECT SHIELD

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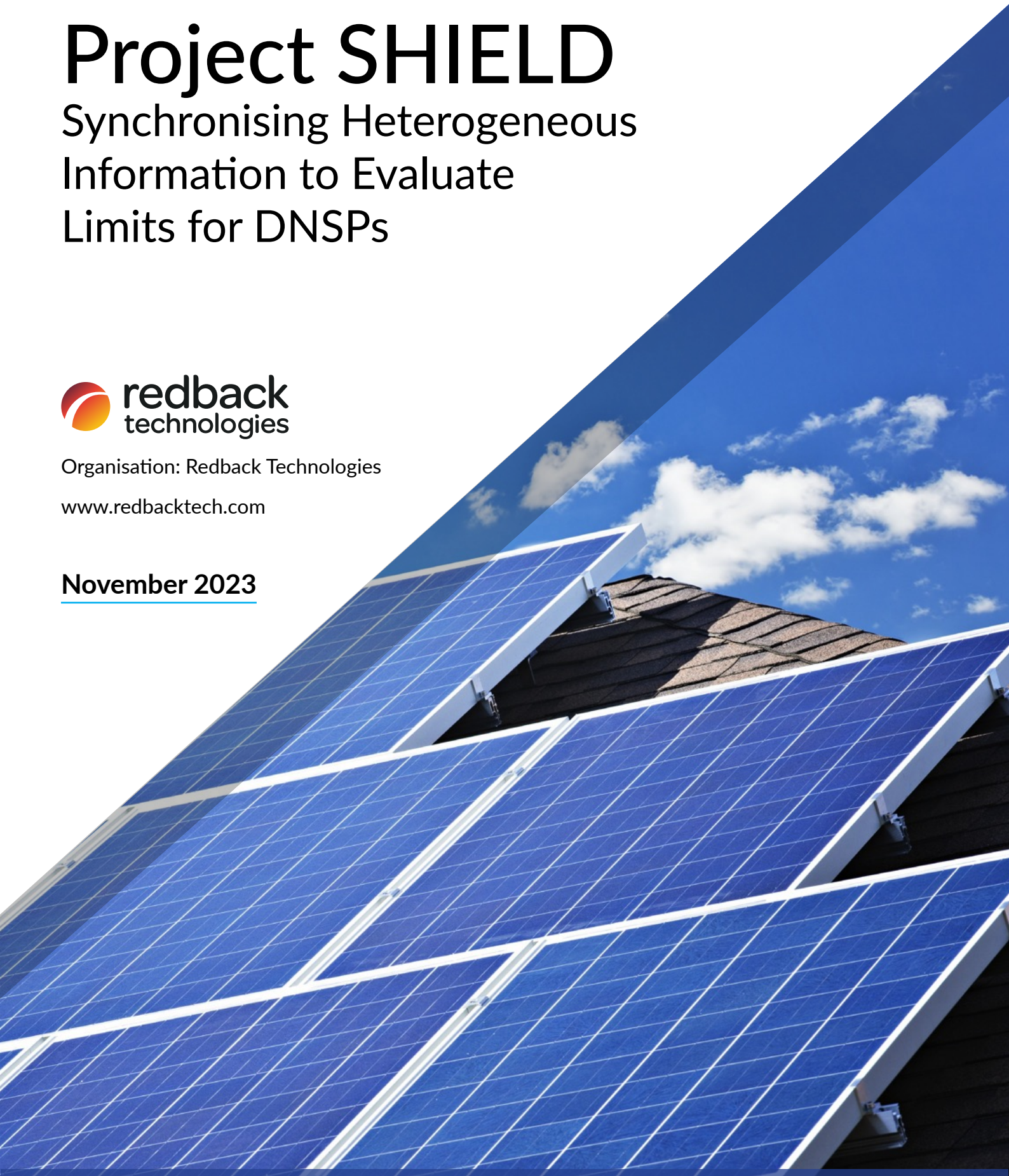
Synchronising Heterogeneous Information to Evaluate Limits for DNSPs



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Executive summary

Project SHIELD: Navigating Challenges to Achieve Network Visibility

The Project SHIELD initiative, launched in January 2020, aimed to provide Distribution Network Service Providers (DNSPs) in Australia with enhanced network visibility using available data and minimal additional monitoring devices. However, the project encountered multiple external challenges, including pandemic-related disruptions, adverse weather events, labour market dynamics, and supply chain shortages, which impeded progress. Despite these hurdles, the project team persevered, leading to significant alterations in the project's scope and funding structure.

Initially addressing the lack of network visibility due to the surge in distributed energy resources (DER), Project SHIELD sought to create a solution using diverse data sources, offering insights into low voltage network capacity. This approach aimed to support increased renewable energy generation without compromising network safety. The collaboration included Luceo, the University of Queensland, GridQube, Energy Queensland, and Essential Energy, focusing on data sharing and innovative technology solutions.

The project's intended outputs encompassed a Dynamic Operating Envelope solution, a Visibility Platform, a Business Case, a Simulator Tool, and a Data Repository. Notably, Stage 1 successfully demonstrated the system's capability to produce real-time Dynamic Operating Envelopes using existing data sources. This innovation stood out for its speed, cost-effectiveness, and scalability in contrast to existing systems.

However, Stage 2 faced challenges in accessing additional real-time data due to cost and security concerns, leading to modifications in partner contributions and reduced funding needs. Consequently, the project's focus shifted to leveraging available data sets to generate Dynamic Operating Envelopes.

As issues persisted, including difficulties in categorising participant contributions and concerns regarding real-time data application, the project was temporarily paused following the December 2022 submission. Intensive discussions followed, resulting in a scaled-down project scope emphasising the creation of Dynamic Operating Envelopes using diverse data sets as the core outcome.

Moving forward, the revised project, scheduled for completion by November 2023, prioritises the delivery of this critical component. The team refocused efforts on utilising existing and newly procured data sets to generate Dynamic Operating Envelopes. Acknowledging resource limitations and reduced funding, this approach aims to fulfill the project's primary objective within feasible timeframes.

Despite facing unprecedented challenges, Project SHIELD remains committed to demonstrating the feasibility of using heterogeneous data sets for network visibility, paving the way for effective management of dynamic network limits.

In summary, the revised project strategy aligns with its core objective of enhancing network visibility through innovative data utilisation, despite adaptations necessitated by external constraints.

Introduction

In January 2020, Project SHIELD set out to develop a method for Distribution Network Service Providers (DNSPs) to obtain network visibility using available data augmented by minimal additional network monitoring devices. At the time, DNSPs faced challenges in justifying investment in measurement data and analysis to support visibility, and it was hoped that this work would assist Networks to validate efforts to improve visibility.

From the very start in January 2020, the project was affected by factors outside of its control that impacted collaboration, travel, resourcing, sensor supplies and data access. Paired with a general push by DNSPs in Australia to address the same challenges, the project saw some answers being developed as a byproduct of other proactive collaborations and efforts. By early 2023, the project was running eight months behind schedule. Despite these challenges, the project team progressed in their work in seeking solutions.

Following the December 2022 submission, with the project well underway, it became apparent that the project's approach had changed materially from the original vision as a result of environmental influences, increased data availability and technological advances. One of the consequences of that change was a reduction in expected partner cash contributions, replaced instead with in-kind contributions.

The result was a reframing of the original project intent and a change in funding structure in order to deliver key components of the project within acceptable time frames and at the lowest risk.

This report outlines the project's journey up to the December 2022 submission, and documents the subsequent changes to scope and timeframe that followed.

Background

When Project SHIELD was first proposed in late 2018, one of the biggest strategic challenges for DNSPs was enabling exports from the growing amount of distributed energy resources (DER) on the network. At the time, these stood at approximately 2 million rooftop solar installations with a capacity of more than 8 GW.

The AEMC, AEMO and ESB had highlighted the lack of network visibility (data showing the power quality along low voltage feeders in the network) as one of the fundamental barriers to an enabled future grid. The data required to balance grid imports with DER exports and manage parameters such as voltage wasn't widely available from network metering outside of Victoria, where Smart electricity meters on customer premises were ubiquitous. Furthermore, Distribution Network Service Providers (DNSPs) were being challenged by regulators to justify investment in measurement data and analysis to support the visibility and management usecase.

Project SHIELD recognised that it would take a considerable period of time until full, quality data sets would be available to DNSPs with sufficient data latency (close to real time) to be utilised for this purpose and that a solution was required in the interim. The team set about seeking to develop and demonstrate such a solution.

The Project

Project SHIELD's aim was to develop a solution for assessment of Distributed Energy Resources (DER)[1] hosting capacity at low voltage (LV) network feeder level for DNSPs where:

- data could be sourced from a range of traditional network and non-traditional devices and equipment connected within the network,
- data would likely possess a range of different traits (quality, latency, frequency),
- there almost certainly would be a less than complete data set from each of the LV feeders.

To date, no DNSP in Australia had sought to utilise these existing data sources to improve the visibility of their LV networks. This is likely due to a combination of limited data skills, limited data infrastructure and competing priorities as well as the challenge of accessing these data sets.

The novelty of this approach was that a growing amount of data was being generated at points along the low voltage network. If this data could be effectively collected, combined and analysed using the latest state estimation software[2], there was a high likelihood that Dynamic Operating Envelopes (DOE) could be generated with sufficient accuracy to implement into network operations. The unknown issue was the quality and availability of the data, and the challenge was to successfully integrate the heterogeneous data sets into a single view of a feeder incorporating all of those different data points.

The Project aim was, and remains, to support the increase in renewable energy generation in the LV networks by improving the visibility of network capacity in a dynamic setting - until more data from smart meters is available to perform this task - without compromising network safety or reliability.

The potential consequence of such granular, data-based insights was that additional DER capacity could be installed on LV feeders, export curtailment could be avoided or reduced and, in the future, more accurate dynamic operating envelopes could be enabled.

Project participants included Luceo, the University of Queensland (UQ) (Research Partner), GridQube (Technology Partner), Energy Queensland (EQ) (DNSPs Energex and Ergon Energy) and Essential Energy (EE) (Network Partners) (Data Sharing partners).

1 DER include rooftop solar, household batteries, electric vehicles and energy management systems (DER integration expenditure guidance note, AER June 2022)

2 State estimation is a process that provides an estimate of the internal state of a given real system, from partial measurements of the input and output of the real system. It is typically computer-implemented.

Project Design

The project originally intended to deliver a number of outputs.

The Dynamic Operating Envelope solution

The Solution proposed would comprise of:

- A proof-of-concept cloud-based network data platform, being developed by Luceo (the Luceo Platform) that was capable of managing electricity data and in compliance with data security and privacy laws. The Luceo platform would be improved to receive, validate, sequence, synthesise, store and analyse energy (voltage, current, etc.) data from a diverse range of data sensors and sources situated at the LV network.
- An LV network State Estimation Algorithm that had been developed by GridQube (the GridQube Estimator) which would be fed data from the Luceo Platform to demonstrate its ability to generate DER hosting capacity estimations.

When connected and refined, the system was expected to be able to demonstrate that DNSPs could use multiple data sources to generate DOE data.

A Visibility Platform

The Luceo platform would demonstrate digital network visibility capability leveraging data from the project. The visibility platform would enable DOEs to be interrogated across trial areas.

Business Case

Development of an evidence-based Business Case that described the cost-benefits identified during the project. This Business Case included investment in, and analysis of third-party and/or network data on LV feeders with high DER density in order to improve the cost-effectiveness of short-term feeder modifications (rebalancing, tap changing) and defer planned capacity upgrades.

A Simulator Tool

A tool designed to enable DNSPs to understand data point quantity and location was required. Such a tool would enable cost-effective hosting capacity visibility for a given feeder using state estimation. Specifically, a tool to help them identify optimal locations for the installation of additional data devices, while enabling the identification of customer types that aid in creating visibility.

A Data Repository

The data repository was to be an online portal containing project data sets that had been collected and deidentified. Its purpose was to make the data available to researchers who were conducting low voltage data studies.

Figure 1 below maps the basic system architecture that was designed and implemented.

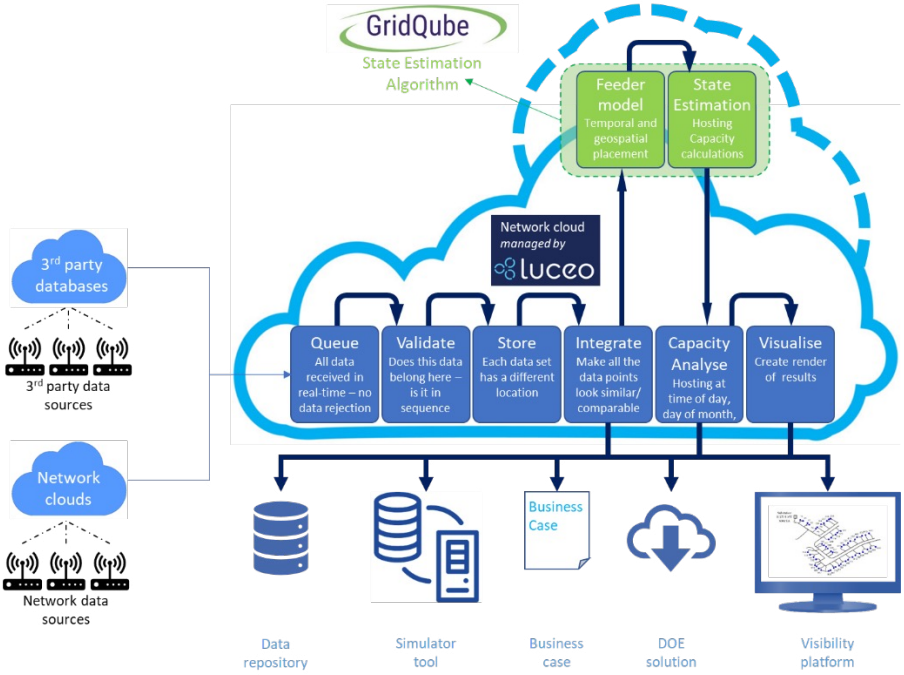

Figure 1: Project SHIELD system design

Project Staging

The Project was to be delivered in two stages as shown in figure 2 below

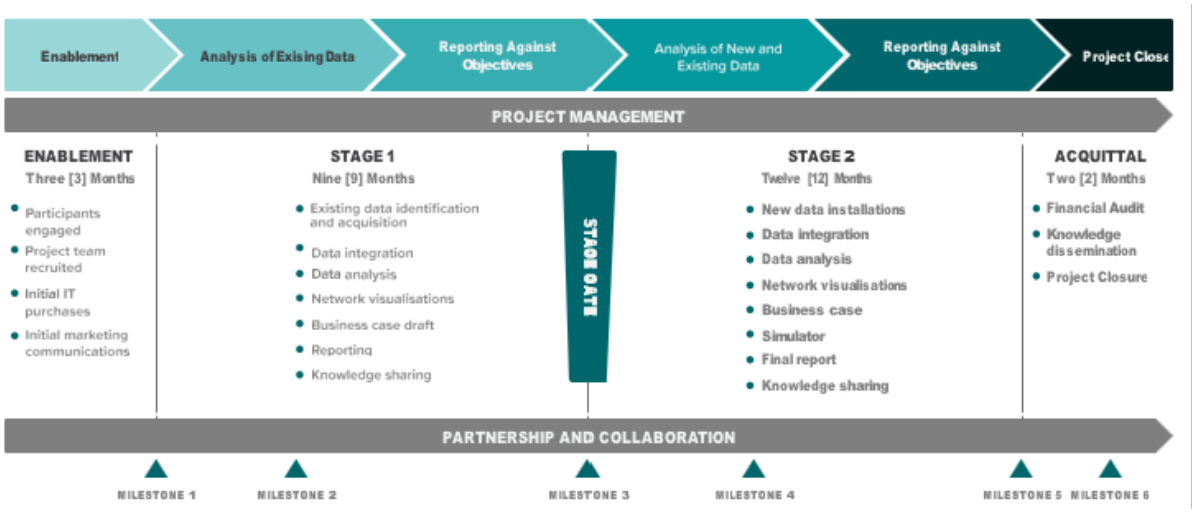

Figure 2: Phased approach for delivery

Stage 1 would:

- Build out the digital solution architecture.
- Collect data from existing data sources supplied by networks project partners (Energy Queensland and Essential Energy) and Third Party Owned Equipment.
- Use the data to generate network visibility, create initial DOEs and inform the business case.
- Develop prototypes of the Simulator tool and the data repository.

The intent of Stage 1 was to demonstrate that DNSPs could confidently use the system to leverage existing data sources to improve LV network operational decisions with regards to network hosting capacity.

More details regarding the processes and outcomes of Stage 1 were published through ARENA in April 2022[3].

Stage 2 would:

- Access new data by installing network measurement devices within the target areas.
- Explore the relationship between increased data levels and accuracy of hosting capacity calculations.
- Use the data to generate network improved visibility, create more accurate DOEs and help finalise the business case.
- Develop working versions of the Simulator tool and the data repository.

The intent of Stage 2 was to install the most cost-effective network measurement devices to fill the key data gaps restricting the system from calculating actionable LV network hosting capacity. This action was intended to improve the level of accuracy required by DNSP.

In order to achieve this, the Recipient sought to acquire energy data from Data Sharing Agents. The data sources were to include network sensors, transformer monitors, smart meters (AMI), smart DER (e.g., solar inverters, home battery systems, etc.), solar analytic solutions, home energy management systems and other devices.

Following a stage gate review in mid-2022, Stage 2 - comprising of Period 4 in December 2022 (data collection), Period 5 in June 2023 (data analysis) and Period 6 (report finding) - commenced in July 2023.

3 Refer to Project SHIELD Outcomes report at https://arena.gov.au/knowledge-bank/project-shield-stage-1-outcomes-report/

Project Outcomes Delivered

During Stage 1, a fully operating solution was designed, built, and tested on immediately available data. During this stage, the team demonstrated that the system built was fully capable of producing real-time DOE. More details regarding the processes and outcomes of Stage 1 were published through ARENA in April 2022[4].

The project team had seen no other system in Australia, with the exception of SCADA-based systems, that delivered the round-trip from sensor to envelope at a higher speed, lower cost, and at scale than the Project SHIELD. Conversely, no other system in Australia (including SCADA) had been able to do it with less than complete, heterogeneous data sources. The project set-up and results delivered were unique and highly relevant for Australia's DNSPs and other key stakeholders (such as the AEMC, AEMO and the AER), in their work towards defining the future energy system of Australia in a highly decentralised and variable setting based on renewable energy sources and dynamic demand.

The solution and its visibility platform were demonstrated for ARENA, and they clearly expressed support for Project SHIELD to provide a pathway to commercialisation for the participating Australian innovators Luceo (Redback) and GridQube. Following the commencement of the project, both Luceo and GridQube were able enter into contracts with their respective, commercialised versions of the solution modules. The Luceo monitoring and analytics solution has been installed at more than 35,000 LV connection points in Queensland whilst the GridQube State Estimation module began solving real issues for the Northern Territory Network.

The project team also provided prototype versions of the business case, the simulator tool and the data repository.

As the project transitioned into Stage 2, work commenced seeking to access increased amounts of data from different sources. During this stage, it was envisioned that this data would most likely come from project partners procuring and installing new and additional data devices to supplement the data sourced and used in Stage 1.

The purpose was to understand how the addition of extra data points would improve the confidence level of the DOEs generated by the solution.

The project team submitted reports at the end of December 2022, five months later than originally planned, due to issues discussed below.

4 Refer to Project SHIELD Outcomes report at https://arena.gov.au/knowledge-bank/project-shield-stage-1-outcomes-report/

Project Challenges Encountered

COVID-19 Pandemic

At the outset, the project developed a detailed and comprehensive risk management plan with the assistance of ARENA and external consultants, Oakley Greenwood. That plan listed COVID as an extreme (pre-treatment) risk, and this rating remained high post-treatment.

Like all businesses, the impact of that pandemic was much larger and extended much longer than could be reasonably expected. The key challenge of the COVID Pandemic was the sickness which afflicted each of the partners throughout the project at often inopportune moments. However, the breadth of impact of COVID was much wider than originally envisaged in the risk management plan, manifesting in many other impactful yet subtle ways.

Adverse Weather Events

Compounding upon the impacts of the pandemic, across the networks and a large portion Australia's Eastern Seaboard saw multiple significant adverse weather events. These included, but were not limited to, the bushfire season impacting the volume of work in backlog followed almost immediately by some of the greatest flood levels of the past century. Field crews at this time were solely focused on addressing the primary businesses work volume to manage risk and continue to provide a reliable network for customers.

Labour market pressures

Throughout the period of the project, the Australian economy experienced continually falling unemployment rates, creating a highly buoyant Labour market with many well-paying jobs on offer. These conditions had affected the project in a number of ways:

- Delays in initial recruitment resulting in a slower than expected project start up.
- Greater than expected turnover of staff during the project as employees sought to move from fixed-term project SHIELD work into more permanent and profitable jobs. While key person risk was identified as a key risk by the project, it was expected to be manageable. In the end, turnover occurred at rates rarely experienced in projects and in almost every project role (sometimes multiple times) during the first two and a half years. This was particularly challenging to manage when specific, highly trained technical staff with core knowledge began to turn over.
- Challenges with governance and management at a project level with higher-than-expected turnover in the ARENA contract management team responsible for liaising with Project SHIELD creating gaps in legacy knowledge between the two parties.

Other challenges

Travel and movement restrictions also created a range of unexpected complications.

- Negotiations with data vendors were made more difficult by an inability to meet in person, build rapport and trust as a way of addressing barriers to participation.
- Trial area visits by technical staff could not occur and as a result, shortcomings in trial area architecture, that may have been identified in walkthroughs, were not identified until much later in the project during development of the digital architecture.

- Limited opportunities for face-to-face contact between project partners, and in particular, Essential Energy who remained remotely based for the entire project.
- Supply chain shortages that delayed equipment delivery and some monitoring equipment.

The project expected to encounter delays and take appropriate actions to counter these challenges, employing tactics to make up lost time where it could. However, the number of issues and the unexpected subtleties that created further project hardships could not always be easily redressed.

Accessing real time data

Data possesses a range of dimensions. For project SHIELD, power data collected within the Low Voltage network needed to consider a range of qualities. The ones that were most important to the project included completeness, frequency and latency. Important amongst the dimensions was the quality of latency - a measure of how old the data is when it is received. This dimension was seen as critical in developing real time DOEs for application by network.

The project team was capable of measuring, collecting and retrieving data in real time. In Stage 1, the team sought to augment that data with as much existing close-to-real time data as could be found in the market. It was known that there were devices capable of measuring and collecting close to real time data (e.g., Inverters, smart meters).

What the project found was that while data of high frequency could theoretically be retrieved in close to real time, the cost to the project to fund the establishment of the infrastructure (and systems required to do this for a short period) was prohibitive. Moreover, establishing these systems and infrastructure would rely heavily on the cooperation and engagement of third parties outside the project participants - for example, retailers or meter providers in the case of smart meter data. This issue was identified and discussed in late 2021 and formally documented in the June 2022 reporting.

Addressing data security issues

During 2021, Australia began to be exposed to the start of the data mega-breaches: large and highly public data breaches. Firstly, came the Microsoft server breach in March that accessed emails of more than 200,000 Australian companies. This was followed by the Facebook breach in April and LinkedIn breaches in June that respectively affected more than 1 billion users worldwide. Indeed, by the time the project sat down with data vendors, many were hyper aware of the risks of exposing their customers data to unnecessary risk. This situation diminished the project's ability to access data from a broad range of sources.

Categorising Participant Contributions

Following the December 2022 submission, it became apparent that there were some timing and provenance challenges associated with devices procured by Project SHIELD for Stage 2 of the project.

In seeking to act early on the procurement and installation activities, the project team sought to leverage a larger data device procurement and deployment program being undertaken in the networks. That program moved faster than expected, resulting in devices being procured and partly

installed before final agreements were completed. The timing was an issue and clearly separating the SHIELD devices from the larger procurement proved to be more problematic than expected. As a result, this expenditure was not claimed as a cash contribution.

Further, some smart meter data was sourced at rates that were significantly less than originally projected. Network partners also identified sources of large amounts of usable internal data that had become available during the project period that could be used for project purposes.

These changes to the original "buy and install" plans for the project resulted in a material reduction in expected cash contributions by project partners.

It also meant that less ARENA funding would be required for the "Buy and install" phase.

Using historical data in a real time Proof of Concept

The limited amount of near-real time data available to the project had been flagged since July 2021. The project team had developed the real time simulator and used it to process the real time data that was available to produce DOEs.

However, the project could not push all the available project data through these real-time systems and so a virtual real-time solution was developed. This system incorporated real-time data and historical data and fed it through the platform as if it was being received in real time. This enabled the project team to demonstrate that more accurate DOEs could be produced.

It was these final two issues centred on participant contributions and the real-time application of the solution that resulted in the project being placed on hold following the submission in December 2022.

Moving forward

Following ongoing discussions regarding these issues, it was agreed between the parties:

- To recognise the early procurement and other data as in-kind contribution and an agreement was reached on its value.
- To reduce the overall contributions of project partners.
- To reduce the funding commitment by ARENA.
- The use of the virtual simulator did in fact demonstrate that DOEs could be generated in real time if real time data was available. Furthermore, this could be made available by networks willing to contribute to the initial and ongoing costs of said data (i.e. they could use the system developed by negotiating and paying for ongoing real time access to the data that is currently measured on the low voltage network).

During the hiatus in the project, while these issues were considered, progress slowed dramatically and with less than eight months left in the project, most of the project's current staff sought to make alternate employment arrangements.

It became clear to the project team and to ARENA that re-establishing project capability would be both time consuming and costly. Further, there was a risk of losing the remaining project expertise if the project was not refocussed. Indeed, this was seen as a major risk to completing the project.

Accordingly, it was agreed that a cut-down version of the project should be developed and fast-tracked in order to deliver the core outcome of the project.

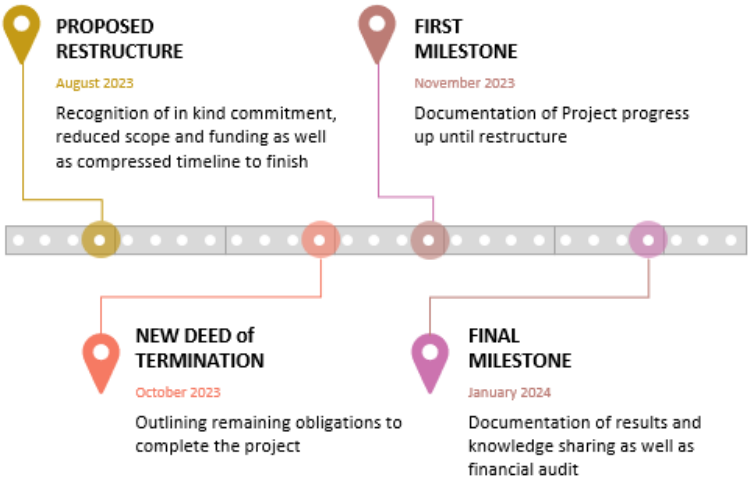

Figure 3: Timeline of project restructuring

The rescoped project

The original project sought to deliver five outputs

1. The Dynamic Operating Envelope solution
2. The Visibility Platform
3. The Business Case
4. The Data Capture Simulator
5. The Digital Observatory

The visibility platform had been delivered and demonstrated during Stage 1 (see Figure 3 below) and most of the work required to deliver Stage 2 of the Dynamic Operating Envelope Solution had been completed.

Figure 4: Luceo platform showing network visibility (Transformer with DOE)

More work was required to complete the Business Case, Simulator and Digital Observatory, and the resources working on these components were no longer working with the project making them the highest risk deliverables.

The Project team remained united in the view that the core value of this project was to demonstrate that incomplete heterogeneous data sets could be used to develop network visibility in timeframes that were appropriate for managing network limits (the dynamic operating envelope solution). With available resources, timing and reduced funding in mind, it was agreed that the lowest risk, highest value approach was to deliver this key component of the project.

That focus would be solely upon the generation of DOEs using heterogenous data sets. The data sets would comprise all the data used in Stage 1, the data devices installed early in the project for Stage 2, devices installed during Stage 2 and additional data provided in kind by partners for Stage 2.

This gave the project access to significant heterogenous data sets and a working platform to analyse the data.

As at 1 November 2023, the project team set about completing this work and recording the outcomes.

Definitions

AER	Australian Energy Regulator
AMI	Advanced Metering Infrastructure – an integrated system of smart meters, data management systems and communication networks that enable 2-way communication between the utilities and the customers
DER	Distributed Energy Resources – the name given to renewable-energy units or systems that are commonly located at houses or businesses to provide them with power. Includes rooftop solar PV units, battery storage, thermal energy storage, electric vehicles and chargers, smart meters and home energy management technologies.
DOE	A dynamic operating envelope is a principled allocation that maximises additional export (generation) and import (load) the network can accept at any one time without breaching any of the specified technical and operational limits.
DNSP	Distributed Network Service Providers – e.g. Energex, Ergon Energy Network, Essential Energy
EE	Essential Energy
EQ	Energy QLD Limited representing the networks or Energex and Ergon Energy
LV	Low Voltage
SCADA	Supervisory Control and Data Acquisition – a SCADA system gathers the data from various electrical componentry within an electricity network and correspondingly process it in order to aid monitoring and control of the network.
UQ	University of QLD