Energex

DMIAM Report 2022-23

September 2023

Part of Energy Queensland

Contents

1. Introduction

1.1 Purpose and Compliance

Energex is pleased to present the Demand Management Innovation Allowance Mechanism (DMIAM) Report for the 2022-23 regulatory year. The purpose of this report is to allow the Australian Energy Regulator (AER) to:

- assess Energex's 2022-23 DMIAM initiatives and entitlement to recover the expenditure under the AER's DMIAM; and
- confirm Energex's compliance with the annual reporting requirements of the AER's Regulatory Information Notice (RIN).

This report has been completed in accordance with Schedule 1, item 7 of the AER's RIN (refer Figure 1), which requires a distribution network service provider (DNSP) to which the DMIAM applies, to submit an annual report to the AER on its expenditure. This report, and the information contained in the report, is suitable for publication by the AER.

Figure 1: DMIAM reporting requirements Schedule 1: Item 7 – Demand Management Incentive Allowance Mechanism

7.1 Identify each demand management project or program for which Energex seeks approval.

7.2 For each demand management project or program identified in the response to paragraph 7.1:

a) Explain how it complies with project criteria detailed at section 2.2.1 of the Demand Management Innovation Allowance Mechanism

b) Submit a compliance report in accordance with section 2.3 of the Demand Management Innovation Allowance Mechanism

2.2.1 Project Criteria:

(1) An **eligible project** must:

(a) be a project or program for researching, developing or implementing **demand management** capability or capacity; and

(b) be innovative, in that the project or program:

i) is based on new or original concepts; or

ii) involves technology or techniques that differ from those previously implemented or used in the **relevant market**; or

iii) is focused on customers in a market segment that significantly differs from those previously targeted by implementations of the relevant technology, in relevant geographic or demographic characteristics that are likely to affect demand; and

(c) have the potential, if proved viable, to reduce long term network costs.

(2) A **distributor**'s costs of a project or program are not eligible for recovery under the **mechanism** if those costs are:

i) recoverable under any other jurisdictional incentive scheme;

ii) recoverable under any state or Australian Government scheme; or

iii) otherwise included in forecast capital expenditure or operating expenditure approved in the **distributor**'s distribution determination.

(3) For avoidance of doubt, the **mechanism** does not require a **distributor**'s **eligible project** to be geographically constrained to its **distribution network**.

2.3 Compliance Reporting

(3) Each compliance report must include, for the regulatory year to which the compliance report relates:

(a) the amount of the allowance spent by the distributor;

(b) a list and description of each eligible project on which the allowance was spent;

(c) a summary of how and why each eligible project complies with the project criteria;

(d) For each eligible project on which the allowance was spent, and in a form that is capable of being published separately for each individual eligible project, a project specific report that identifies and describes:

i) The nature and scope of the eligible project;

ii) The aims and expectations of the eligible project;

iii) How and why the eligible project complies with the project criteria;

iv) The distributor's implementation approach for the eligible project;

v) The distributor's outcome measurement and evaluation approach for the eligible project;

vi) The costs of the eligible project:

1. incurred by the distributor to date as at the end of that regulatory year;
2. incurred by the distributor in that regulatory year; and
3. expected to be incurred by the distributor in total over the duration of the eligible project.

vii) For ongoing eligible projects:

1. a summary of project activity to date;
2. an update of any material changes to the project in that regulatory year; and
3. reporting of collected results (where available).

viii) for eligible projects completed in that regulatory year:

1. reporting of the quantitative results of the project;
2. an analysis of the results; and
3. a description of how the results of the eligible project will inform future demand management projects, including any lessons learnt about what demand management projects or techniques (either generally or in specific circumstances) are unlikely to form technically or economically viable non-network options.

1.2 Demand Management Innovation Allowance Mechanism projects summary

In its Distribution Determination for the 2020-2025, the AER decided to apply the DMIAM to Energex, approving an innovation allowance amount of $5,582,165 over the 2020-25 regulatory control period.

The DMIAM is provided to investigate opportunities that are not yet commercial, in addition to any business-as-usual capital and operating expenditure allowances for demand management and embedded generation projects approved in Energex's Distribution Determination. This provides a direct incentive for DNSPs to assess emerging opportunities for potentially efficient non-network alternatives, to manage the expected demand for standard control services in some other way or to enable more efficient connection of embedded generation other than through network augmentation.

Energex's 2022-23 DMIAM program comprised five projects active during the year. The total cost incurred for the DMIAM initiatives during 2022-23 was $168,349.21. This total amount is exclusive of indirect costs (financial overhead and fleet on-cost). The table 1 below summarises the costs of eligible Energex DMIAM projects.

Table 1: DMIAM Eligible Project Costs ($)

DMIAM Project	The costs ($) of the eligible project[1]:			
	expected to be incurred in total over the duration of the eligible project	incurred in 2022-23 regulatory year	incurred to date[2] as at the end of the 2022-23 regulatory year	Status (as of 30 June 2023)
Carseldine Home Energy Management System (HEMS)	59,584	28,000.00	37,090.91	Continuing
Electric Vehicle Research	745,942	57,138.31	286,244.91	Closed
Dynamic Operating Envelope (DOE) Phase 1 Commercial	241,854	30,446.00	149,005.18	Continuing
Model Free Dynamic Operating Envelopes	141,849.50	48,750.25	48,750.25	Continuing
Development of an Aggregated Dynamic Model of Consumer Energy Resources Master	145,565	4,014.65	4,014.65	Continuing
Totals ($)	**1,334,794.50**	**168,349.21**	**525,105.90**	

Energex confirms that the costs of the projects specified in this report are:

- not recoverable under any jurisdictional incentive scheme
- not recoverable under any other Commonwealth or State Government scheme
- not included as part of:
  - the forecast Capital Expenditure or the forecast Operating Expenditure; or
  - any other incentive scheme applied by the 2020-25 Distribution Determination.

2. Demand Management Innovation Allowance Mechanism Project development and selection process

Energex considers DMIAM investments an important component of its commitment to delivering customer value over the longer term. The DMIAM program complements our demand management program, which is geared toward providing a more efficient solution to network augmentation. The DMIAM initiatives have enabled Energex to investigate and test innovative approaches to a range of network issues, customer behaviours, renewable integration and cost reflective tariffs which have the potential to reduce long term network expenditure.

[1] As per DMIAM reporting requirements Schedule 1: Item 7 –DMIAM section 2.3 (3) (vi) 1,2,3

[2] For the current 2020-25 regulatory period

For the 2022-23 DMIAM program, all nominated DMIAM projects are subject to a screening and feasibility processes, consistent with the AER's criteria. The standard DMIAM project development and assessment process applied in Energex involves:

- Promotion of DMIAM funding and criteria
  - Internal stakeholders: To encourage project ideas to be submitted, as an expression of interest (EOI) or more formal DMIAM Project Scope
  - External stakeholders: Through improved web presence to invite any interested parties to make contact
- Review of EOI or DMIAM Project Scope against DMIAM criteria as a minimum, and against relevant internal strategy documents, including the Future Grid Roadmap[3], the Demand Management Plan
- Project proponents are encouraged to discuss project ideas with other Energex subject matter experts, which helps guide and refine the idea
- Projects that are deemed to meet the DMIAM criteria are then formally submitted to the DMIAM Program Manager for approval, or endorsement to the appropriate financial delegate

Budgets are prepared in accordance with Energex standard project methodology, detailing information including project goals, deliverables, milestones and resources required. Cost estimations were developed for the requirements identified, for each phase of the project. These cost estimations drew upon various sources including the cost of similar projects undertaken by Energex, current preferred contractor panel contracts and market research.

[3] The Future Grid Roadmap is a document that outlines a range of themes and supporting activities and no-regret investments necessary for Energex to achieve a transition to the intelligent grid of the future over the next 10-20 years. It is not essential to meet criteria other than the stated DMIAM criteria, however project proponents within Energex should, where possible, ensure their project aligns with these existing Energex strategic network direction and priorities.

3. Demand Management Innovation Allowance Mechanism Project updates

This section of the report details the status of the Energex DMIAM projects in 2022-23 by describing each project, its objectives, progress and findings to date.

3.1 Carseldine Home Energy Management System

A program to rollout out Home Energy Management Systems (HEMS) throughout a new building housing development. The project aims to develop a model for best practice integration of consumer energy resources (CER) in new infill and master planned communities with learnings to be shared with the property sector.

3.1.1 Compliance with DMIAM Criteria

The Carseldine HEMS project was viewed as meeting the DMIAM criteria. The project pilots using developer-led customer acquired market-delivered demand response at a Queensland affordable housing greenfield site. Market-delivered demand response via third-party suppliers (i.e. where network procures from a 3rd party, customers' load and generation control) has the potential to significantly reduce the network's cost of acquisition of demand management.

3.1.2 Nature and Scope

The project involved partnering with Economic Development Queensland (EDQ) as the developer, who with assistance from Energex secured suitable supplier(s) of HEMS, that were included in the new build premises at their time of build.

Energex funding support is proportional to the load/generation under management. For every home in the development, the solar PV, battery, hot water and living space air conditioning are under HEMS management. A funding agreement between Energex and EDQ allocated a 50/50 share between the two parties for total HEMS install costs.

3.1.3 Aims and expected outcomes

This project enables Energex to find and trial solutions for mitigating constraints and network challenges associated with CER. Findings will inform better integration of CER in the future for new infill and greenfield property developments. It will also enable measurement and verification of demand response from greenfield residential developments with high saturation of CER.

3.1.4 The process by which it was selected, including its business case and consideration of any alternatives

Following the technical success of the previous DMIAM project Market Delivered Demand Response Pilot (MDDR) as a means of networks accessing third-party management of CER, the opportunity was to establish the cheapest and simplest pathway to customer participation. Greenfield residential development was seen as one pathway to achieve this opportunity.

Carseldine Village, a mixed-use residential project, being developed by EDQ, part of the Queensland Government, is pushing traditional electrical subdivision boundaries by delivering 196 terrace homes with 100% solar PV and battery within the Brisbane region to create low energy, low emission, comfortable homes over four stages commencing in 2020. The project aims to develop a model for best practice integration of CER in new infill and master planned communities with learnings to be shared with the property sector. The Carseldine Village project provides a perfect opportunity for Energex to have a clear view on the behaviour created from a high uptake of CER in a very localised area on the distribution network within the context of a broader energy system. Twenty-five (25) homes within the 56 home Stage 1 build will have access to a HEMS optimising the solar, battery, air-conditioning and hot water use.

3.1.5 How it was/is to be implemented

Due to COVID complications, the occupancy of the Stage 1 homes was delayed by 18 months. However, at end of financial year 2022-23 nearly all homes are occupied and HEMS installed. The finish date of the trial has been extended to end of June 2024 to enable collection of sufficient data on household energy consumption and demand.

3.1.6 Any identifiable benefits that have arisen from it, including any off peak or peak demand reductions

Data collection across the 25 participant cohort has commenced, but it is too early to derive any concrete learning or observations on baseline data until October 2024. Our next report will have some leading observations to report.

3.2 Electric Vehicle (EV SmartCharge Queensland) Research

A longitudinal program of monitoring EV charging primarily at customer residential properties.

3.2.1 Compliance with DMIAM Criteria

Through understanding of residential EV charging profiles and willingness to accept charging to be managed, Energex will be able to assess the value of demand management within the EV market.

By understanding charging profiles and behaviours and testing the control available to Energex and Ergon Energy networks, will further inform:

- how EVs can be managed effectively for network reliability and stability whilst also fulfilling a customer need for assurance of their charging requirements
- The value of EV load management for the network and customers in both a broad-based and targeted sense; and
- how the introduction of vehicle-to-home/grid may be optimised to best effect for the customer and the network.

Once EV charging profiles of residential customers is better understood, and trialling of load control of said vehicles illustrates the flexibility available in managing these charging profiles, so value propositions can be established that encourage either:

- behavioural and attitudinal changes to charging profiles that suit the network (generic primary tariff solutions)
- opportunities for third-party (aggregator) influence in managing charging profiles, or
- direct control by the DNSP of charging profile through load control tariffs.

3.2.2 Nature and Scope

Energex needed to better understand the charging patterns of residentially used EVs to mitigate potential risks and maximise opportunities that EVs present. The project involved recruiting customers with home garaged and charged EVs across Queensland to participate through agreeing to have a device installed in their vehicle that provided data to Energex, and the customer, on the use and charging habits. This data formed that basis of various analysis to be undertaken.

3.2.3 Aims and expected outcomes

The specific objectives of this research program were to understand the charging behaviour of EV owners to:

- provide charging profile data for Scenario Planning and Forecasting to assess the impact on Queensland networks and other EV-related purposes
- determine any policy issues and requirements regarding connection of private EV chargers and their ability to be managed
- inform requirements for any future EV specific data capture systems
- assess the necessity for possible EV low voltage (LV) network monitoring
- incorporate residential charging models to inform future planning of public charging station locations and network requirements for supply
- prepare for vehicle to home/grid EVs
- customer journey mapping to understand buying behaviour and likely spatial take-up using Energex new market segmentation
- better educate and communicate optimal options for best charging practices for customers and the network
- inform Energex on how EVs will influence future tariff requirements, and

3.2.4 The process by which it was selected, including its business case and consideration of any alternatives

There was no primary research undertaken in Australia to deliver actual charging profiles of residential EVs across a wide model range, their geographic location, potential charging capacity, and the availability of renewables at home.

Through DMIAM funding this project allowed Energex to understand charging profiles and the behaviours of EV customers. Testing the control available to Energex has provided bench marked data, informed how existing connection processes may need to be modified to improve customer and network outcomes and provided evidence and direction on what energy management options are available to optimise network and customer outcomes.

The standard DMIAM process was adhered to in seeking funding to support this project. A formal business case was developed; alternative considerations were identified, including attitudinal research on how EV owners expect to charge their EV's as well as modelling of internal combustion engine vehicles as a proxy for EV driving and charging data.

Both were eliminated given less reliable and less accurate data as well as only being informative at a static point in time. Additionally, these considerations were limited by lack of customer knowledge of their EV charging, and their intention not matching actual activity.

Real charging data also allows confirmation of assumptions around charging of an EV and importantly the peak demand generated and associated load profile analysis. Internal combustion engine and EV usage patterns are assumed to be different, and this project will allow confirmation of same.

3.2.5 How it was/is to be implemented

The program was provisionally planned for a period of three years but closed at the end of August 2022. Geotab, our program partner was refocussing their efforts on fleet programs and ceased supporting any residential focussed programs. Whilst this was unfortunate, the 19 months of trip and charging data captured has provided significant knowledge and insights of early EV adoption.

Stage 1 (Recruitment & Data Baseline): The program launched at the end of May 2020. After the recruitment phase, as 30 June 2021, 197 participants commenced in the program. As at the end of July 2022 there were 167 participants. Small financial incentives of $100 for sign-on were provided to entice participant involvement in addition to access to individual portal dashboards for participants. All channels to market embraced the program well particularly during the participant recruitment phase and have been proactive in promotion to constituent or member bases.

Participant sub segment user groups were identified and targeted during recruitment phase considering:

- EV details – make/model, model year, max charge rate, registration, purchase date
- Vehicle size and categorisation- Battery EV small/large or plug in hybrid electric vehicle (PHEV)
- Geography- urban, regional and rural
- Electrical connection type & tariff connected to, retailer association
- Charge method
- Dwelling type- detached house, apartment, townhouse
- Integration of solar and battery energy storage systems (BESS)

A small sample of fleet vehicles were included within the participant base to supplement residential findings of EV driving and charging behaviour. Participants needed to have EVs registered in Queensland and be connected to the Energex distribution network. Energex purchased ‘plug and play’ C2 devices in bulk upfront from Geotab and facilitated the participant pre-registration process. Each participant received a C2, 3G connected car device from Energex that monitored their driving and charging data. Some initial teething issues were experienced and data cleansing was undertaken to ensure validity of the data. Energex received raw data files in addition to access to its own utility dashboard. Some definitions and modifications to data sets were made to ensure usefulness of data going forward for respective internal audiences and external stakeholders.

Stage 2 (Baseline & Control): mid 2021 – mid 2022 original planned program timing but program ended August 2022 as indicated.

A behavioural study was also completed in March/April 2022 to understand the opportunity to incentivise participants to change their charging behaviour around peak times (4-9pm) and during the day to assist with solar soak. A total of 14 events were conducted in total consisting of either ‘charge your EV’ or ‘do not charge your EV’.

Sixty participants were involved in the study and received event notifications via SMS. Events were called at different times of the week and weekend with different durations and incentive amounts. A capped threshold of $150 in total per participant was introduced with greater than 90% of participants reaching the maximum amount. Participants were overwhelmingly positive about their involvement and the ease with which to participate and it did not interrupt their day-to-day lifestyle. Being early adopters highlighted the potential for managed charging going forward. The key determination is the extent to which managed charging can extend to the mass market.

3.2.6 Any identifiable benefits that have arisen from it, including any off peak or peak demand reductions

Benefits from this program include identification and understanding measurable uncontrolled and controlled charging behaviour of private EV (car) owners. This has assisted Energex with planning, forecasting, demand management of EV loads. It also helped support and determine any policy issues regarding connection of private EV chargers. It is critical to understand how EV usage and charging behaviour will alter over time as owners become more confident with their EV range, speed of charging and access to suitable public charging. Collated data will also be used to validate the potential for public destination (fast) and travel (ultra-fast) charging station installations for third-party, commercial charging operatives.

A number of use cases to satisfy were developed, including:

- Energy use whilst charging:
  - Level of charge – home vs public (impact of housing type e.g. apartment dwellers)
  - Energy and Diversified Demand profiles (impact of charger type/connection for network diversity)
  - Type of EV – residential BEV focus
  - Renewable impact – solar vs solar/BESS vs non solar
  - Energy losses (at time of charge and battery deterioration over time)
- When does charging occur:
  - Time of day: solar soak option, peak demand management, weekday vs weekend
- Influence on charging behaviours
  - Battery state of charge (minimum and maximum) and state of health analysis
  - Seasonal impacts and peak day analysis
  - Tariffs
  - Length of ownership (more trips, longer trips, eased range anxiety etc.)

Some findings amongst this small cohort include:

- Across all EV categories (BEV large/small and PHEV) approximately 8kWh per day plug in charging of average commute of 40km daily
- 10.5% of EV participants let their battery discharge to 20% or below, before recharging
- 25% of charging occurs when the battery is at least 80% State of Charge (significant 'top-up" charging)
- 39% of BEV charging sessions end at 80% State of Charge, 21% to full (battery protection)
- Almost 39% of participants do not exercise any control when their EV charges (e.g. timers, tariffs, soft controls);
- Charging losses are just 10% but when State of Charge reaches 90% losses jump to almost 20%;
- Higher middle of the day home charging profiles highlighted a desire to self-consume solar rather than exporting to the network
- Conveniently timed charging for PHEV and smaller EVs is common during the evening period
- Weekday and weekend charging is generally consistent although we found a higher daily average charge on weekends during the middle of the day
- Early adopters demonstrate the influence tariffs can have with some charging peaks around 1am associated with some retail tariffs
- Time of use tariffs, particularly for Level 2 charging and timers heavily influence charging behaviour
- EV's battery 'whole of life' is best extended by avoiding charging it to 100% regularly.

- The additional average diversified evening demand (4-9pm) from EV charging was 0.25kW, but this tripled to 0.75kW (a significant demand growth) when observing the single highest diversified demand day for EV charging during these hours.

Full report is available on the Energex website: [EV insights - Energex]

3.3 Dynamic Operating Envelopes Phase 1 Commercial

This project is part of a broader Dynamic Operating Envelope (DOE) Program designed to explore the merits, challenges and financial viability of the concept of DOEs as applied to small to mid-sized (10kVA - 1500kVA) CER (consumer energy resource). A DOE defines a range of values for CER export/import to/from the grid such that the network's technical and operational limits are not breached. DOEs will play an important role in supporting dynamic customer connections to manage CER at scale such that the CER is able to provide benefits to customers, the network and the wider market without posing a risk to the operation of the network.

Phase 1 of the program trials the concept at five Energex owned and operated depots.

3.3.1 Compliance with DMIAM Criteria

Having a mechanism to allow a greater penetration of CER into the network through the implementation of DOEs will assist in alleviating demand. The typical PV connection process assesses a new application based on a worst-case scenario assuming full export from all existing systems at a time of minimum load. A system assessed as "Nil" export cannot export at any time, even under times of high network load. The DOE concept also applies to managing EV or BESS charging to reduce demand when the network is constrained.

3.3.2 Nature and Scope

DOE Phase 1 is focussed on trialling the concept at a commercial level targeting three phase 30kVA-100kVA LV connected systems typical of small-medium commercial or industrial establishments. This work extends the initial implementation at Energex's Cleveland Depot by transitioning beyond the one-way broadcast concept to a two-way communications approach. DOE-enabled PV systems have been installed at five sites with a DOE management platform, a robust and secure operational platform developed to support the necessary data capture, processing and publishing of operating envelopes, implemented in the network businesses' operational technology environment.

3.3.3 Aims and expected outcomes

The DOE Program has the following key objectives:

- Demonstrate as a proof of concept the data, communication and controls required for DOEs to be implemented in near real-time at commercial sites as applied to PV and any available BESS or EVs.
- Evaluate the effectiveness of DOEs as applied to sources of generation and chargeable loads.
- Evaluate the impacts of variations in the DOE on other customers connected to the same LV and medium voltage (MV) feeder on which the DOE is being trialled. Ensure DOE management does not negatively impact other customers as a result of the dynamic nature of the control.
- Evaluate the effectiveness of Institute of Electrical and Electronics Engineers (IEEE) 2030.5 in implementing Dynamic Operating Envelopes.
- Initiate amendments to standards and connection contracts to facilitate the offering of DOE for embedded generation (≤1500kVA) at a broader scale in the Energex and Ergon Energy Networks.

3.3.4 The process by which it was selected, including its business case and consideration of any alternatives

The business case for the project was reviewed against the DMIAM criteria and was deemed to meet the DMIAM criteria and costs confirmed to be not in any way recoverable from another source. The business cases were presented to the Energex Investment Review Committee which endorsed the projects for DMIAM funding. The project was evaluated against the business' Opportunity Matrix and identified as being an innovative venture with high opportunity potential.

3.3.5 How it was/is to be implemented

The final stage of the project is underway. This work will upgrade the existing DOE interface at each of the depots to the newly developed Smart Energy Profile 2.0 (SEP2) compliant gateway which is a requirement of the new Energex Dynamic Connection standard. The existing Application Programming Interface (API) approach was adequate for a rapid deployment but not suitable to support large numbers of connected customers. The gateway will allow standardised communication between the site and the network's SEP2 utility server. The depots will then be transferred to dynamic connection agreements and be managed in the same way as other dynamic connections in Queensland.

Image: Cleveland Depot Dynamic Solar PV Installation

3.3.6 Any identifiable benefits that have arisen from it, including any off peak or peak demand reductions

The solar generation available at each site is offsetting most of the typical energy requirements throughout the day with four of the five DOE-enabled sites exporting surplus generation to the grid. The business' standard PV connection assessment process was used to evaluate the connection of all five systems. Two systems were evaluated as partial and Nil export, due to the risk of problems on the network at critical times that aligned with minimum network load and 100% export from existing connected systems. Detailed network modelling based on real time telemetry has shown that there is sufficient surplus capacity for the network to host additional export from these two depots much of the time.

3.4 Model Free Dynamic Operating Envelopes

This project is part of a broader DOE Program. It is focused on exploring alternative methods for determining DOE without any network model data, leveraging available LV visibility from Network Service Monitors and procured smart meter data. A DOE specifies a varying operating range at the connection point for exports and/or imports within the operational limits of the network. DOEs will play an important role in supporting ongoing uptake of CER by enabling dynamic CER connections at scale to provide benefits to customers and the wider market while mitigating risks to the operation of the network.

3.4.1 Compliance with DMIAM Criteria

The project was viewed as meeting the DMIAM criteria by developing a method for determining more optimal DOE in parts of the network, particularly the LV, where network model data is poor which can reduce the degree of curtailment in comparison to more conservative alternatives – zero (ZOE), fixed (FOE) or scheduled (SchOE) operating envelopes for example. DOEs can also be applied to flexible loads such as EV chargers reducing the need to restrict charging to times when the network is truly approaching constraints rather than on a more frequent (eg. SchOE) or constant (eg. FOE) basis. Improving DOE performance enables demand and generation management with the lowest impact possible without further network augmentation.

DOEs maximise utilisation within existing network capacity only driving augmentation when excessive/unacceptable curtailment or load reduction is caused. A model free DOE can generate a more optimised DOE on networks with poor model quality (such as LV). It leverages available network visibility and machine learning based methodology via Software as a Service, to determine DOE in a new innovative way, potentially reducing DOE implementation costs.

3.4.2 Nature and Scope

This Project has two stages, the first focuses on three LV networks with high PV penetrations (60% - 120% of transformer rating) that also have moderate coverage of Network Service Monitors or procured smart meter data to provide LV visibility. The second extends the focus to the rest of the MV network the stage one LV networks are supplied from and all other LV networks with some monitoring. In the second stage near real time closed loop performance of DOEs will also be tested from different LV visibility sources and the performance will be compared with other methods for generating DOE such as a basic calculated methodology and a capacity constrained optimisation.

3.4.3 Aims and expected outcomes

The purpose of this project is to develop and demonstrate a new DOE generation engine that determines DOEs based on customer and network monitoring but independent of network model or topology. The project has the following objectives:

- Demonstrate generation of DOE based on machine learning (ML) using LV and MV telemetry
- Compare model free DOE with other DOE determination approaches in terms of curtailment and computational requirements
- Identify minimum data requirements to generate a model free DOE that reliably outperforms basic DOE

Figure 2: Model Free DOE platform (source Gridsight, 2023)

3.4.4 The process by which it was selected, including its business case and consideration of any alternatives

The DMIAM project approval process was followed for selecting this project (Model Free DOE). Potential DMIAM projects are selected and scoped to respond to current and emerging network limitation drivers and adhere to the standard governance framework. Accordingly, once projects are identified and nominated, the eligibility-screening process is performed on nominated projects as a high-level assessment, to determine whether the projects meet the DMIAM criteria. Other internal criteria are then assessed – including how the findings of the project, should it be successful, could be applied within the business. Provided all the specified conditions are met, then the project proceeds to the feasibility assessment and approval stages, as per a gated governance framework and with internal subject matter expert review and feedback. Information from the development activities undertaken enables implementation scheduling, milestone planning and confirmation of resources.

3.4.5 How it was/is to be implemented

Transformer and anonymised LV telemetry data has been uploaded to the Model Free DOE for key months in Spring (peak export) and summer (maximum demand) to enable training of the system. The platform, shown in Figure 2 is now estimating accurate voltages for the networks it has been trained on, without a network model or LV connectivity as shown in Figure 3 for a specific site and Table 1 for one of the modelled LV networks.

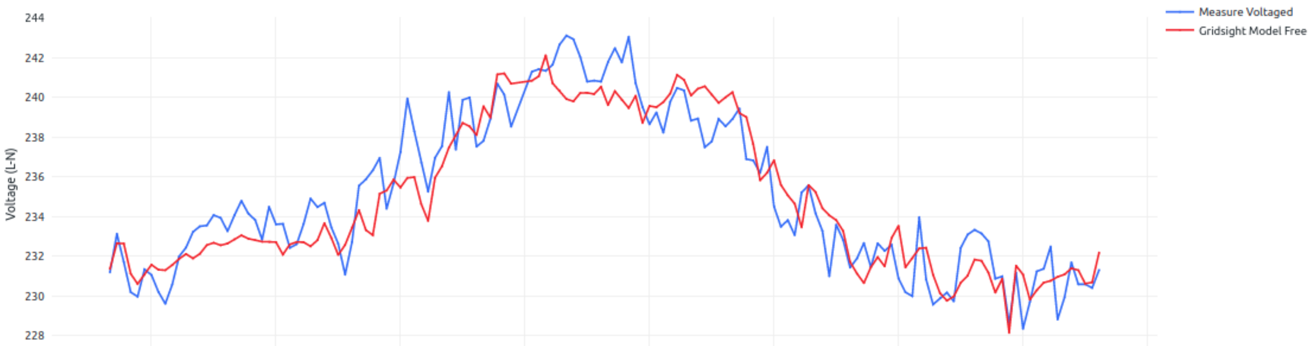

Figure 3: Example of LV network voltage estimation compared with measurement

DOE determination and curtailment has been simulated on the small number of sites where specified limits were exceeded as shown in Figures 4 and 5. 248V was used to induce a response as this LV network did not experience voltages in excess of the 253V limit.

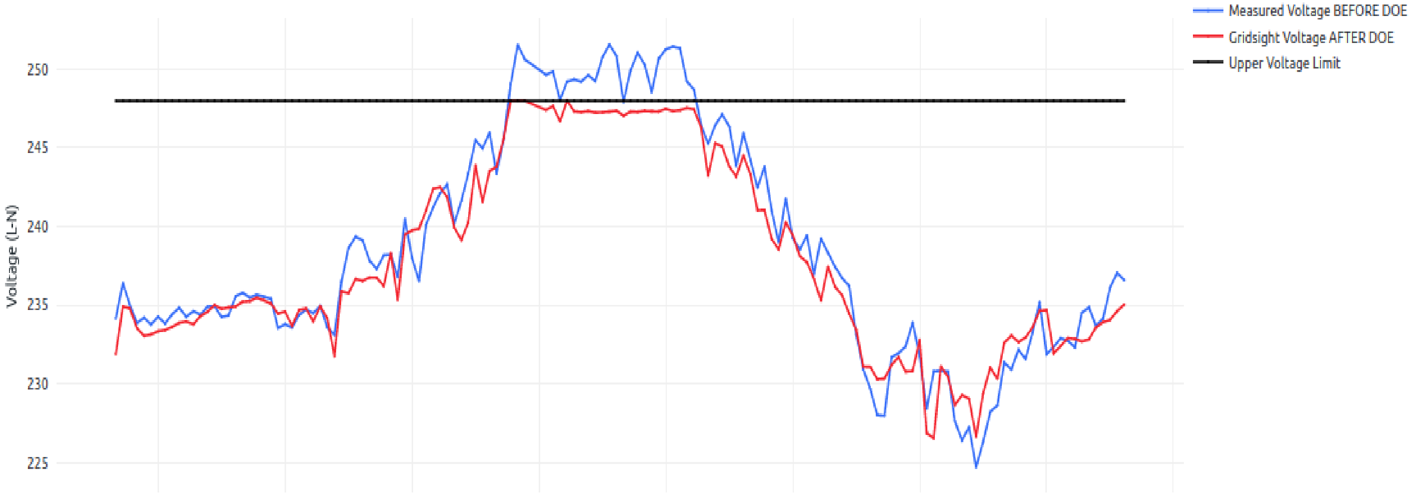

Figure 4: The modelled reduction in voltage from a DOE intended to limit voltage to 248V

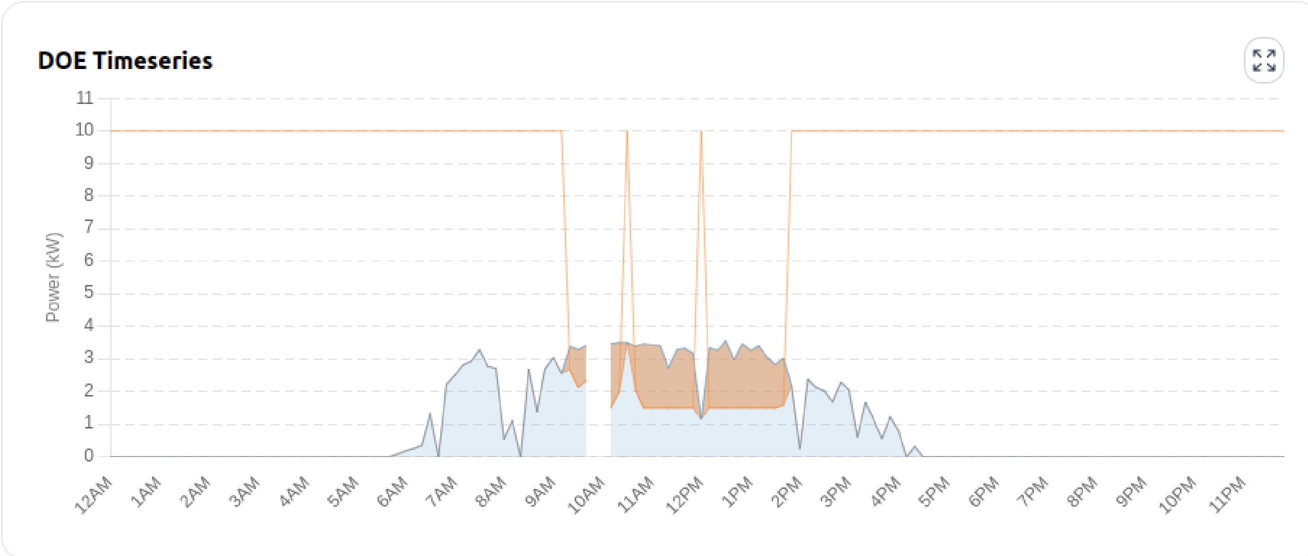

Figure 5: The DOE determined at a site to limit voltage to 248V by restricting export

Both equitable and a more optimal individual DOE have been generated with substantially higher curtailment resulting from an equitable allocation method as shown in Table 2. It also shows the expected reduction in the 99th percentile voltage (V99%) from the DOE and the max and root mean square error (RMSE) of voltage estimated for all monitored sites.

Allocation Method	Total Energy Curtailed (kWh)	Total Energy Released (kWh)	Average % Time < Max DOE	Max V99% Before	Max V99% After	RMSE (V)	Max Error (V)
Individual	96.1	2260.6	0.4%	250.1	248.0	1.28	6.0
Equitable	203.1	2154.4	2.88%	250.1	248.0		

Table 2: The performance of a simulated Model Free DOE on an LV network with two allocation methods

The next step is automating data transfer and closing the loop to publish DOE in real time and observing performance.

3.4.6 Any identifiable benefits that have arisen from it, including any off peak or peak demand reductions

The Model Free DOE approach has different pros and cons compared with other methods for DOE generation. It holds promise on networks with poor network model data but high grid visibility such as LV networks with smart meters reporting data in near real time or significant penetrations of dynamic connections that can provide near real time telemetry. This has the potential to increase network utilisation and only curtail distributed supply or demand when the network is constrained during minimum or maximum demand.

3.5 Development of Aggregated Dynamic Model Consumer Energy Resources Master

The purpose of this project is to develop an aggregated dynamic model of distribution networks with CER such as solar PVs, batteries, and electric vehicles, to be used in enhanced modelling of the whole electrical grid for the future stability studies and network capacity assessment to host all combination of renewable energy resources.

3.5.1 Compliance with DMIAM Criteria

The project meets the DMIAM criteria in terms of providing the initial research and development of demand management capabilities, is innovative and has the potential to reduce long term costs.

This project will develop individual / aggregate models & planning techniques required to identify stability constraints and develop processes for evaluating solutions to understand the effectiveness of various network & non-network solutions.

Electromagnetic transient (EMT) models for LV connected Inverter Based Renewables (IBR) and verified aggregation techniques, for the purposes of assessing system strength impact, do not exist today. Therefore, the proposed project is both new and innovative.

The outcomes of this research project would lead to a reduction in effort and costs that would otherwise be borne by both networks and others. The developed aggregation techniques will be simpler and less costly than modelling individual IBR models and the complex and high volume of low voltage networks they are connected to.

3.5.2 Nature and Scope

This preliminary research study will develop an aggregated dynamic model of distribution networks with consumer energy resources connected at Low Voltage (LV). Once these models are developed, the focus will then be on identify processes to integrate LV CER models into existing Energy Queensland models and forecasts so that these systems can be considered in the overall Demand Management, CER Management & Network Connections Processes.

3.5.3 Aims and expected outcomes

- Literature review report
- A power systems computer aided design (PSCAD) model of single-phase CER
- Final PSCAD model of single-phase CER
- Report on dynamic behaviour of two CERs with mathematical analysis

- Report on dynamic behaviour of CERs collectively
- Aggregated model of CERs on a feeder case study in PSCAD
- Final report with developed models
- Processes & tools developed for integrating PSCAD CER models into existing DEM, CER Management & Network Connections processes

3.5.4 The process by which it was selected, including its business case and consideration of any alternatives

The DMIAM project approval process was followed for selecting this project (Development of Aggregated Dynamic Model Consumer Energy Resources Master). Potential DMIAM projects are selected and scoped to respond to current and emerging network limitation drivers and adhere to the standard governance framework. Accordingly, once projects are identified and nominated, the eligibility-screening process is performed on nominated projects as a high-level assessment, to determine whether the projects meet the DMIAM criteria. Other internal criteria are then assessed – including how the findings of the project, should it be successful, could be applied within the business. Provided all the specified conditions are met, then the project proceeds to the feasibility assessment and approval stages, as per a gated governance framework and with internal subject matter expert review and feedback. Information from the development activities undertaken enables implementation scheduling, milestone planning and confirmation of resources.

3.5.5 How it was/is to be implemented

This project will be delivered by a joint research team across Deakin and Monash University. The universities will provide in-kind support via Senior Professors to supervise, guide and project manage the project delivery by dedicated researchers. The industry partners across Energy Queensland, Powerlink Queensland and Australian Energy Market Operator will provide cash contributions to support the acquisition of the two dedicated research fellows. The project will also be supported by C4NET who will provide additional cash contributions and in-kind contributions for project management and administration.

The project has just commenced with all parties recently agreeing on the scope of work and support.

3.5.6 Any identifiable benefits that have arisen from it, including any off peak or peak demand reductions

The project has just commenced with all parties recently agreeing on the scope of work and support. The key benefit of the scoping process to date has been to clearly identify the common priorities and benefits for the distribution network service provider, the transmission network service provider and the system operator.