DEIP

DISTRIBUTED ENERGY INTEGRATION PROGRAM

EV AND DER MARKET INTEGRATION DEIP DIVE

Marie Reay Teaching Centre ANU, Canberra ACT

12 September 2022

Australian National University

Battery Storage and Grid Integration Program

An initiative of The Australian National University

Australian Government

Australian Renewable Energy Agency

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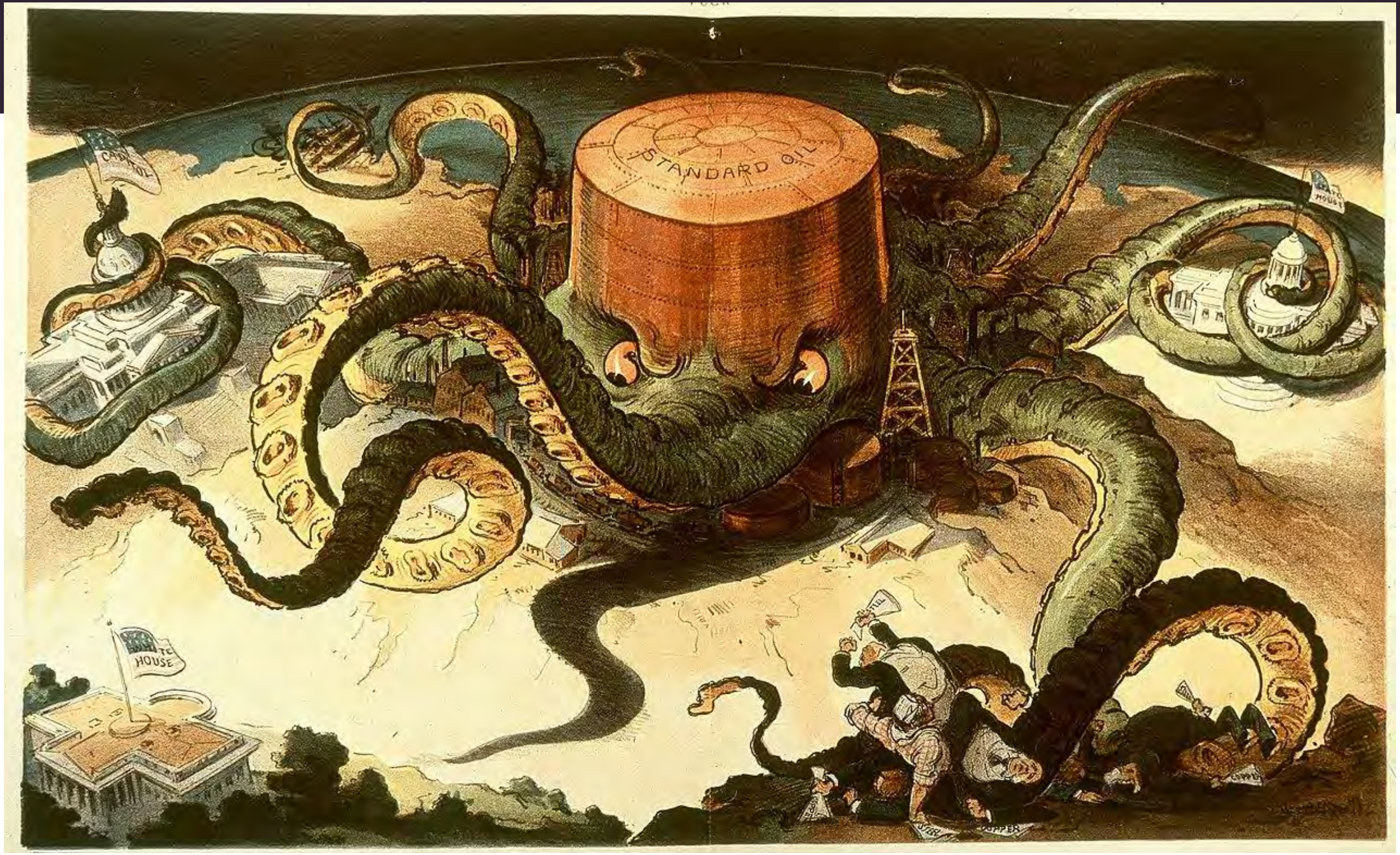
What is ‘social’ about the energy transition?

Hedda Ransan-Cooper

Battery Storage and Grid Integration Program

The Australian National University



1904 depiction of an acquisitive and influential energy company (Standard Oil) as an all powerful octopus

For an effective transition we need to:

- Understand contestation and conflict
- Anticipate issues/barriers
- Meet public expectations and deliver public benefit

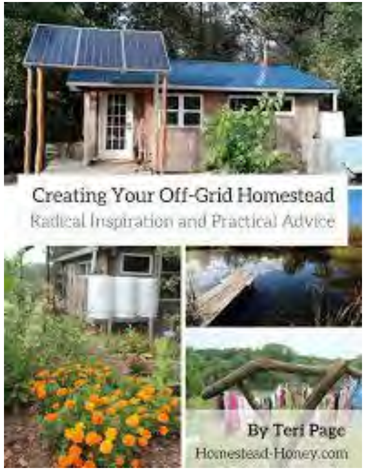
Sociotechnical imaginaries

Meme generated by
Kat Lucas-Healey

"Collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Sheila Jasanoff 2015)

Three Sociotechnical imaginaries for DER integration

Swarm



Individual
Autarky

Local autarky

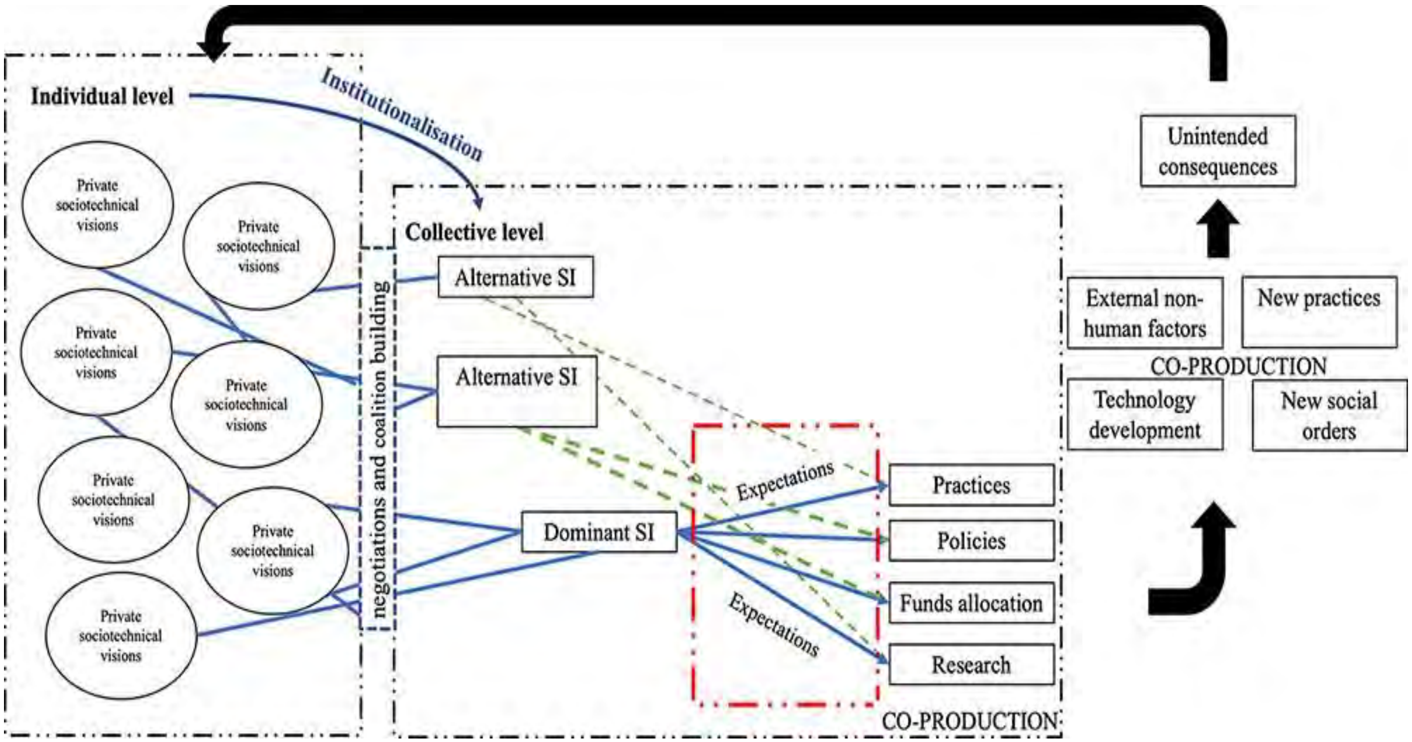


Diagram taken from: Rudek, Tadeusz Józef. 2022. “Capturing the Invisible. Sociotechnical Imaginaries of Energy. The Critical Overview.” Science and Public Policy 49(2):219–45. doi: 10.1093/scipol/scab076.

Key questions

- What assumptions about the public underlies each imaginary?
- What are the potential distributional impacts? [who is being left out?]
- What different roles would people, businesses government etc need to take on to make this energy future transpire? What capacities are missing?

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EV Grid Integration

EXAMINING GRID INTEGRATION IN A HIGH EV WORLD

Session One
Stream One

L2 Charging Data Key Insights – Knowledge Sharing

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Agenda

- Project Background
- Trial Context
  - Project Summaries
  - Data Available
  - Participant Characterisation
- Key Insights
  - Unmanaged Charging
  - Smart Charging by Trial

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Executive Summary – Key Learnings to Date

- **Unmanaged Charging Patterns – Trial participants tend to avoid charging patterns which negatively impact the grid**
    - The average driver charged 4-5 kWh per day
    - Battery Electric Vehicle (BEV) customers typically charge overnight, did not exhibit behaviour of charging immediately when they arrive home, during typical system peak hours of (3-9pm)
    - Customers with rooftop solar panels coordinate charging during solar hours
    - Regional customers have larger charging load requirements than urban dwellers
    - Note large parts of the unmanaged control period were during COVID lockdowns

- **Smart Charging Impacts – EV charging load is highly flexible and responsive to incentives, both to shed demand during system peaks and shift demand to off-peak periods, overnight and during solar hours**
    - Consistent price signals to customers result in significant voluntary charging behaviour changes on a daily basis, even with only a modest bill discount
    - Opt-out behaviour remain low amongst all trials during controlled charging events
    - Controlled limiting of charging during smart charging events result in higher off peak demand immediately after for evening peak event, less evident for morning peak event
    - Fixed incentives that require participation to provide demand response may have adverse consequences in mass-market

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Background

Projects

Knowledge Sharing

Key Questions

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ARENA's EV Projects Included in this Insight

Year Commenced	Project Name	ARENA Funding	State	Lead Organisation	Summary
2020	Electric Vehicle Orchestration Trial	$2.9m	NSW, QLD, VIC, SA	agl	Demonstrate a range of smart and managed charging solutions including controlled, smart and vehicle-to-grid charging
2021	Dynamic Electric Vehicle Charging Trial	$1.6m	ACT, VIC, TAS	EVGRID	Demonstrate the use of hardware based smart charging directed by signals from networks as opposed to electricity retailers
2020	Electric Vehicles Smart Charging Trial	$0.8m	ACT, NSW, QLD, SA, VIC	origin	Demonstrate the benefits of and barriers to controlled smart charging for residential, commercial and industrial customers

Source: ARENA

- ARENA has funded a wide range of EV projects to support the uptake of renewable energy
- Data from the above projects have fed into this analysis
- All projects have targeted insights into behind-the-meter L2 charging and the potential for various forms of load control

The Role of the Knowledge Sharing Partner

- The ARENA Act specifies Knowledge Sharing as a function of ARENA and requires ARENA to:
  - Store and share information and knowledge about renewable energy technologies;
  - Collect, analyse, interpret and disseminate information and knowledge relating to renewable energy technologies and projects; and
  - Promote the sharing of information and knowledge about renewable energy technologies.
- Energeia, as ARENA's knowledge sharing partner for its EV portfolio, provides services including:
  - Reviewing current data arrangements from existing portfolios to maximise their value.
  - Ensuring that the data requirements in future EV funding agreements can provide valuable insights for the EV portfolio.
  - Coordinating data collection and storage for the whole EV portfolio.
  - *Analysing data collected through individual projects to provide aggregated insights on charging performance, customer behaviour and value.*
  - *Producing aggregated insights and key themes emerging from the data in a form that is digestible and relevant to the industry*

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Key Stakeholder Questions about L2 Charging

Unmanaged Charging

- How charging varies by:
  - Day type
  - Season
  - Customer Class
  - Vehicle Type
  - Location
  - Charger Power

Response to Smart[1] Charging

- How response varies by:
  - Incentives
  - Frequency
  - Customer Class
  - Vehicle Type
  - Location
  - Charger Power
- Level of opt-out
- Level of technical issues

Notes: [1] Charging managed by a third party driven by real-time data

Trial Context

Project Summaries

Data Available

Participant Characterisation

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Project Summaries

Summary of Charging Trials

Trial Component	Method	agl	EVGRID	origin
Treatments Assessed	Grid Peak Management	Fixed (varies by state) and dynamic	Dynamic[1]	Fixed (3-9pm)
	Grid Off-Peak Management	×	Dynamic[2]	Fixed (10am - 3 pm, 9pm - 5am)
Method of Management	Incentive	Fixed ($/day)	Fixed[3]	Time of Use
	Charging Control	✓	✓	✓
Key Control Terms	Dynamic Notification Period	Day(s) Ahead	Day(s) Ahead	×
	Dynamic Events per Year	Unlimited	10	×
	Control Opt-out	Unlimited via app	Manual, Once per Customer	Unlimited via app
Reward / Incentive for Participation	Charger and Installation	Free charger and standard installation	Free charger and standard installation	$1 charger and standard installation
	Bill Discount	Up to $200 each year + Carbon Neutral Energy Plan	×	10c/kWh for off-peak charging 25c/day for smart charging
	Monetary Bonus	×	$300 cash bonus on trial completion	×

Notes: [1] One ad-hoc events to date, [2] Two ad-hoc events to date, [3] Existing trial utilised fixed incentive, EV Grid to trial variable charging rates for customers

- Dynamic charging refers to the hours of an event being flexible, with customer notified beforehand
- All three providers offered participants a free charger with installation
- All trials allowed customers to override any charger control

Data Received

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Data Received – Key Customer Characteristics

Provider		Meter Data	Charge Detail Records (CDRs)	Available Participant Characteristics										
				State	Postcode	EV Make	EV Model	Annual km Driven	DNSP	Charger Power	Charger Model	Rooftop Solar?	Battery Storage?	Existing Charger?
Origin	From:	Jun-20	May-20	✓	✓	✓	✓		✓	kW				
	To:	Jun-22	Jun-22											
EV Grid	From:	Jul-21	Jan-18	✓	✓	✓	✓	✓	✓	Amps		✓	✓	✓
	To:	Jul-22	Jul-22											
AGL	From:	Oct-21	Jan-22	✓						kW	✓			
	To:	Jul-22	Jul-22											

Source: AGL, EV Grid, Origin

- All 3 trials provided data on location of participants and installed chargers
- EV Grid provided additional data including:
  - Distance travelled per year
  - Existing DER installed by customers
- AGL provided additional data including:
  - Charger type

Data Received – Participants and Observations

Summary of Customers, Charging and Control Events

Summary	AGL	Origin	EV Grid
Participant IDs in participant data	193	151	171
Participant IDs in meter data	183	144	165
Participant IDs in Charge Detail Records	182	155	166
Participant IDs All Datasets	**182**	**144**	**165**
Total Charge Detail Records (CDRs)	27,086	22,186	15,297
Smart Charging Event Days	143	146	3

Source: AGL, EV Grid, Origin

- Each provider has provided participants based on trial sign-ups to date
- A Charge Detail Record (CDR) is a record produced after each charging transaction and includes information pertinent to billing such as time, duration and energy
    - There may be multiple CDRs per day for a given location
- Trials have a high data collection rate from active participants
- This data represents the data collected to date, complete data for all trials is anticipated to be available by early 2023
- It is important to note that the EV Grid is only planning to trial 10 smart charging events per year

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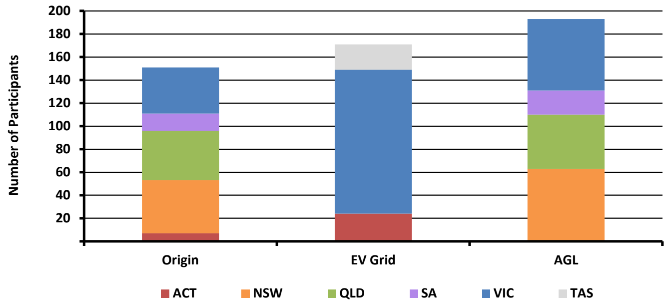
Participant Characteristics

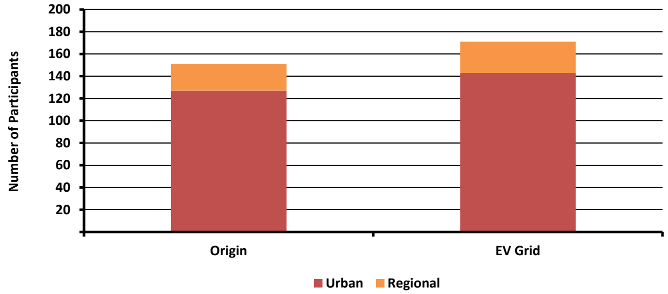
Participants Involved by Location

Participants by State and Provider



Source: AGL, EV Grid, Origin

Participants by Location and Provider



Source: EV Grid, Origin, Energeia

- Each provider is conducting their trials in different states:
  - AGL – QLD, NSW, SA, VIC
  - Origin – QLD, NSW, SA, VIC, ACT
  - EV Grid – VIC, ACT, TAS
- Origin has broken down their participants by residential and business customers:
  - 87 participants were residential; and
  - 64 participants were business
- Vast majority of trial participants to date were from capital cities

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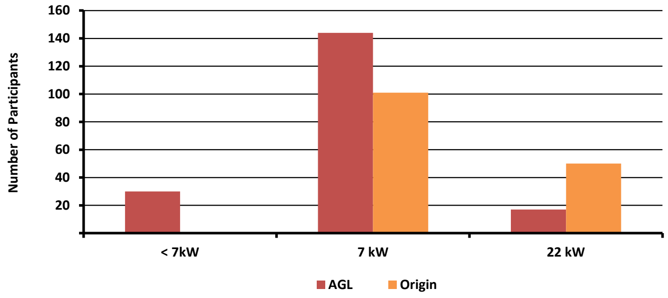
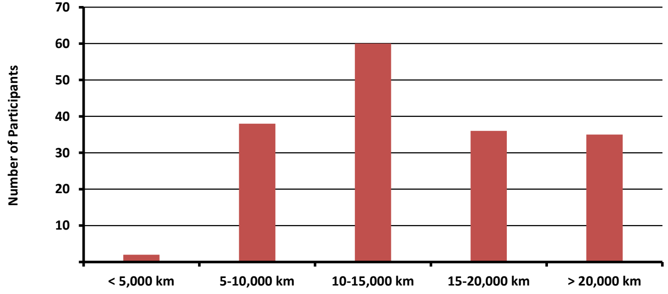
Charger Power and Customer Driving Distances

Level 2 - Charging Power



Source: AGL, Origin, Note: All EV Grid customers were given 7 kW chargers

Annual Distance Travelled



Source: EV Grid

- Data available to further investigate the link between customer characteristics and behaviour
  - Charging power
  - Annual driving distance
  - Vehicle make (i.e. battery / range)
  - Urban and Regional
- Majority of customers used a 7 kW charger, 90% of 22 kW chargers in Origin trial belong to business customers
- Distance travelled is self-reported, however majority 10-15,000 km/p.a., around AU passenger vehicle average

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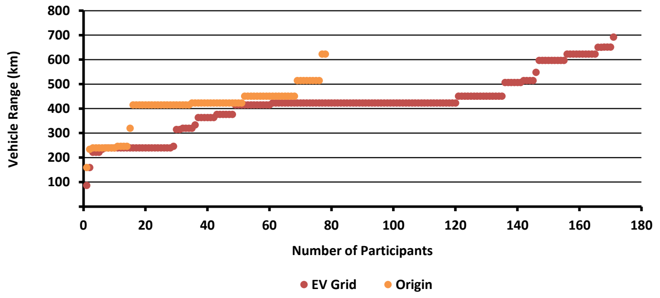
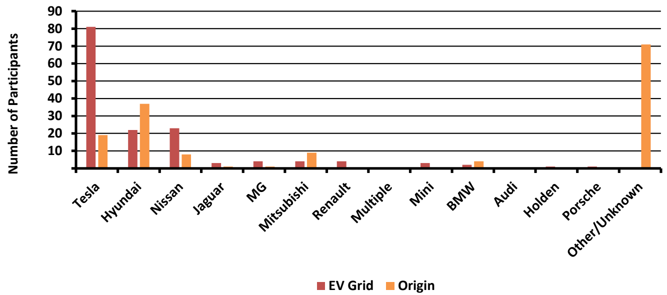
Vehicle Range and OEM

Vehicle Range



Source: Origin, EV Grid, Energeia, Note: Where vehicle model is known for origin

Vehicle OEM



Source: Origin, EV Grid

- Most vehicles trialled fell within the 400-500 km battery range, reflects the most popular models
  - Tesla Model 3 and X
  - Hyundai Kona and Ioniq
- Nissan Leaf also a popular choice, despite lower range
- Energeia investigation found no strong correlation between location of driver and vehicle range from trials

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Key Insights

Unmanaged Charging

Smart Charging

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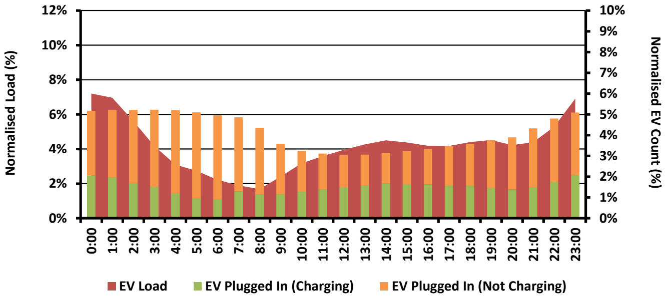
Unmanaged Charging

Average Unmanaged Hourly Charging Load Shape by Trial

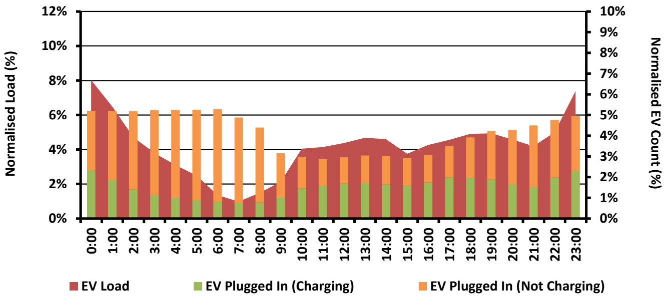
AGL



Source: AGL, Note: 173 customers

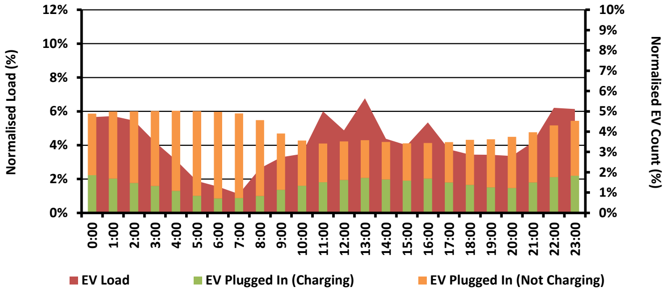
- Load normalisation on a kWh/day, count normalisation on total plug-ins/day
- Load increased when customers plug-in overnight, and is lowest in morning
- Increase in charging load in middle of the day suggests customers actively charged with solar PV
- No observable increase in load between 3-9pm, the traditional system peak time
- Note this does not include charging event load profiles

Origin



Source: Origin, Note: 67 customers (Residential Only)

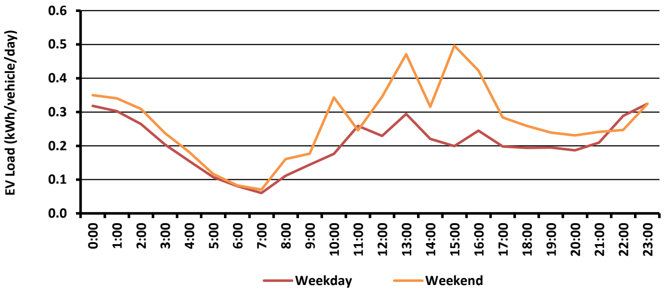
EV Grid



Source: EV Grid, Note 164 customers

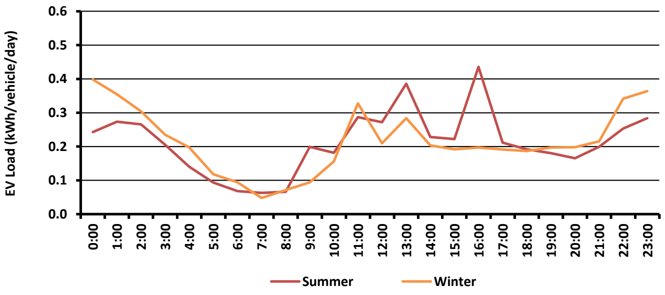
Average Hourly Charging Load – Time Variation

Weekday vs. Weekend



Source: Origin, EV Grid, AGL, Note: 67 Origin customers (period: Jun 20-Jul 21), 164 EV Grid customers (period: Jul 21-Aug 22), 144 AGL customers (period: Oct 21-Jan 22)

Summer vs. Winter



Source: Origin, EV Grid, Note: 66 Origin customers (period: Jun 20-Jul 21), 156 EV Grid customers (period: Jul 21-Aug 22)

- Load averaged on a kWh/vehicle/day basis, not charging session
  - Participating customer who does not charge their vehicle on a given day contributed 0 kWh to load
- The upper chart shows weekend vs weekday profiles over the complete data set provided
- Weekend and weekday load shapes look similar, however weekend load was larger
  - Suggest sample customers drove their vehicles more on the weekends
- Summer and winter load shape and size were fairly similar

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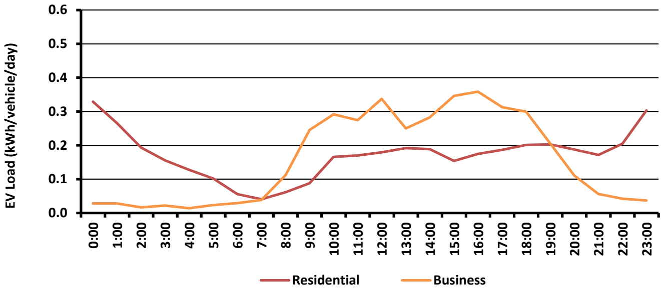
Average Charging Load Shape – Customer Variation

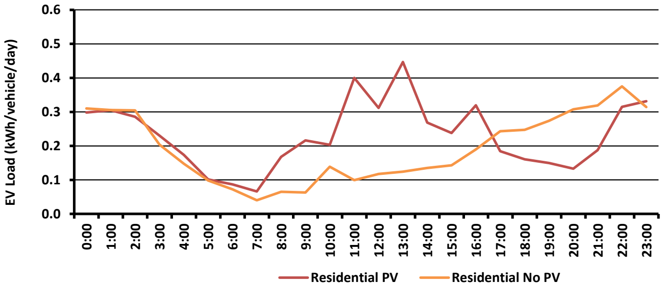
Residential vs. Business



Source: Origin, Note: 67 Residential, 25 Business Customers

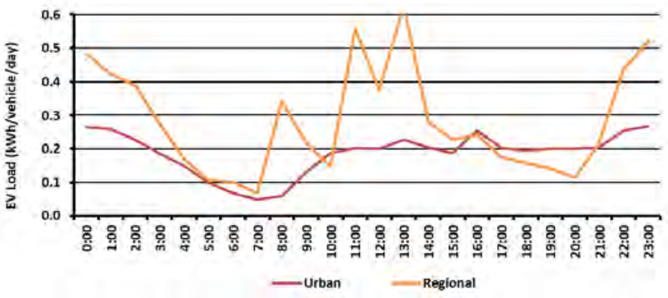
- Business participants contributed a small portion of the sample size collected, but have a distinct day time profile reflecting typical business hours
- Participants with rooftop solar PV were far more likely to charge in the daytime when solar production is highest
- Regional participant EVs had a much higher charging load than urban participants, reflective of typical driving distance

Residential w/ vs. w/out Rooftop Solar PV



Source: EV Grid, Note: 123 w/ Solar PV, 48 w/out Solar PV

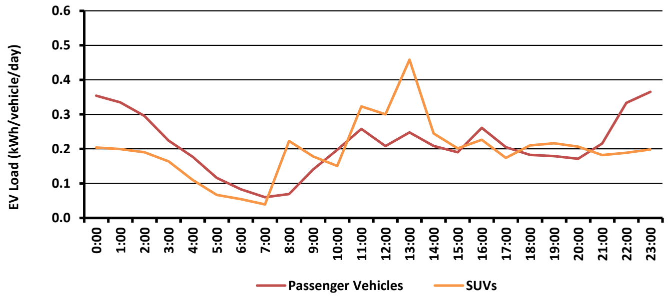
Urban vs. Regional



Source: EV Grid, Origin, Energeia, Note: 270 Urban, 52 Regional Customers

Average Charging Load Shape – Vehicle Variation

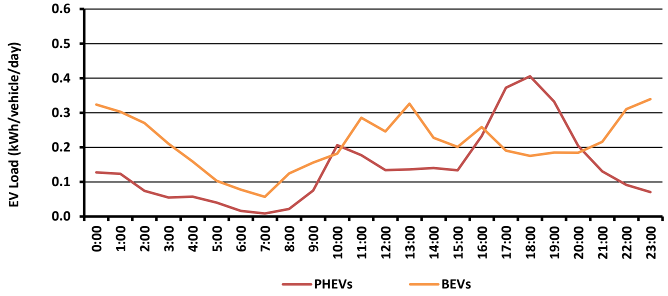
Passenger vs. SUV



Source: EV Grid, Origin. Note: 216 Passenger Vehicles, 67 SUVs

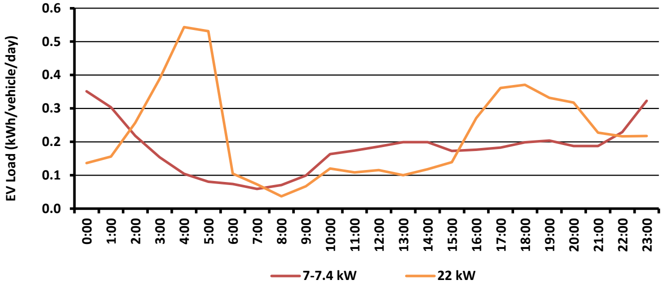
- SUV load shape was more skewed to middle of the day, potentially higher correlation with PV ownership
- PHEV owners tended to charge during early evening and had a lower charging load than BEVs, but very small sample size
- 22 kW charging is predominantly from business customers, which potentially explains load shape

BEV vs. PHEV



Source: EV Grid, Origin. Note: 12 PHEVs, 219 BEVs

Variation by Charger



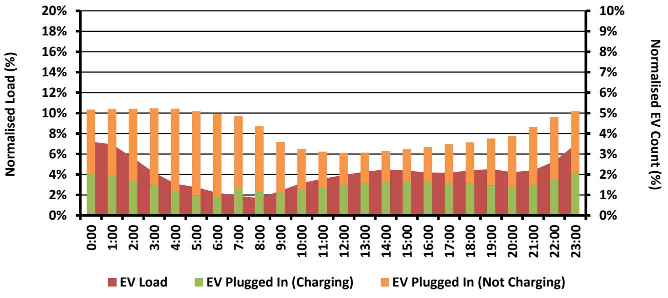
Source: AGL, Origin, Note: 5 22kW chargers, 62 7-7.4 kW chargers. Early morning spike caused by single charger.

Smart Charging

AGL

AGL – Unmanaged vs Smart Charging Profiles

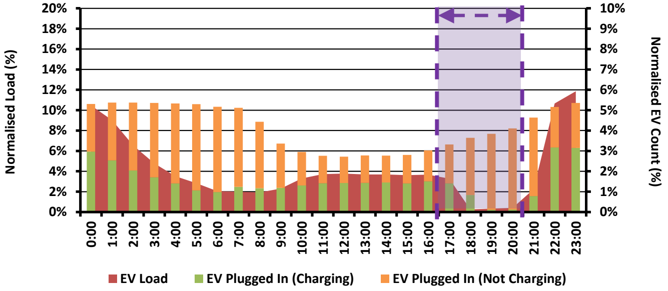
Unmanaged Profile – Weekday



Source: AGL, Energeia Analysis, Note: 173 customers

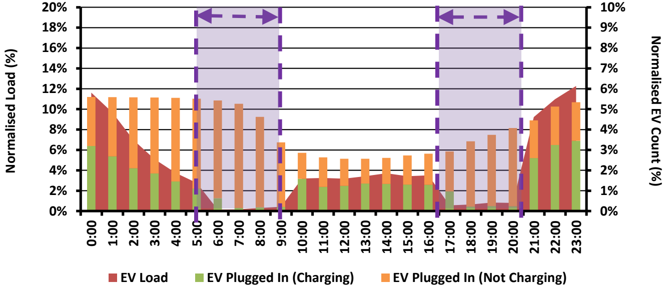
- The charts show unmanaged vs Phase 1 and Phase 2 of Smart Charging
  - **Phase 1**: Evening
  - **Phase 2**: Morning + Evening
- AGL conducted smart charging every weekday throughout the entire trial period
- Potential to add control group to ensure unbiased comparator as baseline data was collected during lockdown affected months
- Post smart charging evening period much higher than unmanaged
- Interestingly, no major increase seen after the morning smart charging period during Phase 2, customers waited to charge

Smart Charging – Phase 1



Source: AGL, Energeia Analysis. Note: 152 customers. Period start and end time varies up to half an hour by state. Purple indicates smart charging period

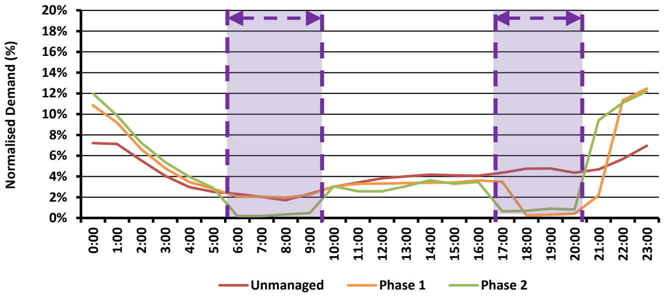
Smart Charging – Phase 2



Source: AGL, Energeia Analysis. Note: 124 customers. Period start and end time varies up to half an hour by state. Purple indicates smart charging period

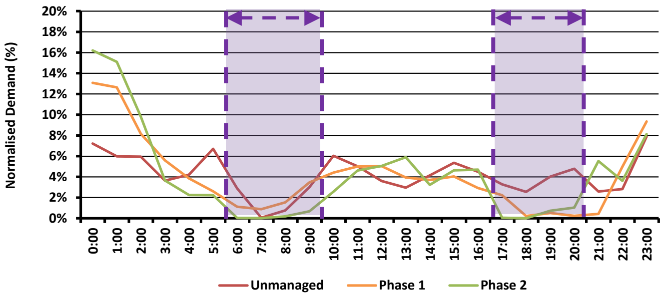
AGL– Smart Charging by Charging Power

Unmanaged vs Dynamic Events – 7 kW



Source: AGL, Energeia Analysis. Note: Unmanaged: 106 chargers, Phase 1: 110 chargers, Phase 2: 89 22 kW chargers. Evening period start and end time varies up to half an hour by state. Purple indicates smart charging period. Morning period occurs in Phase 2 only

Unmanaged vs Dynamic Events – 22 kW



Source: AGL, Energeia Analysis. Note: Unmanaged: 10 chargers, Phase 1: 11 chargers, Phase 2: 8 22 kW chargers. Evening period start and end time varies up to half an hour by state. Purple indicates smart charging period. Morning period occurs in Phase 2 only

- 7 kW charger customers were highly responsive to charging events, reflecting minimal opt-out
- 22 kW chargers responsive to evening event, however charging was already minimal during morning event under unmanaged circumstances
- Results provide evidence that bill discounts can be an effective incentive to entice smart charging
- Customers don't opt-out of frequent peak demand shedding events, instead shifting load to non-event times

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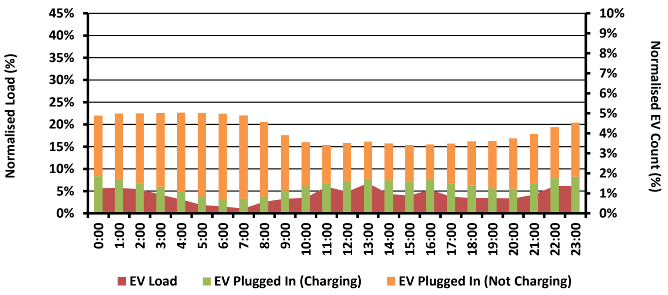
Smart Charging

EV Grid

EV Grid – Unmanaged vs Smart Charging Profiles

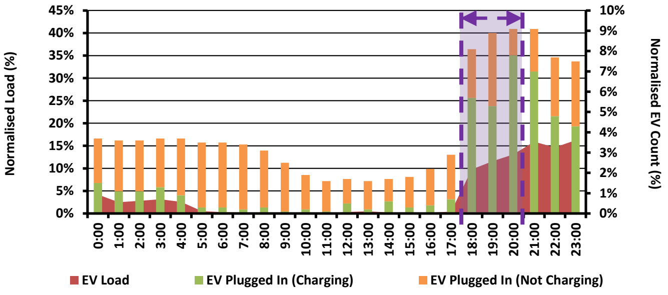
Unmanaged – Weekday



Source: EV Grid, Energeia Analysis

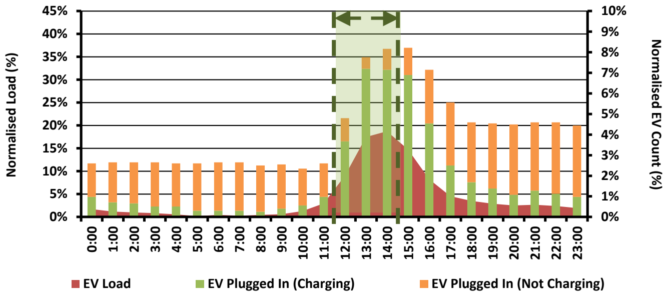
- The charts show unmanaged vs dynamic trials
    - **Demand Response**: 1 event, aimed to investigate ability to control demand in peak period
    - **Solar Soaker**: 2 events, aimed to incentivise demand during solar hours
- Trial figures contain all customers regardless of opt in/opt out
- Customers were requested to plug-in during the demand response event
    - Each DNSP set target level of output in response to local network demand during event

Demand Response – Weekday



Source: EV Grid, Energeia Analysis. Purple indicates smart charging

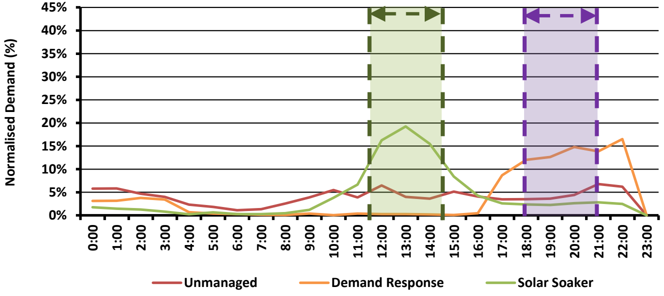
Solar Soaker – Weekday



Source: EV Grid, Energeia Analysis. Note: Green indicates incentive to charge. Event 1: 12-3pm, Event 2: 1-3pm

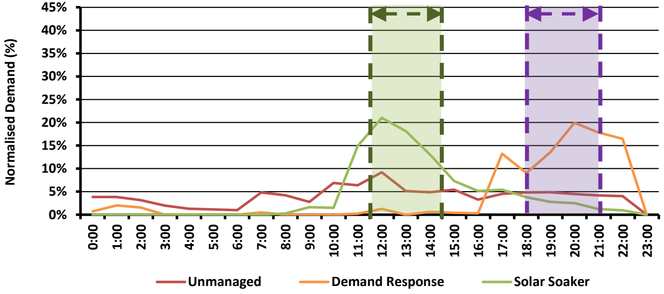
EV Grid – Smart Charging by Vehicle Type

Unmanaged vs Dynamic Events – Passenger Vehicles



Source: EV Grid, Energeia. Note: Green indicates incentive to charge, Purple indicates controlled charging. Unmanaged: 117 chargers, Demand Response: 80 chargers, Solar Soaker: 91 chargers.

Unmanaged vs Dynamic Events – SUVs



Source : EV Grid, Energeia , Note: Green indicates incentive to charge, Purple indicates controlled charging. Unmanaged: 41 chargers, Demand Response: 22 chargers, Solar Soaker: 32 chargers.

- No significant difference in responses to smart charging events between customers with a passenger vehicle or SUV

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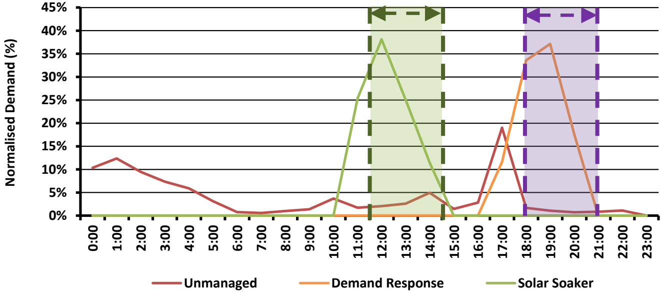
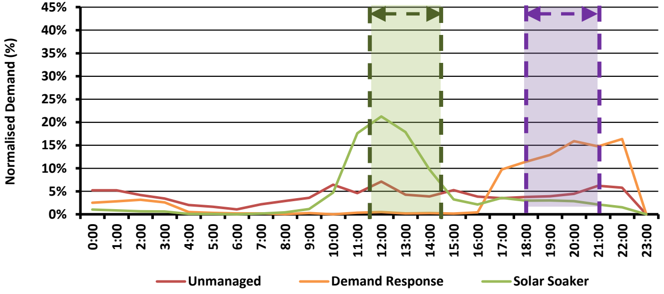
EV Grid – Smart Charging by Electrification Type

Unmanaged vs Dynamic Events – PHEVs



Source: EV Grid. Note: Green indicates incentive to charge, Purple indicates controlled charging. Unmanaged: 4 chargers, Demand Response: 1 charger, Solar Soaker: 3 chargers.

Unmanaged vs Dynamic Events – BEVs



Source: EV Grid. Note: Green indicates incentive to charge, Purple indicates controlled charging. Unmanaged: 160 chargers, Demand Response: 104 chargers, Solar Soaker: 88 chargers.

- PHEV customers were able to recharge their vehicles during the demand response event, whereas there is a load shift for BEV customers to post-event

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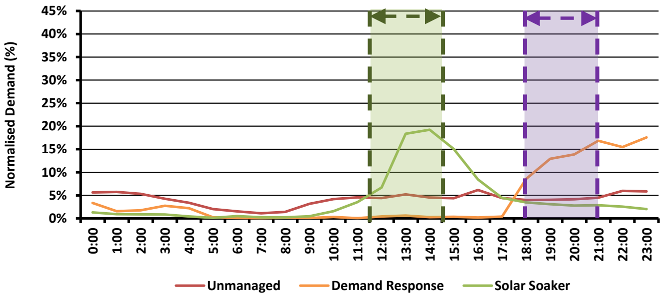
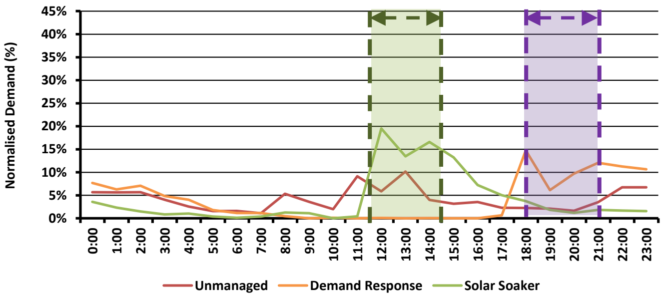
EV Grid – Smart Charging by Location

Unmanaged vs Dynamic Events – Urban



Source: EV Grid. Note: Green indicates incentive to charge, Purple indicates controlled charging.
Unmanaged: 137 vehicles, Demand Response: 87 vehicles, Solar Soaker: 107 vehicles.

Unmanaged vs Dynamic Events – Regional



Source: EV Grid. Note: Green indicates incentive to charge, Purple indicates controlled charging.
Unmanaged: 26 vehicles, Demand Response: 17 vehicles, Solar Soaker: 19 vehicles.

- Customer location did not appear to impact participation in the charging event

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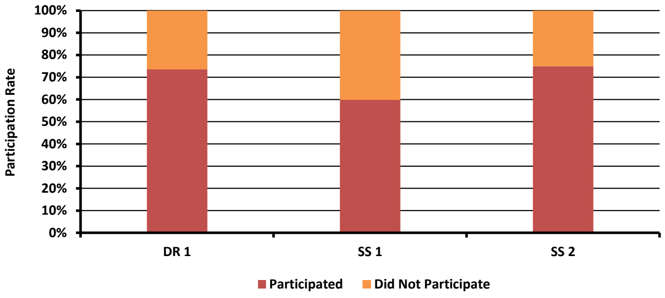
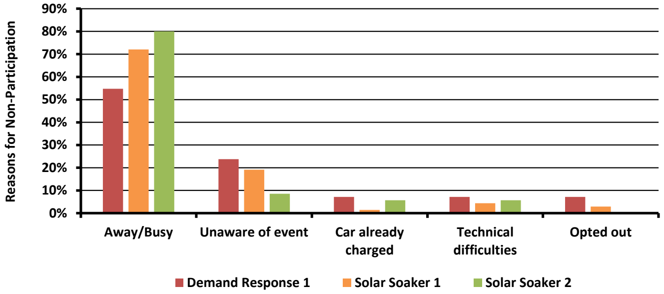
EV Grid – Smart Charging Opt-out Behaviour

Smart Charging Participation Rates by Type



Source: EV Grid

Reason for Non-Participation



Source: EV Grid, Energeia Analysis

- From survey results, 25-40% did not participate in DR events on average
- Main reason for non-participation was due to being away from home during the event
- Lack of awareness decreased with each event
- Very few customers actively opted-out or had technical difficulties
- A monetary incentive with few events appears to be highly effective in encouraging smart charging
- However strict terms of participation can have counter-productive consequences if too many customers were to opt-out mid-event

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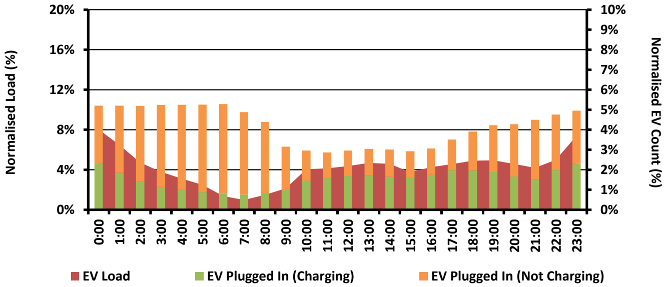
Smart Charging

Origin

Origin – Unmanaged vs Smart Charging Profiles

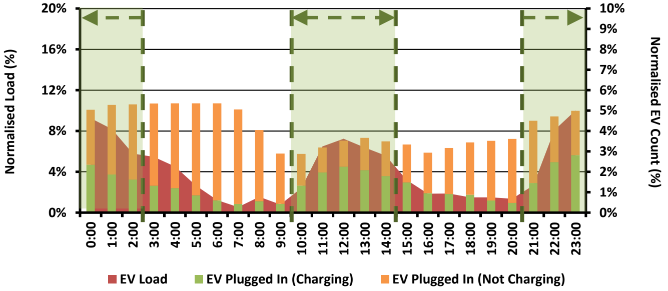
Unmanaged – Weekday



Source: Origin Energy, Energeia Analysis. Note: 67 vehicles

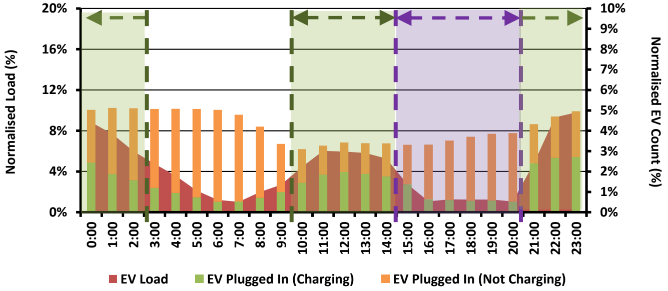
- The charts show Unmanaged vs experiments 1 and 2 across weekdays
  - **Experiment 1** – Off-peak smart charging incentive (10c/kWh midday and overnight)
  - **Experiment 2** – Additionally, a 3 - 9pm controlled smart charging period
- Impact of Experiment 1 significant, Experiment 2's impact more difficult to discern
  - Shows that voluntary incentives were effective in managing charging on their own

Experiment 1 – Weekday



Source: Origin Energy, Energeia Analysis. Note: 68 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

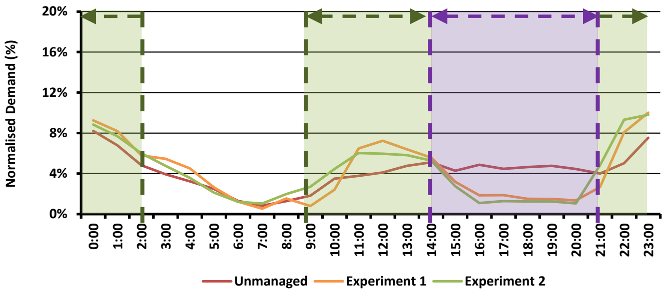
Experiment 2 – Weekday



Source: Origin Energy, Energeia Analysis Note: 70 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

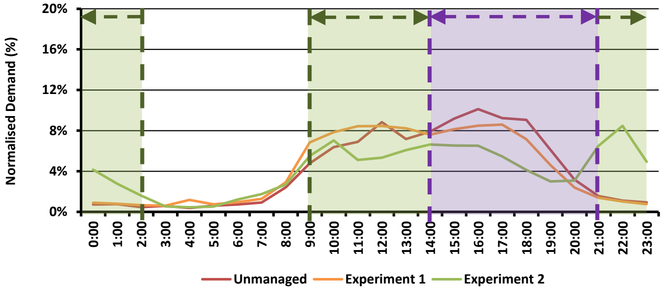
Origin – Smart Charging by Customer Class

Unmanaged vs Experiments – Residential



Source: Origin, Energeia Analysis. Note: Unmanaged: 67 vehicles, Exp 1: 68 vehicles, Exp 2: 70 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Unmanaged vs Experiments – Business



Source: Origin, Energeia Analysis. Note: Unmanaged: 25 vehicles, Exp 1: 26 vehicles, Exp 2: 53 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

- Residential customers appeared more responsive to voluntary charging incentives than business customers
  - Business customers were not likely to interrupt workflow to participate in smart charging
  - Upfront opt out requirements from Experiment 2 for Businesses contributed to low participation in the control experiment
- Controlled charging of experiment 2 demonstrably effective in shifting business customer charging

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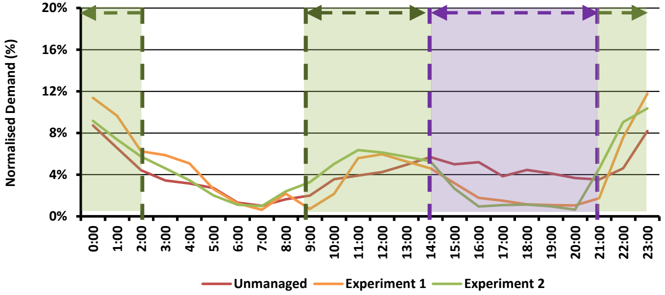
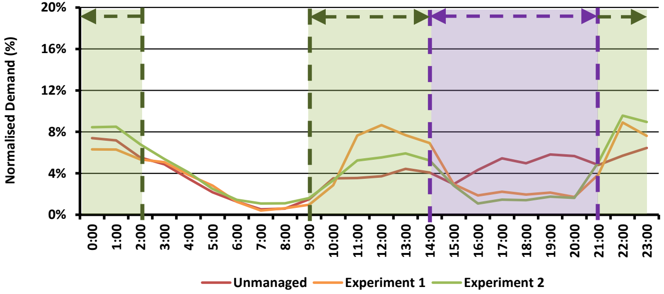
Origin – Smart Charging by Vehicle Type

Unmanaged vs Experiments – Passenger Vehicles



Source: Origin, Energeia Analysis. Note: Unmanaged: 39 vehicles, Exp 1: 40 vehicles, Exp 2: 42 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Unmanaged vs Experiments – SUVs



Source: Origin, Energeia Analysis. Note: Unmanaged: 26 vehicles, Exp 1: 26 vehicles, Exp 2: 26 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

- SUV customers were more responsive to middle of the day charging incentives
- May correlate with solar PV ownership, but this information was not collected for this trial

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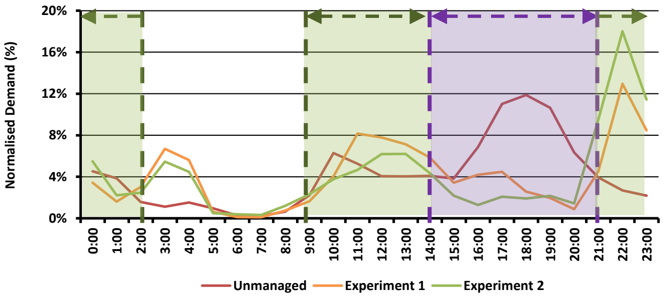
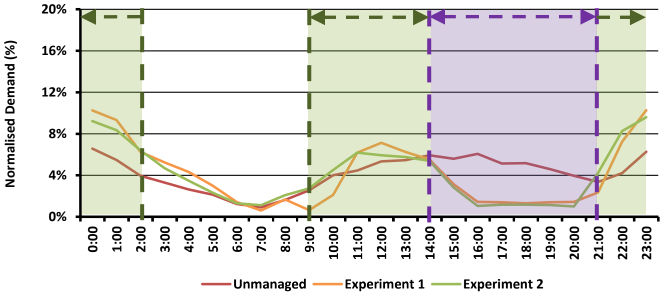
Origin – Smart Charging by Electrification Type

Unmanaged vs Experiments – PHEVs



Source: Origin, Energeia Analysis. Note: Unmanaged: 8 vehicles, Exp 1: 8 vehicles, Exp 2: 8 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Unmanaged vs Experiments – BEVs



Source: Origin, Energeia Analysis. Note: Unmanaged: 59 vehicles, Exp 1: 60 vehicles, Exp 2: 62 vehicles. Green indicates incentive to charge, purple indicates controlled charging (Experiment 2 only)

- PHEV drivers were highly responsive to smart charging incentives, despite typically charging during evening peak

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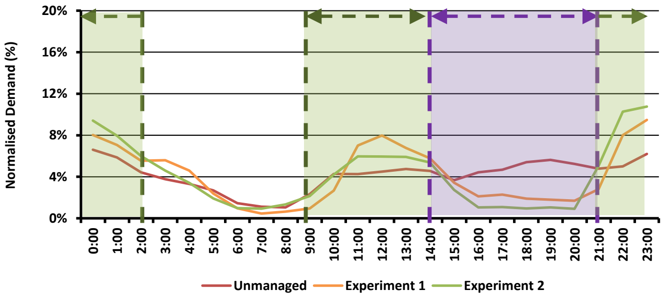
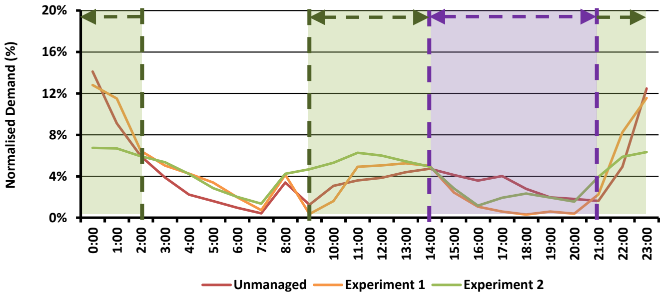
Origin – Smart Charging by Location

Unmanaged vs Experiments – Urban



Source: Origin, Energeia Analysis. Note: Unmanaged: 54 vehicles, Exp 1: 55 vehicles, Exp 2: 57 vehicles. Green indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Unmanaged vs Experiments – Regional



Source: Origin, Energeia Analysis. Note: Unmanaged: 13 vehicles, Exp 1: 13 vehicles, Exp 2: 13 vehicles. Green indicates incentive to charge, purple indicates controlled charging (Experiment 2 only)

- Urban drivers were more inclined to participate in midday charging event
- Trial provides evidence that the EV load is highly response to price incentives
  - With a fixed schedule, customers were willing to shift their charging to off-peak times to receive a reward
  - Customers were not likely to opt-out of controlled charging during the peak, however its impact was minimal given voluntary shifting to off-peak

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ENERGEIA

Thank You

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The bumpy road to V2G

Laura Jones

September 2022

REVS: Realising EV-to-grid Services

ActewAGL

ACT Government

evoenergy

JET CHARGE

NISSAN

sgfleet

ARENA

Australian Government

Australian Renewable Energy Agency

ARENA funded $2.4m toward this $6.26m project

REVS

REVS: Realising EV-to-grid Services

Demonstration

51 V2G equipped EVs in ACT government fleet + ActewAGL

Contingency Frequency control

Beyond demonstration

Investigate technical, social, and economic factors

Model more vehicles, more services, and more value

Knowledge sharing

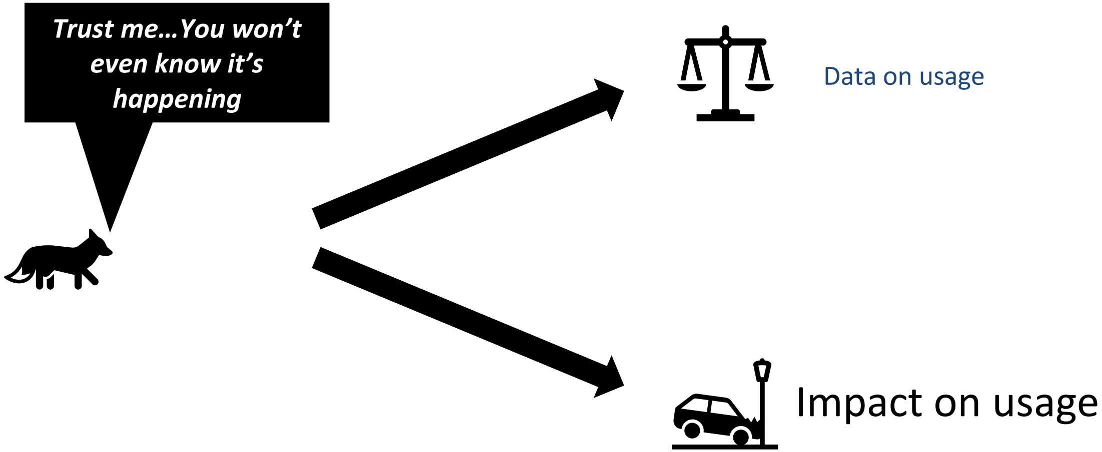
It’s taking awfully long

Charger accreditation

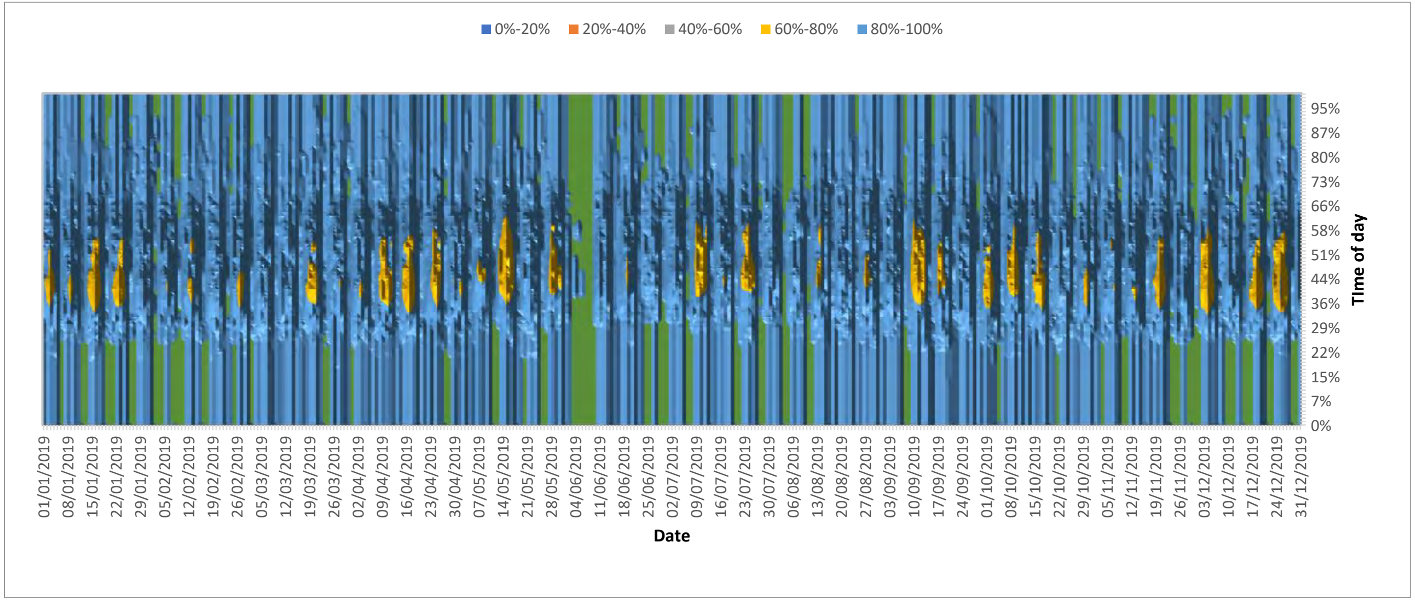
Installation

Getting vehicles into fleets

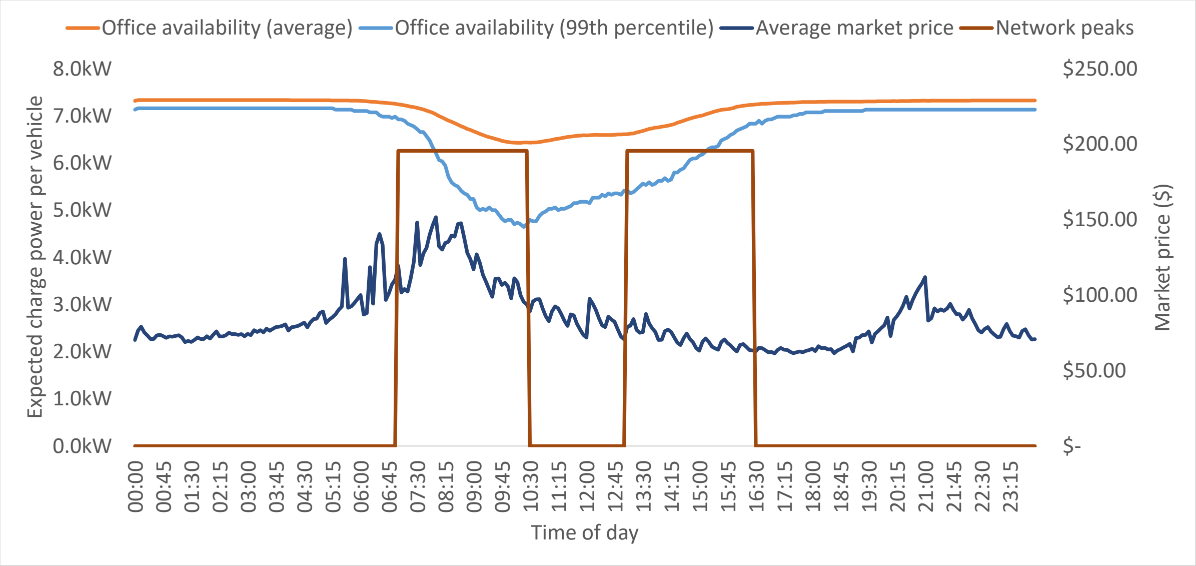
Pulling a thread



Vehicle usage as a fancy carpet

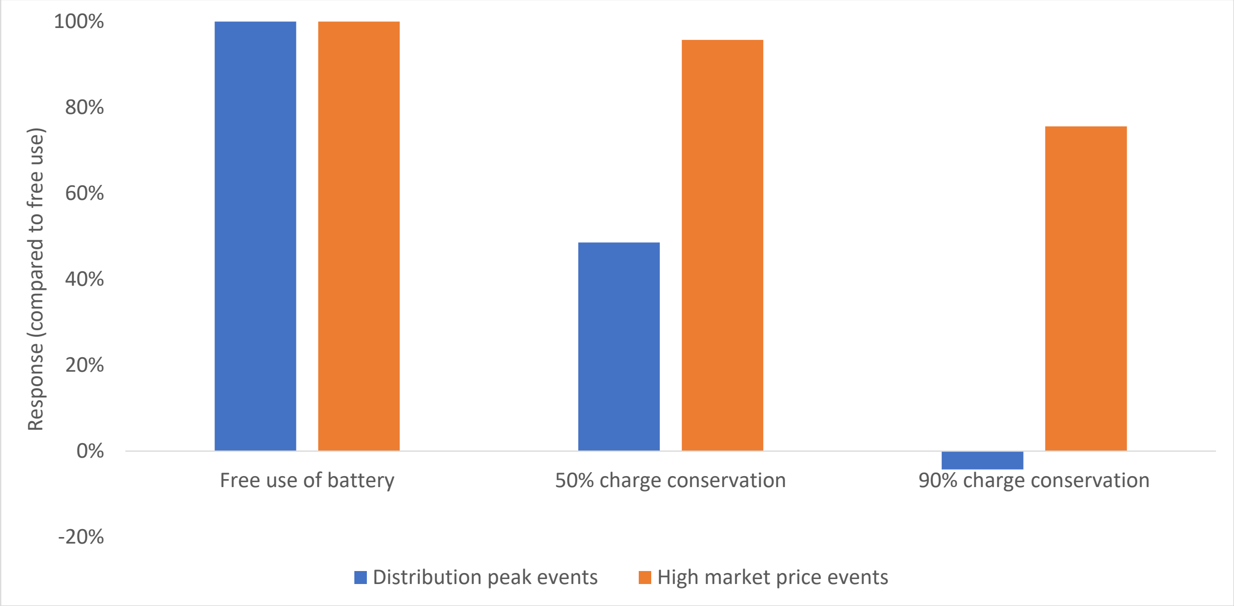


A day

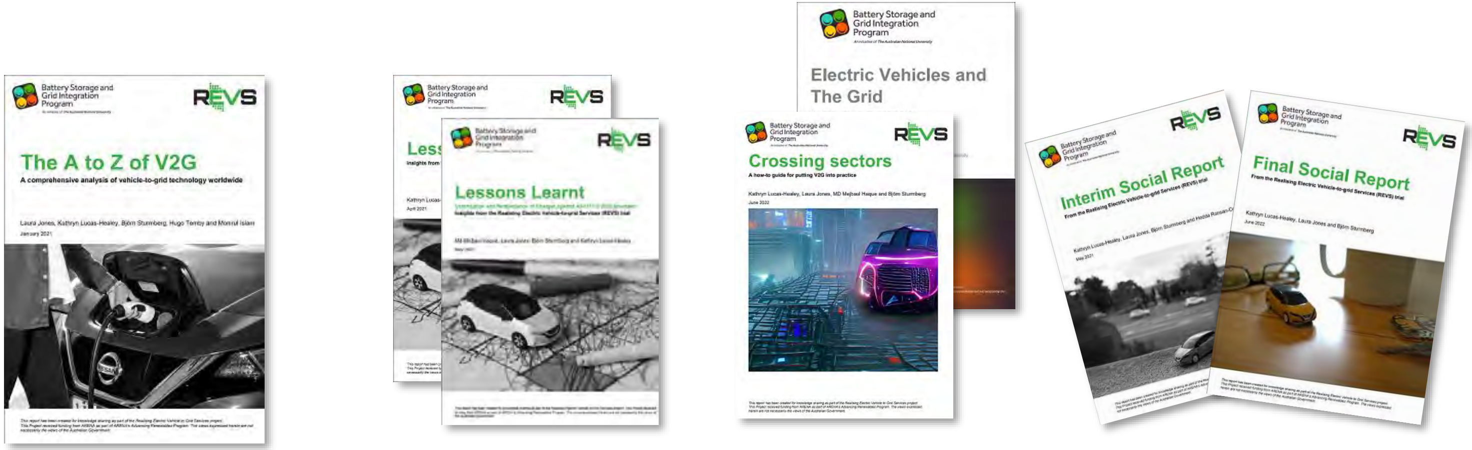


Office availability (average)
Office availability (99th percentile)
Average market price
Network peaks
Expected charge power per vehicle
8.0kW
7.0kW
6.0kW
5.0kW
4.0kW
3.0kW
2.0kW
1.0kW
0.0kW
$250.00
$200.00
$150.00
$100.00
$50.00
$-
Market price ($)
00:00
00:45
01:30
02:15
03:00
03:45
04:30
05:15
06:00
06:45
07:30
08:15
09:00
09:45
10:30
11:15
12:00
12:45
13:30
14:15
15:00
15:45
16:30
17:15
18:00
18:45
19:30
20:15
21:00
21:45
22:30
23:15
Time of day

But what about capacity?



Knowledge Sharing



Visit bsgip.com and arena.gov.au/projects/realising-electric-vehicle-to-grid-services/

DEIP

DISTRIBUTED ENERGY
INTEGRATION PROGRAM

DER Market Integration

EXAMINING GRID INTEGRATION IN A HIGH DER WORLD

Session One
Stream Two

DER Market Integration

Mitch O'Neill, Grids Energy

DEIP

What are DER Market Integration Trials?

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DISTRIBUTED ENERGY INTEGRATION PROGRAM

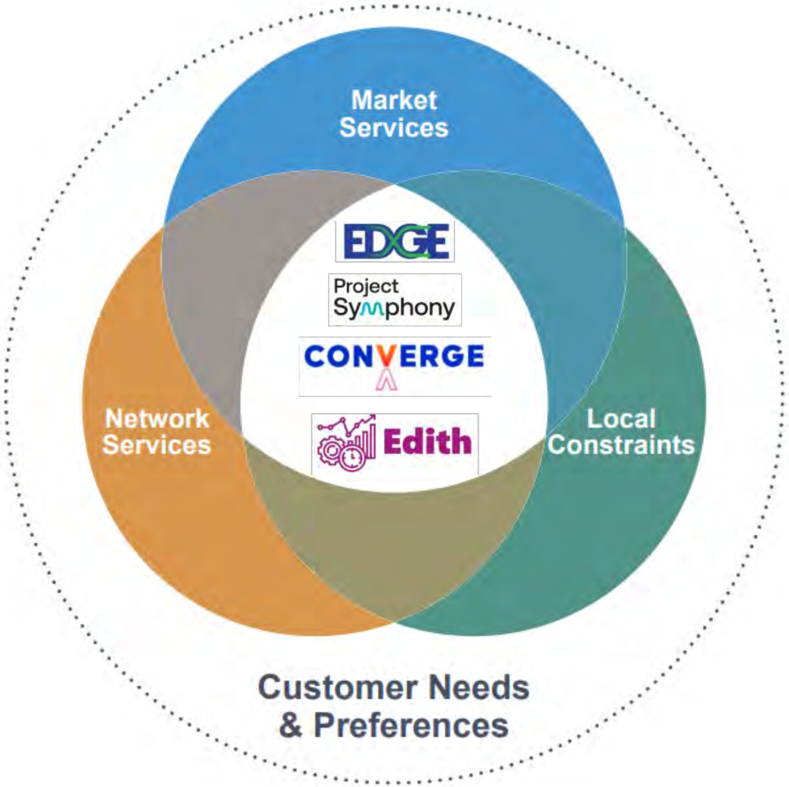
Recently a group of DER market integration trials commenced which examine ways to simultaneously meet core four functions:

Market Services: providing system-level market services such as participating in current wholesale energy, FCAS, or RERT markets.

Network Services: providing capacity to local networks in order to defer or avoid the need for costly network upgrades.

Local Constraints: adhering to the local network capacity available to the DER.

Consumer Needs & Preferences: compelling products and offers created with appropriate value, information and protections that encourage consumer participation in the above three functions.



Technical Settings of the DER Market Trials

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DISTRIBUTED ENERGY INTEGRATION PROGRAM

	Project Symphony	Project EDGE	Project Edith	Project Converge
Metering Point	Connection Point	Connection Point or **Sub-metering**	Connection Point	Connection Point
Energy Market Bidding	Bids into balancing and **contingency reserve raise** markets	**Model consistent with Scheduled BDU from IESS**	Current bidding process for FCAS	**Bids first sent to DSO**
Local Constraints	DOE	DOE	DOE	DOE
Local Constraints Communication Protocol	CSIP-AUS	CSIP-AUS (only using schema)	**CSIP-AUS (extended with pricing)**	CSIP-AUS
DOE allocation	Various	Various	**Subscription model**	**Bid-Optimised**
Network Support	**Contracted Network Services**	**Local Services Exchange**	**Dynamic Network Price**	**Real-time RIT-D**
Data Transfer	**Platform integrations**	**Data-hub**	**Point-to-point**	Point-to-point

Technical Settings of the DER Market Trials

DEIP
DISTRIBUTED ENERGY INTEGRATION PROGRAM

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Network Support	**Contracted Network Services**	**Local Services Exchange**	**Dynamic Network Price**	**Real-time RIT-D**
Data Transfer	**Platform integrations**	**Data-hub**	**Point-to-point**	Point-to-point

A convergence of approaches are in areas where there has been a large amount of industry collaboration and a common understanding.

A divergence of approaches occur in less explored areas.

Project EDGE

Demonstrating scalable and cost-effective solutions to DER integration in a world with many actors (DSOs, aggregators and consumers). Includes AEMO, Ausnet, Mondo and other aggregators.

- Designed to inform short term reforms (IESS, FTA, scheduled lite) and longer term system architectures and processes that support a high level of DER participation.
- Examining information architectures suitable to transfer data between different parties. Testing hypothesis that a data exchange hub is more suitable than all actors individually connecting to each other.
- Social science research through Deakin University.
- Testing energy market participation for DER under new IESS and Scheduled Lite models. Allowing DER to be metered separately from household loads.
- Creating a local services exchange to efficiently procure DER services for localised network support.
- Aiming for 1,000 customers total from multiple aggregators. Runs from July 2020 – mid 2023.

Project Converge

Trailing efficient ways to allocate network capacity, and removing barriers to rewarding DER for providing network support services. Includes Evoenergy, ANU, Zepben and funding from ACT Government.

Designed to test solutions that increase the amount of benefits created by DER without breaching the limits of the distribution network.

Preferentially allocating network capacity to DER that has lower energy costs (represented through market bids) to more efficiently dispatch DER. These are called shaped operating envelopes (SOEs) and are similar to how capacity is allocated on the transmission network.

Social science research through the Australian National University.

Developing real-time systems to procure network support services from DER. These process improvements will allow network support to be procured more efficiently and in a simpler way for aggregator participation.

Aiming for 1,000 customers in total from multiple aggregators. Runs from August 2021 – January 2024.

Project EDGE
(Energy Demand & Generation Exchange)

ARENA DEIP Dive: DER Market Integration Stream

September 2022

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 EDGE | A collaboration between AEMO, AusNet & Mondo

Nick Regan
AEMO

John Theunissen
AusNet Services

Anoop Nambiar
Mondo Power

Project EDGE (Energy Demand and Generation Exchange) is a collaboration between the Australian Energy Market Operator (AEMO), AusNet Services (AusNet) and Mondo (collectively, the Project Partners), with financial support from the Australian Renewable Energy Agency (ARENA).

Project EDGE is an ARENA-funded research project trialling a two sided DER marketplace, designed to provide evidence based insights for the NEM 2025 Reforms in line with the National Electricity Objective (NEO)

Energy Demand & Generation Exchange

Evidence for policy making to benefit all customers

Research Plan

A detailed research plan has been developed by the University of Melbourne to guide the activities undertaken to ensure the data obtained supports the objectives of the project and can be used as part of an evidence base for change and development of the future energy market and systems.

Cost Benefit Analysis

The purpose of the CBA for Project EDGE is to identify and analyse whether the implementation of an operational DER marketplace is in the long-term interests of consumers consistent with the NEO. Deloitte Access Economics has been commissioned to conduct the CBA and will also assess under which scenarios adding more complexity and sophistication to the DER marketplace may be justified.

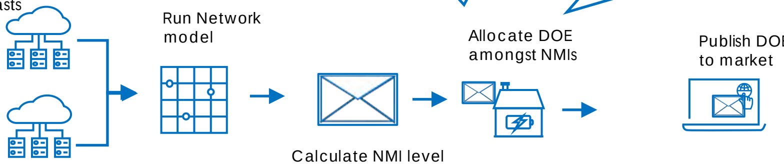
Customer Insights Study

Together with Deakin University, Project EDGE is running a multi- year consumer study that examines perceptions of, and decision-making around, Virtual Power Plants (VPPs) among potential residential and business customers, and current residential battery owners.

Wholesale Market serv… l Service Exchange

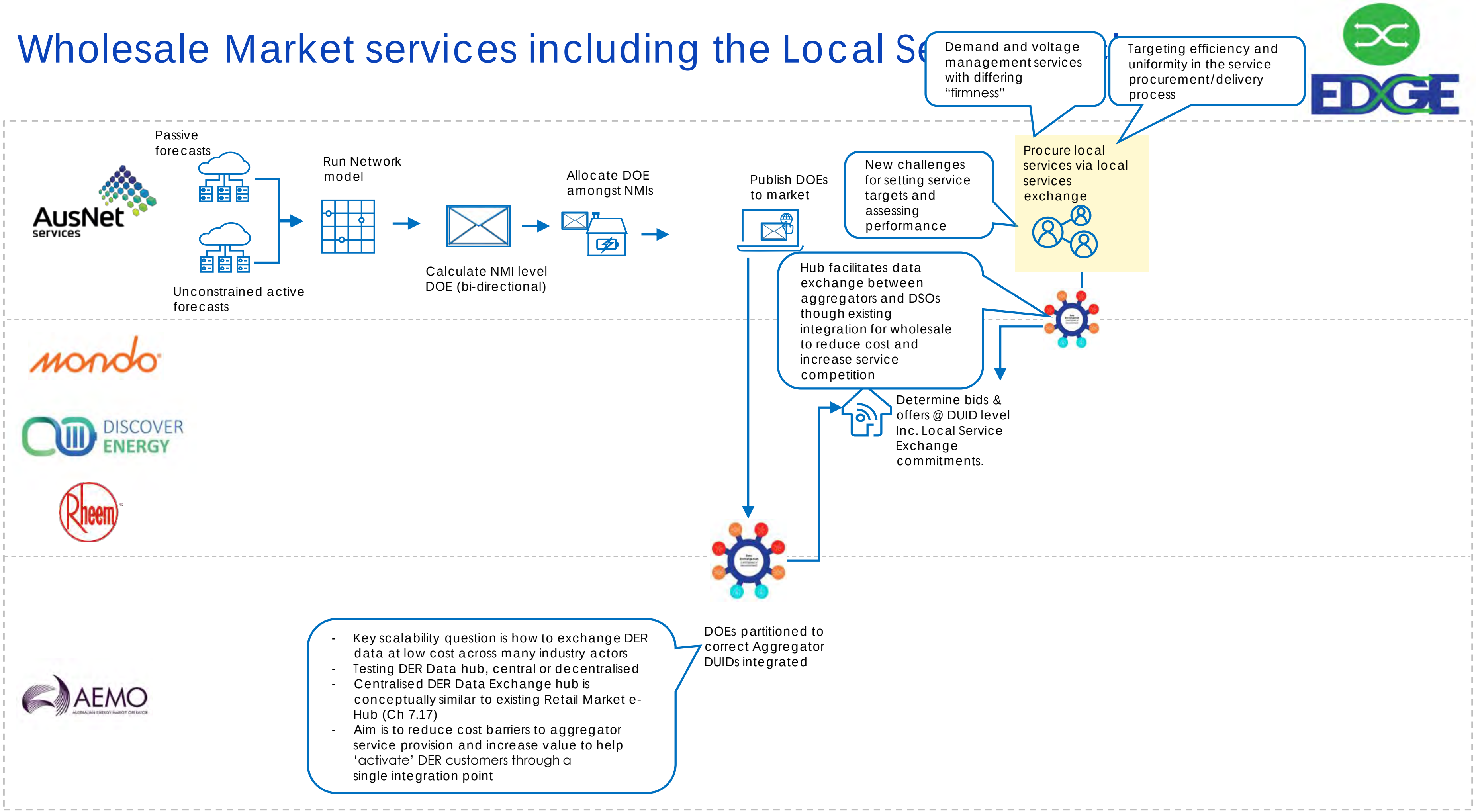
A range of DOE allocation methods is analysed (operational + techno-economic studies)

Early evidence suggests that maximising renewable energy contributions into the market from DER results in higher benefits for all customers, compared to local network customer "fairness" based network access allocation methods

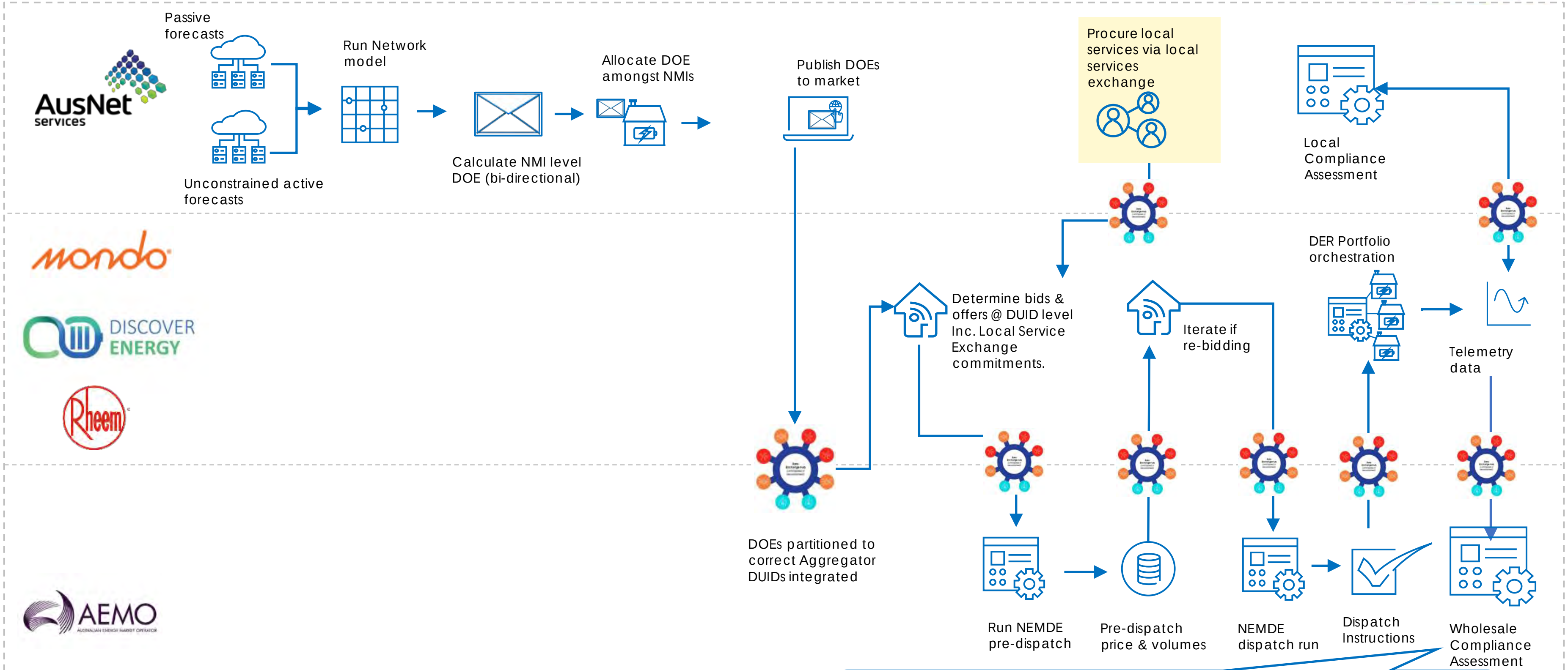


- Multiple DOE calculation methods tested (simple/complex)
- Calculations use smart meter measurement data and network data
- Forecasting LV network conditions can be challenging
- Scaling implications need to be considered

Wholesale Market services including the Local Se

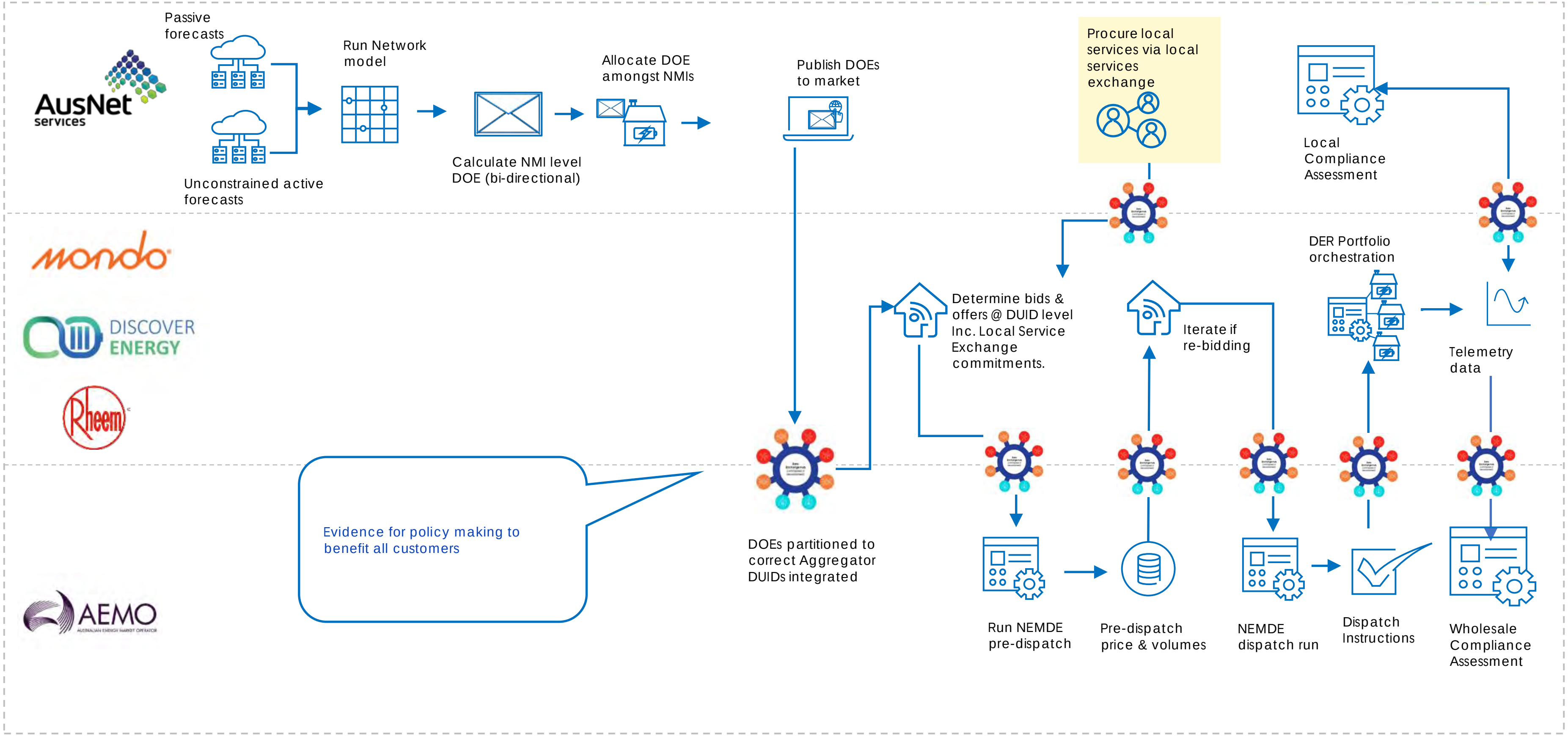


Wholesale Market services including the Local Service Exchange



- Relies on aggregator self-constrained bidding, compliance incentives an open question
- Aggregator able to meet Dispatch Targets provided sufficient DOE capacity, implications for market directions
- Separation of aggregated controlled DER from net site in forecast and telemetry is critical to analysing VPP behaviour and system operations

Wholesale Market services including the Local Service Exchange



Project EDGE – A Snapshot

Project EDGE launched in July 2020 and since then, we have:

- Designed a Research plan
- Released 3 major Knowledge Sharing Reports along with the accompanying recorded public webinars
- Commenced a multi-year Customer Insights Study with DER and non-DER customers
- Presented at an international conference
- Commissioned a Cost Benefit Analysis

Key Upcoming Activities

- Welcoming two additional aggregators into the field trial
- Moving to the next phase of our Customer Insights Study
- Releasing our CBA Methodology
- Working with the University of Melbourne on their Techno-Economic Modelling work
- Using field trial evidence based insights for our Lesson Learned report in November

Project EDGE Publications

Publications	Publication Date
Project EDGE CBA Methodology Consultation Paper	July 2022
Project EDGE Public Interim Report	June 2022
Project EDGE Customer Insights Study	June 2022
Project EDGE Research Plan	March 2022
Project EDGE MVP Showcase	December 2021
Project EDGE Lessons Learned Report #1	May 2021
Project EDGE Public Webinar #1	March 2021
Project EDGE Factsheet	January 2021

For further news and knowledge sharing publications, please visit the Project EDGE Website

For any questions, comments or feedback, please contact: EDGE@aemo.com.au

Thanks for Listening!

Project Symphony

Our energy future

Project Symphony: a policy response for the WEM

September 2022

Presented by: Andrew Blaver

In partnership with:

western power synergy AEMO GOVERNMENT OF WESTERN AUSTRALIA Energy Policy WA Sustainable Futures

Acknowledgement of Country

We acknowledge the Traditional Owners of the land on which we meet, the Ngunnawal people and we also acknowledge the Traditional Owners of the land on which the project will operate the Whadjuk people and recognise their continuing connection to lands, waters, and communities. We also pay our respects to Elders past, present and emerging.

About the Wholesale Electricity Market

2+ million
people connected

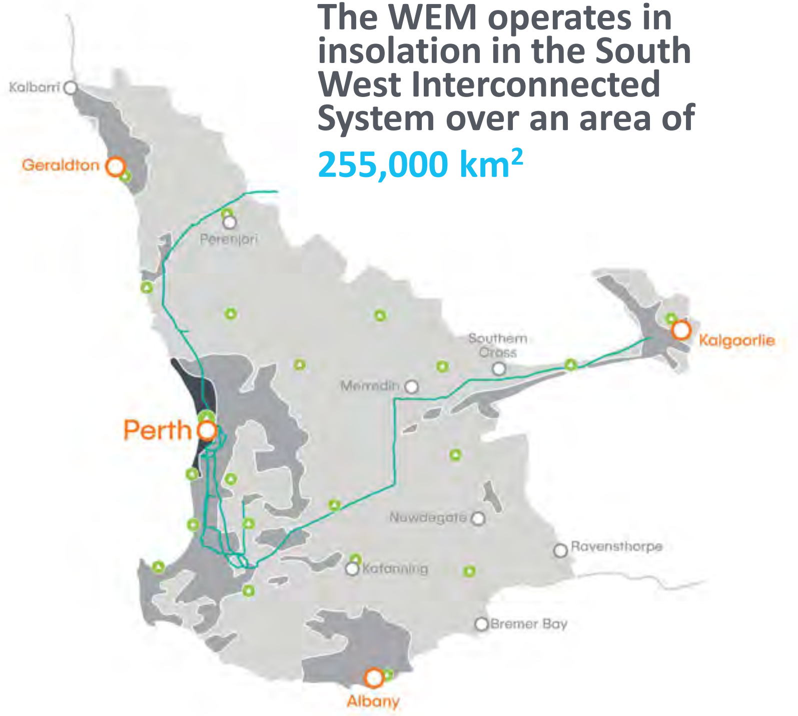
2GW
grid connected solar

7800km
Transmission network

4396MW & 761MW
Demand peak & low

5798 MW
Capacity

67%
underlying demand



The WEM operates in insolation in the South West Interconnected System over an area of
255,000 km²

Project Symphony
Our energy future

In partnership with:

Project Symphony – Scope and Objectives

Vision

A future where DER integration supports a safe, reliable and efficient electricity system, and where the full capabilities of DER benefit and provide value to all customers.

Project Partners

western power | synergy | AEMO | Government of Western Australia Energy Policy WA

Inputs

Who will assist in the delivery of Project Symphony?

Experienced research partners and contractors

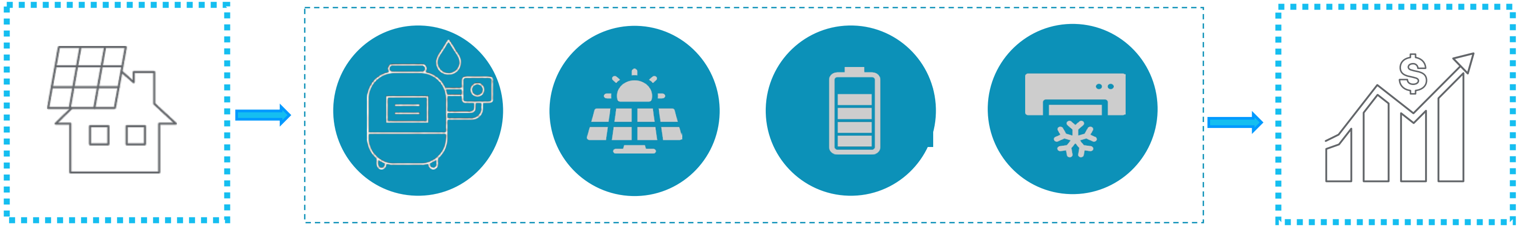
UTS University of Technology Sydney | The University of Western Australia | University of Tasmania Australia

Strong knowledge sharing & stakeholder engagement interfaces

Distributed Energy Resources Roadmap | Distributed Energy Integration Program | Open Energy Networks | Australian Government Australian Renewable Energy Agency

Customers

Participation



Scenarios

What scenarios will we test to determine value?

1 Energy services Bi-directional

2 Network Services

3 Constrain to zero

4 Contingency raise

Project Symphony
Our energy future

In partnership with: western power, synergy, AEMO, Government of Western Australia Energy Policy WA

Lessons learnt

Given the Project is closely linked with energy policy and regulation, it is recommended where possible, to **have policy makers participate in governance and delivery** of strategically important projects in the energy sector.

Lessons Learnt

Milestone 1

Lessons learnt for the 'Scoping and Planning' phase of the project

Lessons Learnt

Milestone 2

Lessons learnt for the 'Build and Integrate' phase of the project

1. Active strategic and tactical participation by the government agency responsible for providing energy policy advice to the WA Minister for Energy.
2. Energy Policy WA (EPWA) is the Chair of the Project Symphony Steering Committee, while also actively participating in day-to-day delivery of the project.
3. Having EPWA as the policy maker involved at a project level continues to be beneficial in helping partners achieve greater clarity, understanding and alignment on future 'DER orchestration' roles and responsibilities.

Background – Distributed Energy Resources in the WEM

We are at the front edge of a **sustained expansion of Distributed Energy Resources (DER).** DER are smaller scale devices that can either *use*, *generate* or *store* electricity, are mostly owned by customers, and are *passively* connected to the local distribution network.

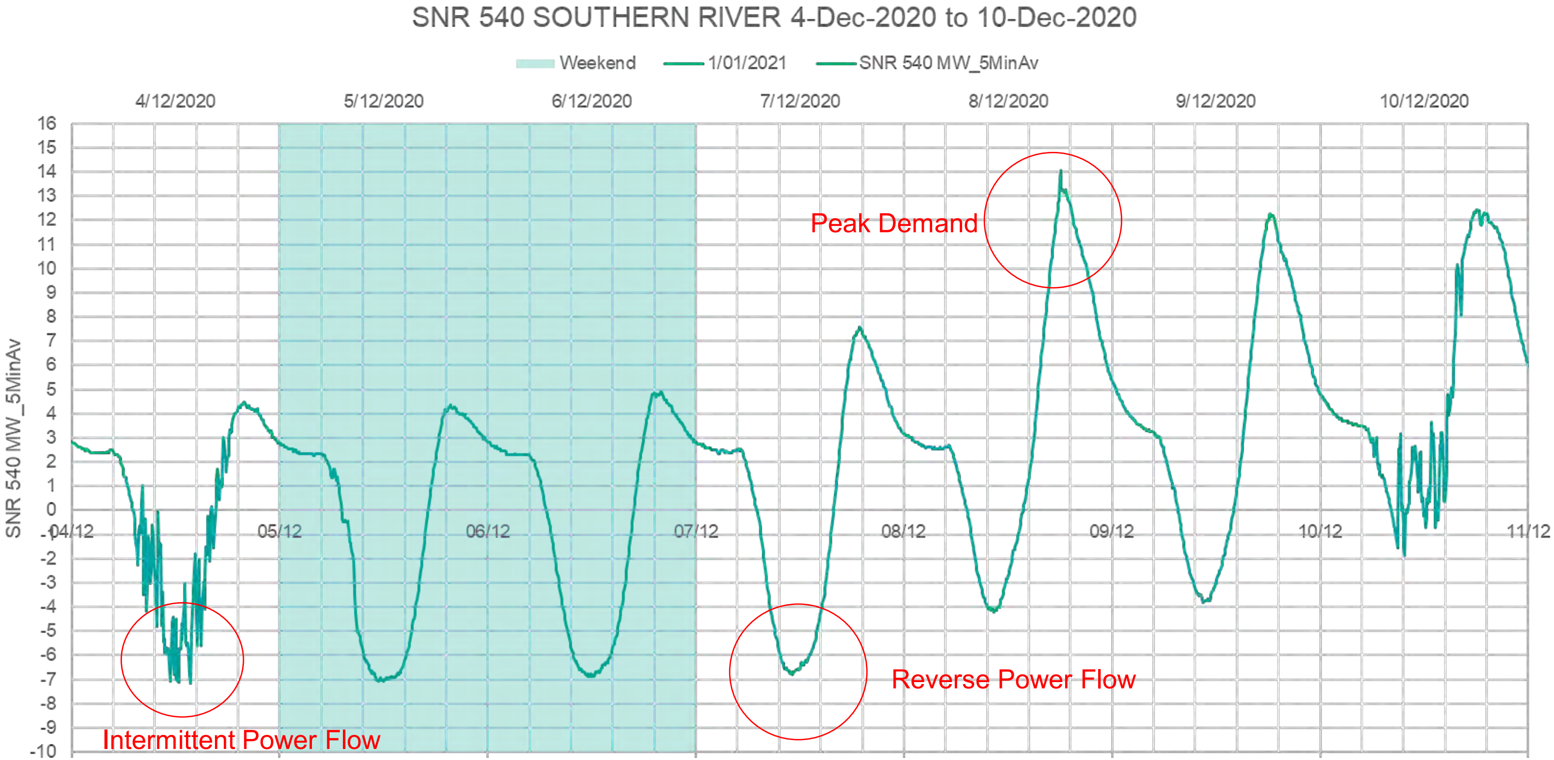
Aggregated rooftop solar is on track to becoming **the largest, cleanest and cheapest source** of electricity generation.

~2.0 GW
DER capacity

Can serve
up to **67%**
underlying
demand

1 in 3

Background – Challenges and Opportunities



High Voltage (HV) Network: we have *high visibility and control* of connected generators to safely operate the network

Medium Voltage (MV) Network: we have *medium visibility and control…*

Low Voltage (LV) Network: we have *very low visibility and almost no control…*and the largest generator (in aggregate) is now connected here…

Project Symphony
Our energy future

In partnership with: western power, synergy, AEMO, Energy Policy WA

Project Symphony was developed as a policy response

The Minister for Energy released the Government's DER Roadmap on 4 April 2020 to: *"Deliver a future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers."*

Action	Roadmap Element	Owner	Description	Priority
22	DER Orchestration	Synergy EPWA Western Power	By July 2020, commence a comprehensive VPP technology pilot to demonstrate the end to end technical capability of DER in the SWIS, and…transition to market participation testing.	High
23	DER Orchestration	Synergy AEMO	By July 2022, complete a comprehensive VPP market participation pilot that tests the incorporation of aggregated DER into energy markets…	High
Various closely related and dependent Roadmap actions related to Technology Integration and DER Participation.				

Project Symphony
Our energy future

In partnership with: western power, synergy, AEMO, Energy Policy WA

Policy Response

Project Symphony
Our energy future

In partnership with:

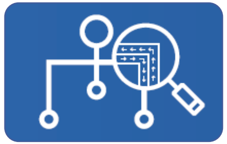
DER Orchestration Roles & Responsibilities

- Multiple workshops with Western Power (as DSO) and AEMO (as DMO) last year.
- Draft EPWA Information Paper
  - Outlines background current context in SWIS/WEM
  - Identifies many DER orchestration issues
  - Sets-out settled & unsettled policy positions, detailing reasons
- Provides certainty in critical policy areas on forward direction to guide investment decisions

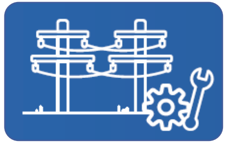
Project Symphony
Our energy future

In partnership with: western power synergy AEMO Government of Western Australia Energy Policy WA

Key Themes on decisions made

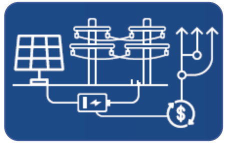


Optimise distribution network access



Build required technology and market infrastructure

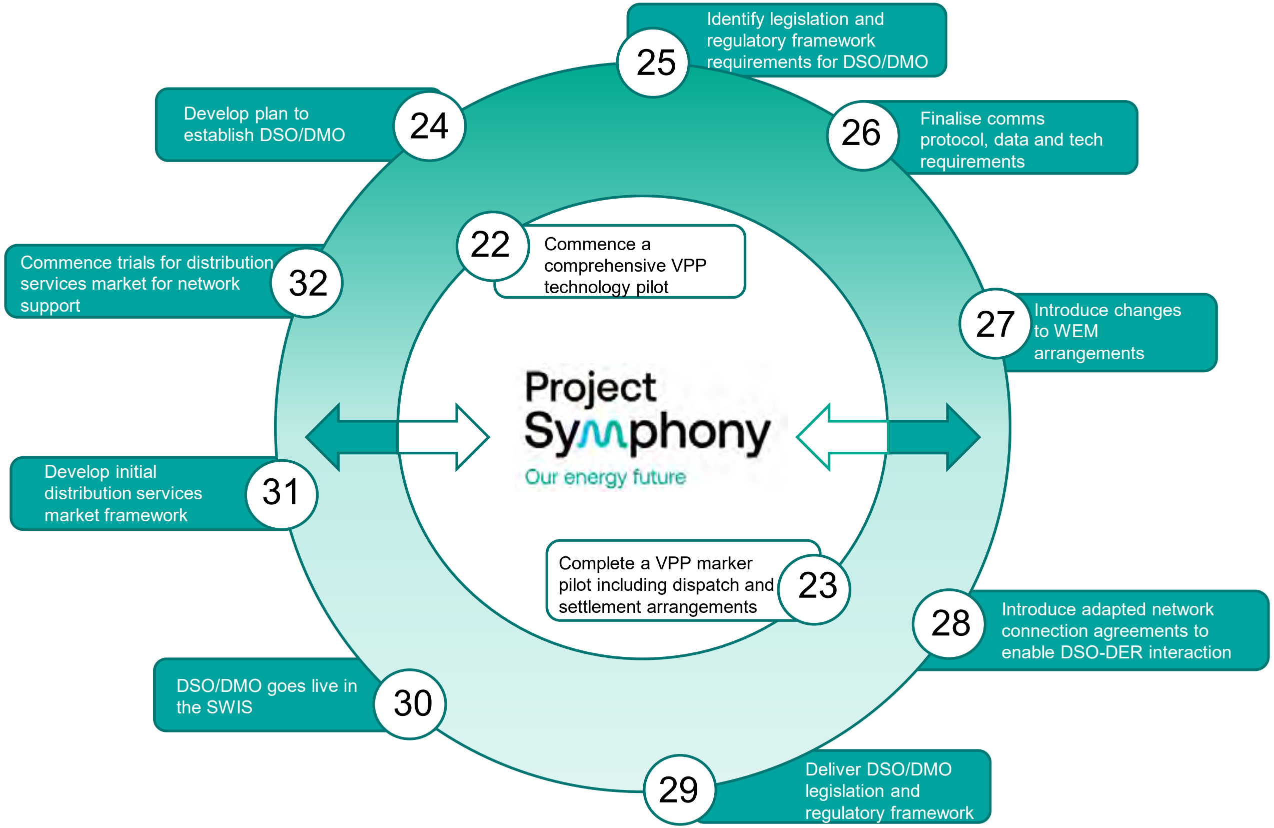
Align customer incentives and protect rights



Integrate and phase implementation

Project Symphony and its role in shaping future policy

- Project Symphony will continue to inform DER participation
- Some policy positions need to wait for project learning outcomes:
    1. Technical / IT / Comms capabilities
    2. Process DSO / DMO interaction
    3. VPP data requirements
    4. Unknown & unexpected issues



In partnership with:

Project Symphony Success Criteria & Achievements to Date

Customer participation

256/500 customers with a combined **632/900** assets

Technology solutions

MVP completed.
Full end to end testing for Network Support Services completed with continued integration testing for the Constrain to Zero scenarios up to the launch of the stability period in October

Value

$1.4B

Potential economic value.
Cost Benefit Analysis
Scope of work finalised and tender process underway

Project Edith

September 2022

Ausgrid | reposit

Price-responsive devices are **shifting the current paradigm**

Increasingly sophisticated resources

- Rooftop solar
- Batteries
- Smart appliances

Capabilities and features

- Price-responsive
- Can actively change output in response to signals
- Can be aggregated into virtual power plants to participate in energy markets

Opportunity to reward customers with flexible demand for responding to market conditions

ENERGY SECURITY BOARD

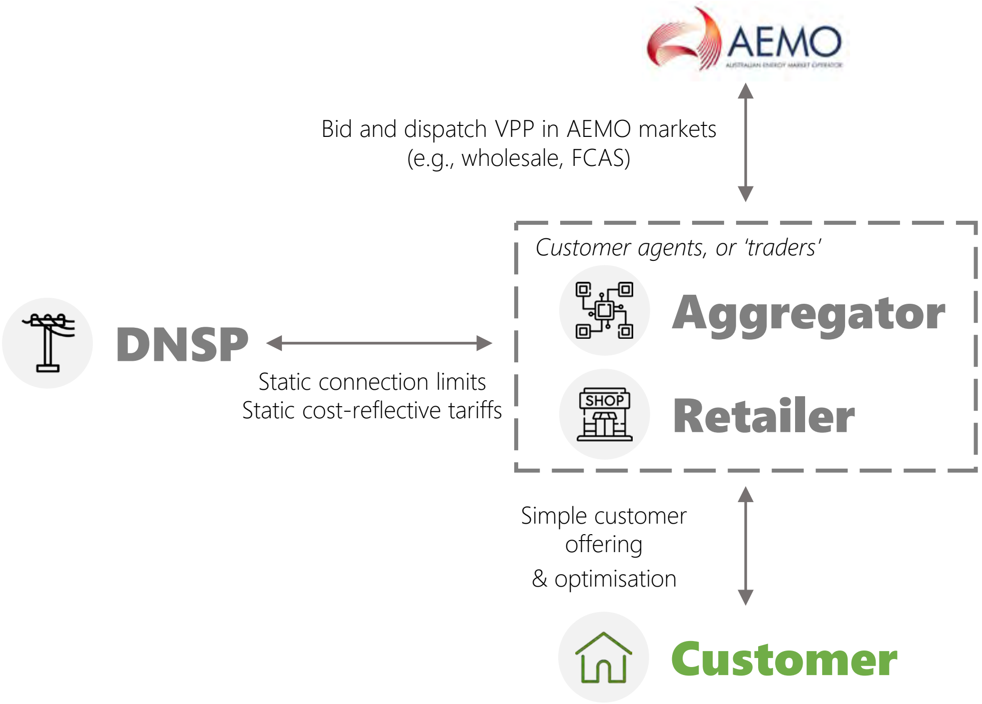
Post-2025 recommendation for a two-sided market

The ESB's CER Implementation Plan prioritises activities and reforms aimed at:

1. **Rewarding** customers for their flexible demand
2. **Integrating** flexible distributed customer resources into the market at all levels, safely and effectively

Current network services can create barriers to efficient VPPs

Aggregating price-responsive resources as VPPs



- Current network tariffs may inefficiently **inhibit the use of price-responsive resources** because they do not always reflect network constraints
- Network limits may be **too constraining during normal operation** as it aims to ensure safe operation in worst case scenarios

Improve the efficiency of VPPs by:

- Moving from current static cost-reflective tariffs into more **dynamic pricing**
- Moving from static connection limits into 'full' **dynamic operating envelopes**

Ausgrid | reposit

Note: Virtual Power Plants (VPPs) are a cloud-based network of customer resources that are aggregated and coordinated to deliver power system and energy market services.

Evolution to dynamic network pricing

Current network pricing

- Averaged across regions – **'postage stamp pricing'**
- Do not fully differentiate available network capacity by time and location – do not reflect enough what is happening **'on the ground'**

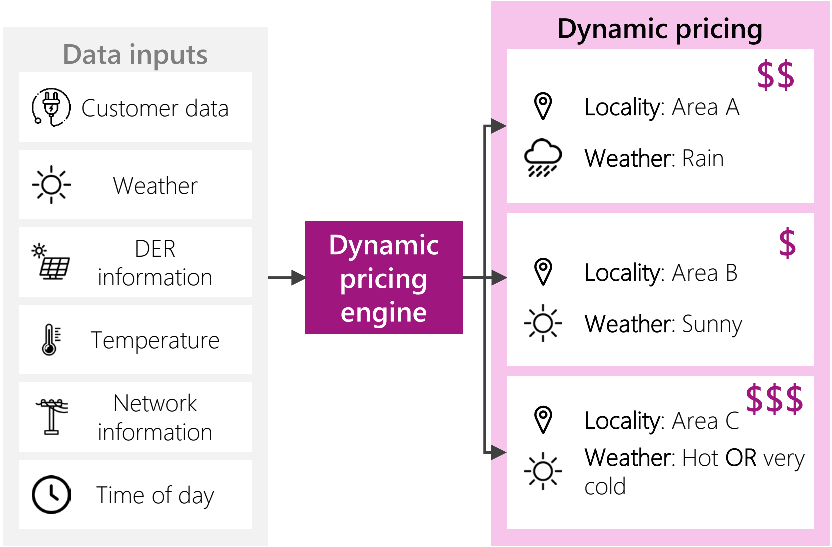
Weather: rain and clouds
PV production: low / zero
Usage charge: $$

Weather: sunny
PV production: high
Usage charge: $$

Customers face the same usage charge, regardless of real-time conditions (e.g. weather)

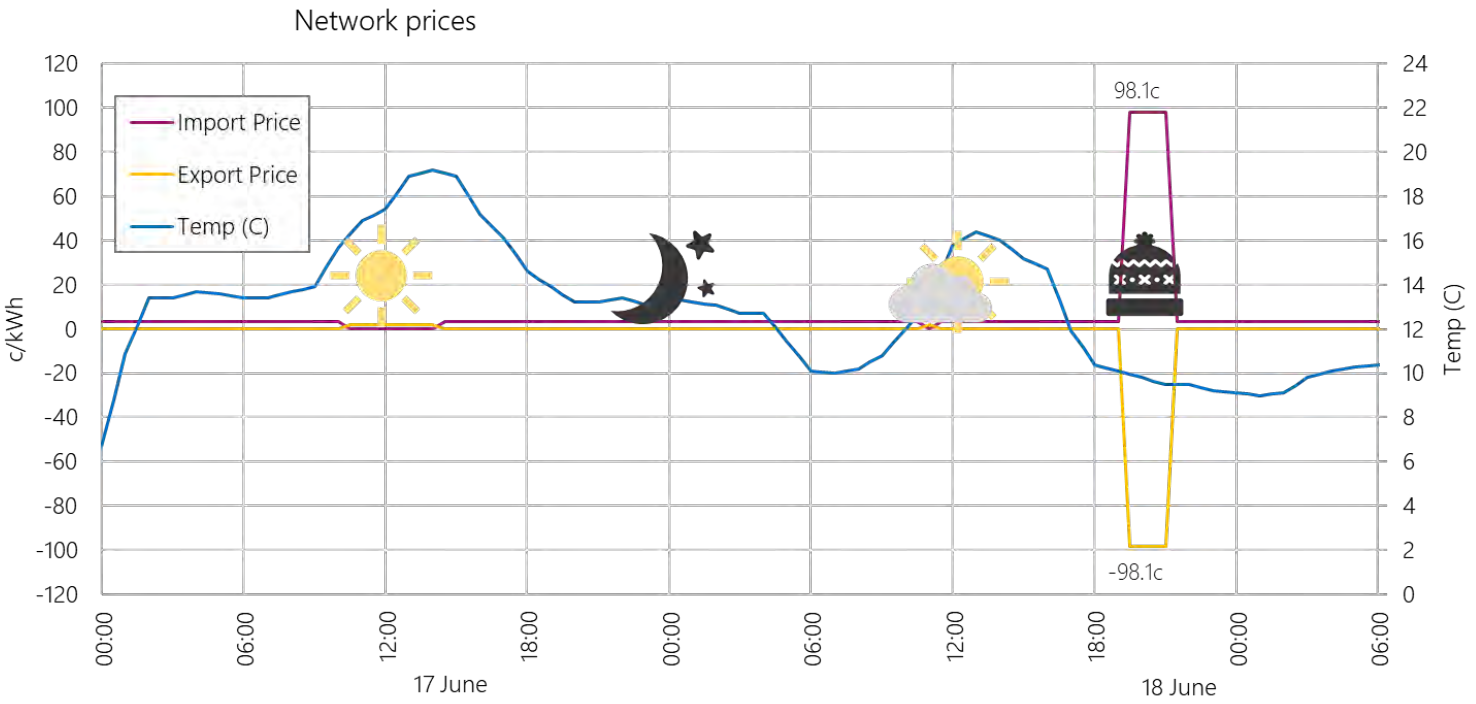
Dynamic network pricing

- **What?** Considers the cost to serve customers and operate the network, based on operational conditions
- **How?** Using time and location-specific incentives to make unused network capacity available to DER



Note: dynamic network pricing can include both positive and negative prices.

Current Dynamic Network Price



Edith network service model

Three-part tariff:

1. **Fixed charge**: residual cost recovery
2. **DOE subscription charge**: LRMC based
3. **Dynamic Energy price (5 minutes):**
   - Below subscription: free or low charge
   - Above subscription: weather dependent LRMC with some residual cost recovery

Over time we will introduce more factors (e.g. network constraint forecasts, locational variation, reactive power support).

Evolving network services could increase value for all

Added value – dynamic pricing

Added value – DOEs

AEMO

Wholesale arbitrage
FCAS

Improves certainty for market operator on wholesale and FCAS reliability

Customer agents, or 'traders'

Aggregator

Retailer

Optimised bids on markets
Benefit from negative network pricing

Certainty about available capacity for system services (know what the network constraints are)

DNSP

Dynamic prices

DOEs

Optimised use of the network
Efficient capacity allocation and rewards network support

Certainty against breaching distribution capacity limits

Simple customer offering
DER optimisation

Customer

Why we're doing a rapid demonstration

To test and demonstrate the effectiveness of managing network capacity through dynamic network pricing in a growing two-sided market.

To highlight and inform key areas in operationalising this model, such as interaction with operating envelopes, appropriate pricing principles and associated regulatory reform.

To engage and share insights within industry and to work together to deliver efficient electricity services to customers.

Project Converge

Team **Converge**

Lead, Demonstrations, Customer

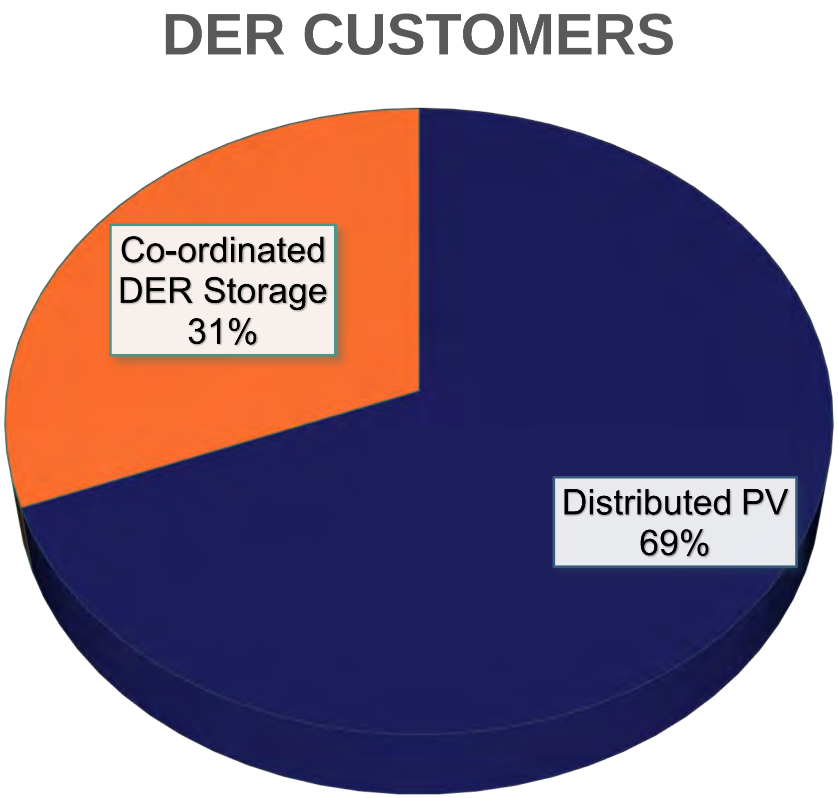
Social and Technical Research, Development and Demonstration

Technology Development, Integration and Support

Financial and Policy Support

Why Converge?

DOE v SOE

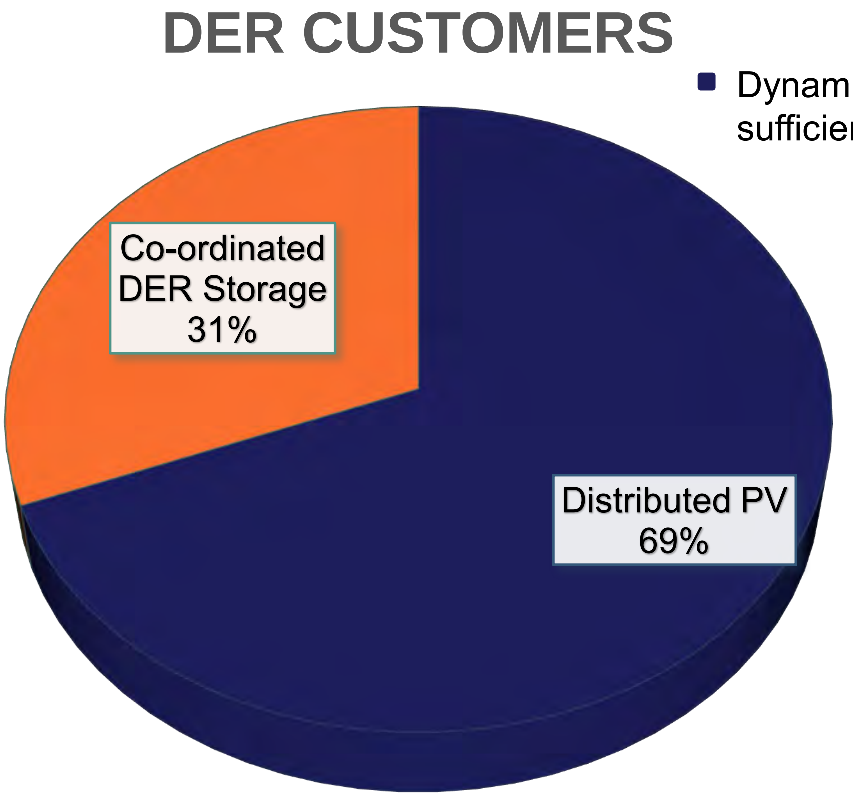


Source: AEMO 2022 ISP Figure 1, coordinated DER storage vs Distributed PV by 2050.

CONVERGE

Dynamic Operating Envelope

SOE v DOE



- Dynamic Operating Envelopes sufficient
- Represent network capacity at a point and time
- Will likely require a level of equitization to be accepted by customers and regulators

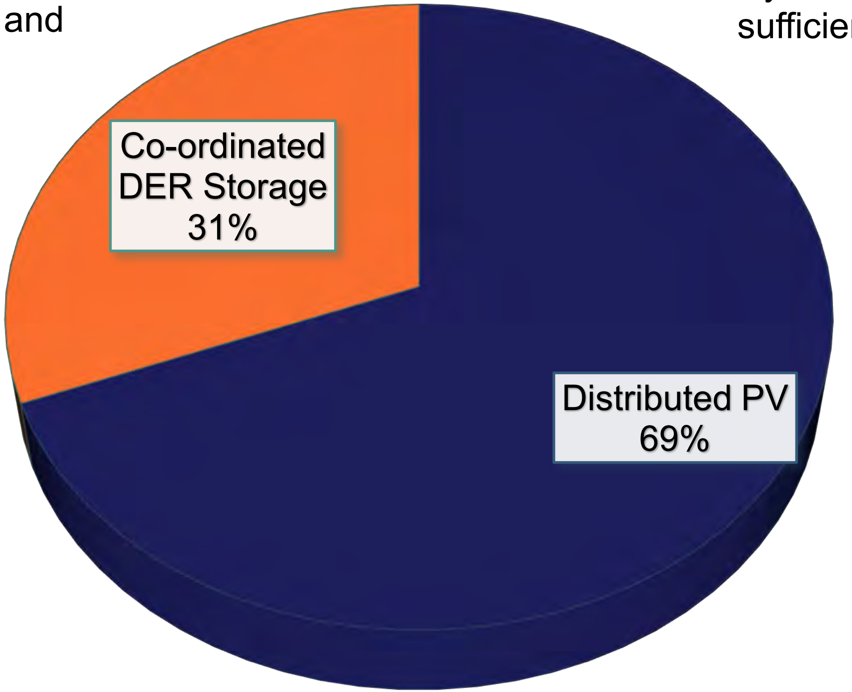
Source: AEMO 2022 ISP Figure 1, coordinated DER storage vs Distributed PV by 2050.

CONVERGE

SOE v DOE

- Advanced Aggregators want more than DOEs: Network Services and Market Participation
- Want an efficient mechanism for providing Network Support to DNSPs
- Want to maximise network connection capacity for market access

DER CUSTOMERS



Source: AEMO 2022 ISP Figure 1, coordinated DER storage vs Distributed PV by 2050.

- Dynamic Operating Envelopes sufficient
- Represent network capacity at a point and time
- Will likely require a level of equitization to be accepted by customers and regulators

CONVERGE

Objectives for SOEs

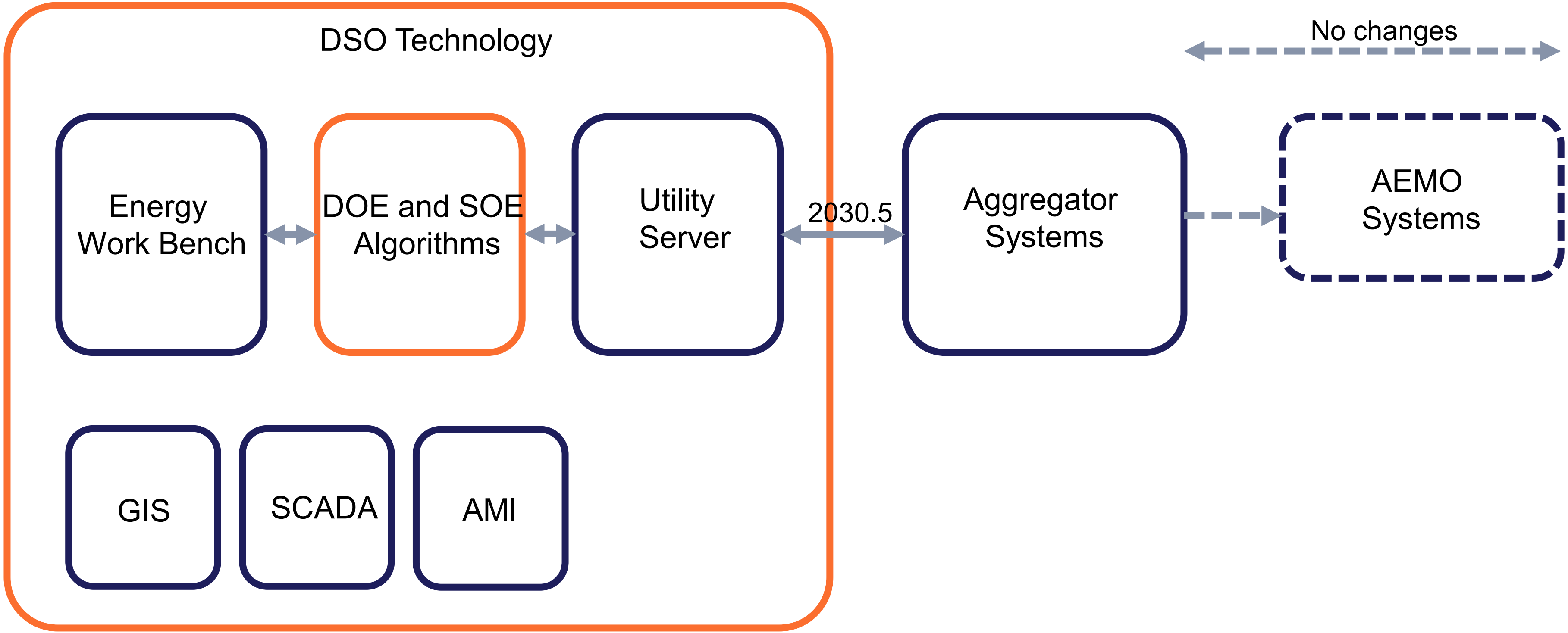
1. A single robust system for DOEs and SOEs
2. Re-uses and builds on the concepts and infrastructure of DOEs
3. Maximise the distribution network capacity in line with wholesale markets (a form of co-optimisation)- i.e. is **Market Aware**
4. Aggregator system changes are incremental, standardised, and build on DOE integration effort.
5. Network support is automated, accessed with low transaction costs, is explicit and transparent

Shaped Operating Envelopes

Dynamic Operating Envelope

Shaped Operating Envelope

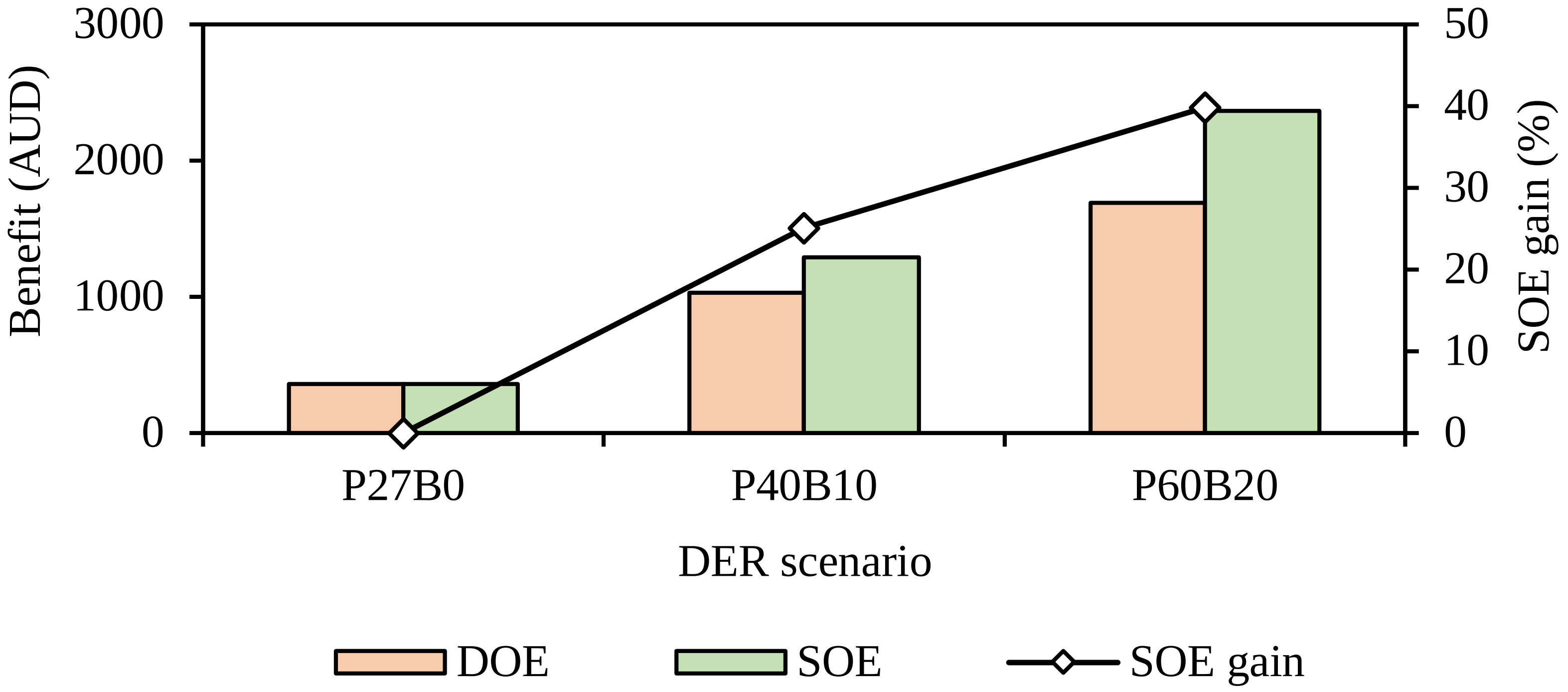
Converge Trial Architecture

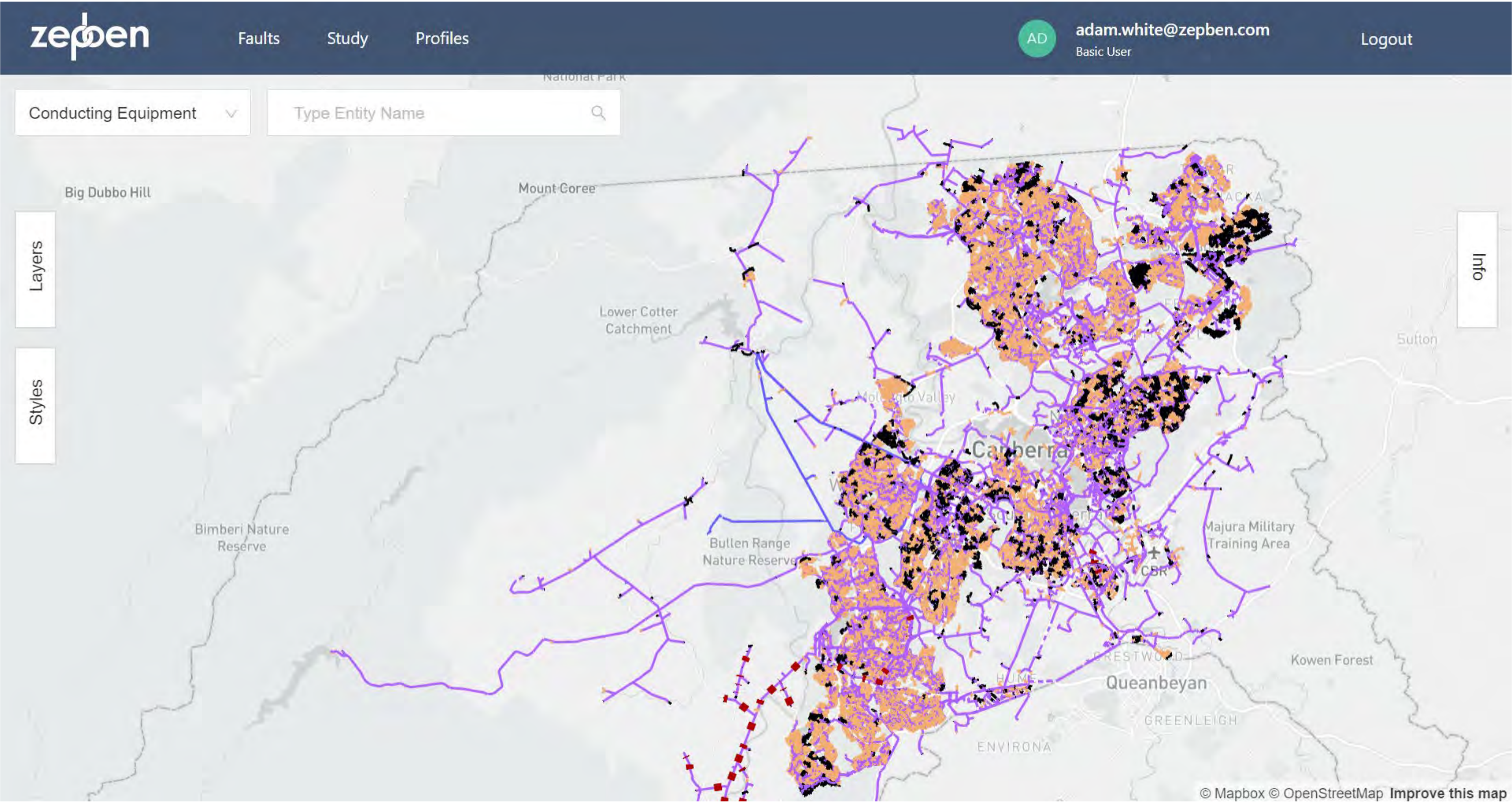


SOE Algorithm

1. Optimal Power Flow approach, similar to NEMDE
2. Uses load and pricing intentions from DER to solve.
3. Reliant on a minimum level of data for solving the algorithm- electrical network model, aggregator load and pricing.
4. Is performant but scaling requires more computing resources.

Simulation Results




zepben
Faults
Study
Profiles
AD
adam.white@zepben.com
Basic User
Logout
Conducting Equipment
Type Entity Name
Layers
Styles
Info
Big Dubbo Hill
Mount Coree
Lower Cotter Catchment
Bimberi Nature Reserve
Bullen Range Nature Reserve
Canberra
Majura Military Training Area
Sutton
CBR
Kowen Forest
Queanbeyan
GREENLEIGH
ENVIRONA
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Real-time RIT-D

Recap on RIT-D

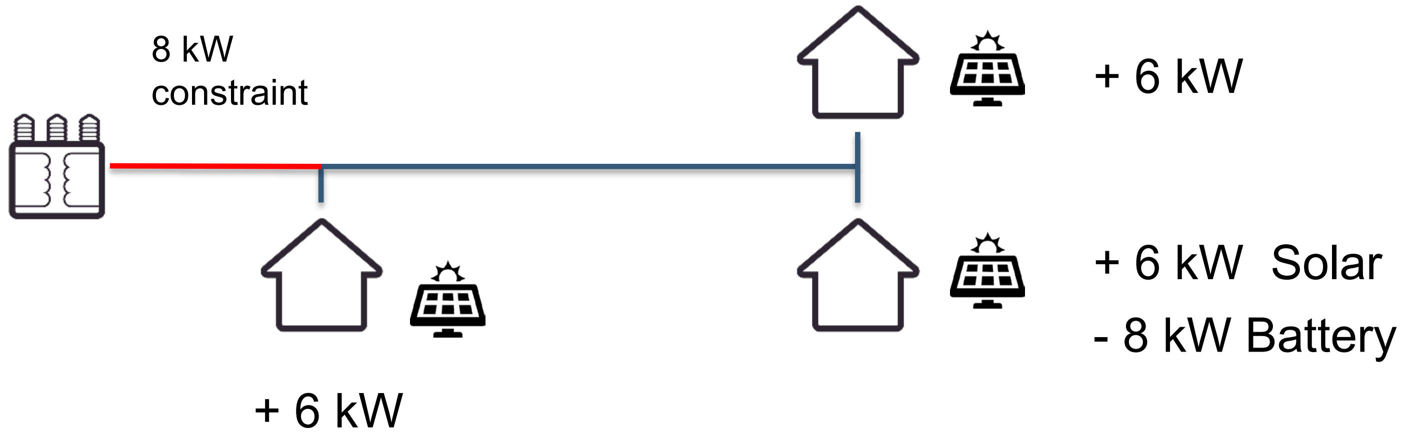
1. RIT-d "maximises the present value of the net economic benefit to all those who produce, consume and transport electricity in the NEM"

2. Net economic benefit equals the **market benefits** less **costs**

3. Needs to be conducted in a timeframe that allows for the lead time of the network options i.e. 18months +

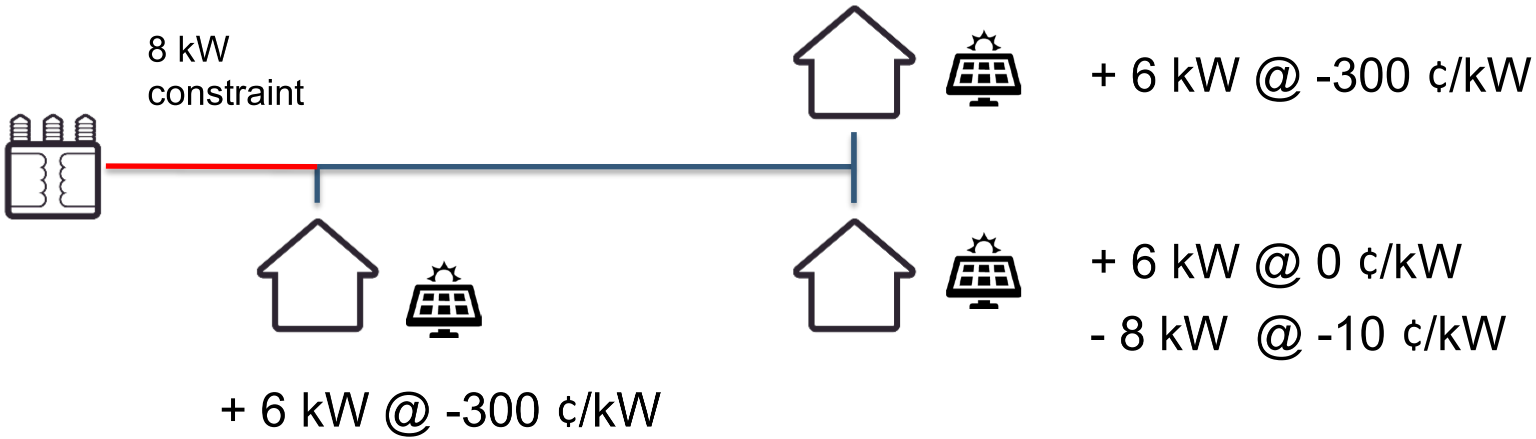
4. As we move to a more congested distribution network, with DER that can support different load patterns, the RIT-d can be calculated in closer to real-time timeframes

Real-time RIT-D

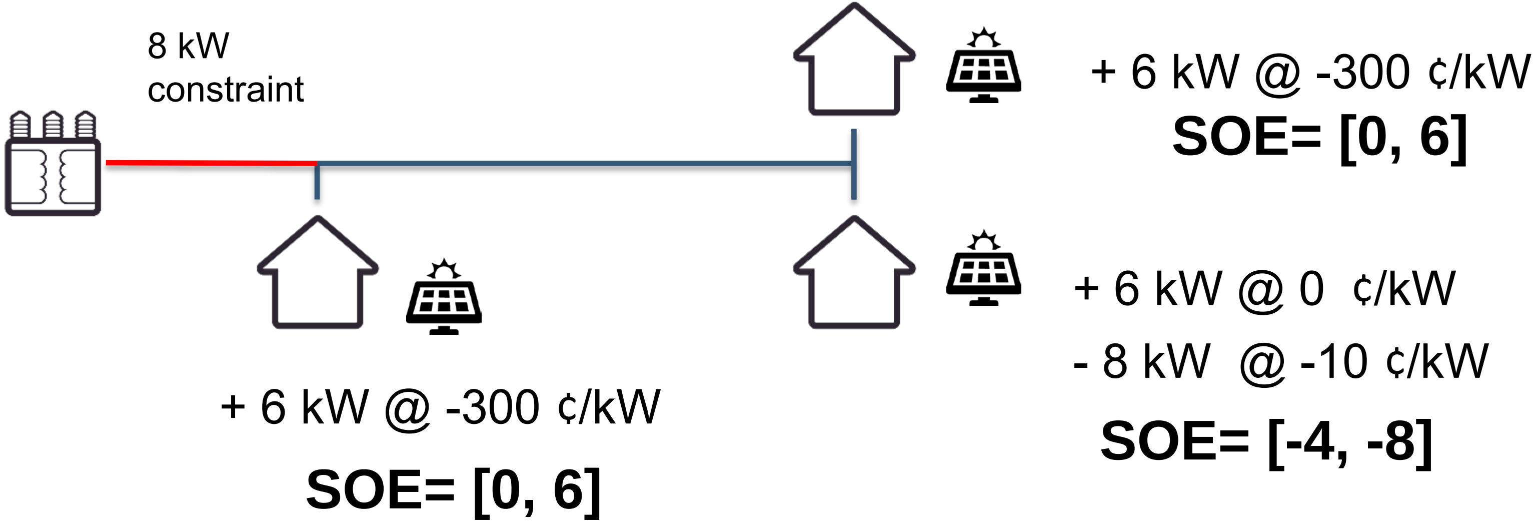


DOEs allocated at transformer level would give an export envelope of 8/3 kW (2.67kW).

Real-time RIT-D



Real-time RIT-D



Customer and Roles

Customer Roles

CONVERGE

Aggregators are engaged on a commercial basis by Evoenergy.

Trialling variety of engagement options in cohort with Aggregator and their partner organisations.

This allows research and testing of network support type programs that arise after the DER has been installed and is operating.

Understanding this element is critical in understanding how SOEs can scale.

CONVERGE

Thank you.

Join ARENA's Insights Newsletter for monthly updates and upcoming events!

Share your thoughts on the event!

DEIP

DISTRIBUTED ENERGY INTEGRATION PROGRAM

(DEIP) Distributed Energy Integration Program

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