Insights from Smart Charging Trials Data (Update)

2 August 2023

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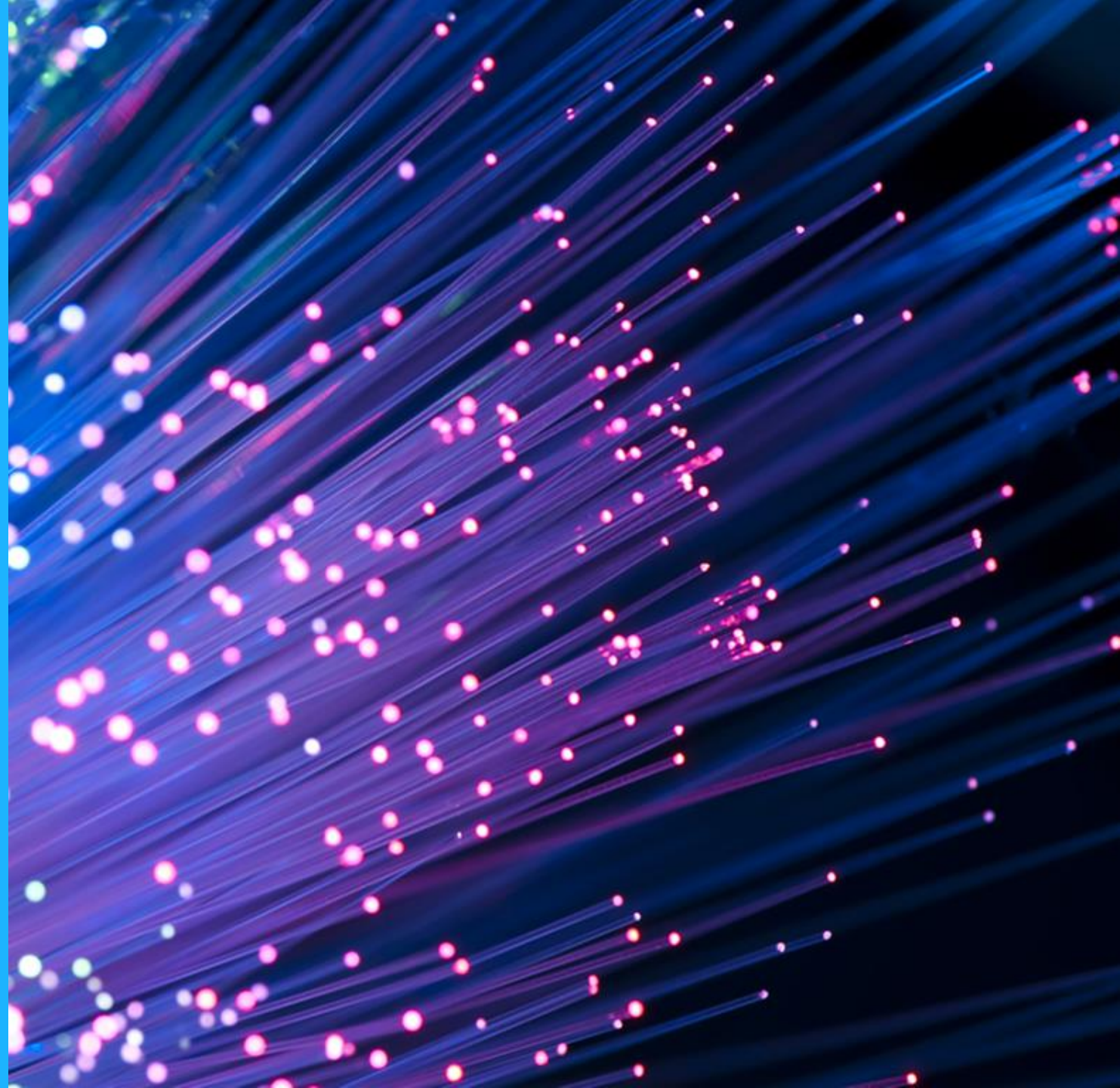

Disclaimer

This report was commissioned by the Australian Renewable Energy Agency (**ARENA**). The report presents the findings of Energeia, which was prepared to share *Insights from ARENA Ultra-Fast Charging Network Data.* The report is provided as is, without any guarantee, representation, condition or warranty of any kind, either express, implied or statutory. ARENA and Energeia do not assume any liability with respect to any reliance placed on this report by third parties. If a third party relies on the report in any way, that party assumes the entire risk as to the accuracy, currency or completeness of the information contained in the report.

To the best of ARENA and *Energeia*'s knowledge, no conflict of interest arose during the course of preparing this report. While Energeia has previously conducted reports, evaluations and other work for ARENA, Energeia has not received any grant funding from ARENA.

Executive Summary – Key Learnings

- **Unmanaged Charging Patterns – Trial participants avoid charging patterns which negatively impact the grid, potentially due to the underlying tariffs**
  - Plug-in Electric Vehicle (PEV) customer charging profiles are different from AEMO's assumed load profiles; more evenly distributed across the day with a low at 7am
  - Battery Electric Vehicle (BEV) customers typically charged overnight, did not exhibit behaviour of charging immediately when they arrive home during typical system peak hours of (3-9pm); 10am to 9pm was flat, and 11am to 1am was the peak
  - Customers with rooftop solar panels coordinate charging during solar hours
  - Regional customers have larger charging load requirements than urban dwellers
  - Large parts of the unmanaged control period were during COVID lockdowns. However, a recollection of baseline data shows that customers exhibit similar charging times
- **Smart Charging Impacts – EV charging load is 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 smart charging behaviour changes on a daily basis, even with only a modest bill discount
  - EV drivers are unlikely to opt-out of ad-hoc load control events should their vehicle be plugged-in
  - Having morning and evening control periods for smart charging still leaves customers with enough opportunity to charge their EVs during network off-peak periods
  - Smart charging-controlled limits to charging during managed 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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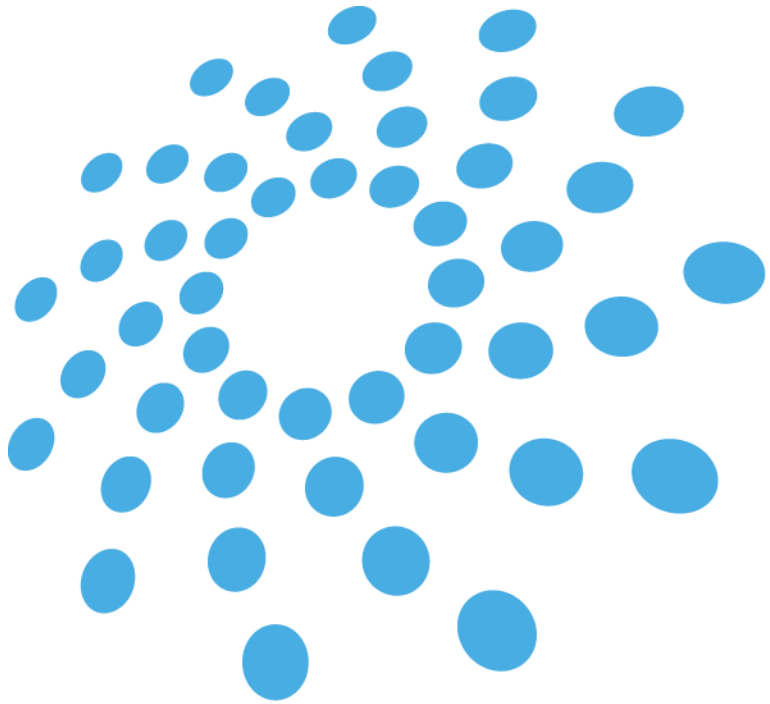
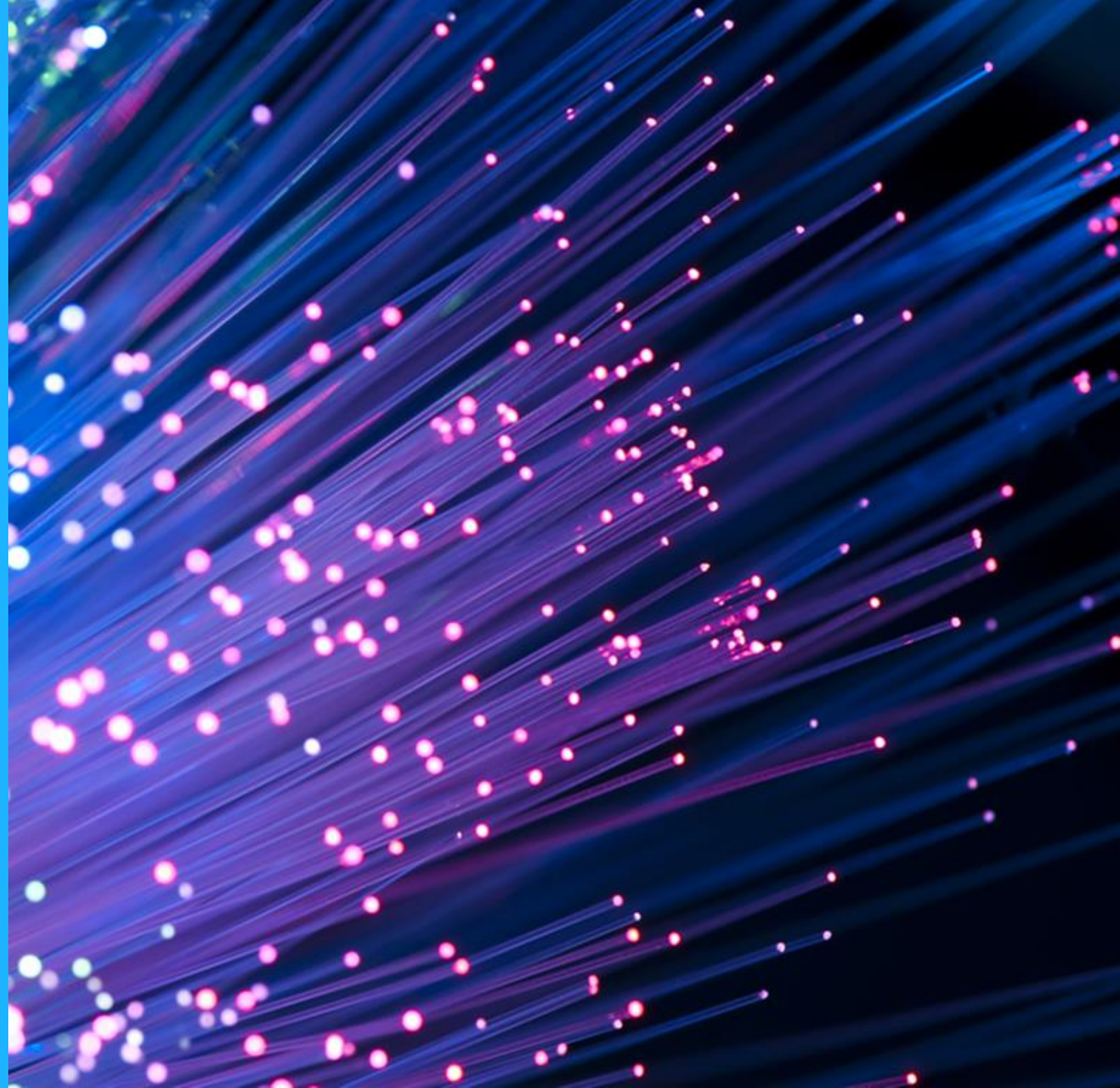


Background

Projects Included in this Insight

Role of the Knowledge Sharing

Key Stakeholder Questions about L2 Charging



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ARENA's EV Projects Included in this Insight

Trial Commenced	Trial Concluded	Project Name	ARENA Funding	State	Lead Organisation	Summary
2021	Apr 2023	Electric Vehicle Orchestration Trial	$2.3m	NSW, QLD, VIC, SA	agl	Demonstrate a range of smart and managed charging solutions including controlled, smart and vehicle-to-grid charging
2021	Feb 2023	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	Dec 2022	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 level 2 (L2) charging and the potential for various forms of load control

The Role of the Knowledge Sharing Agent

- 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 agent 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*.

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

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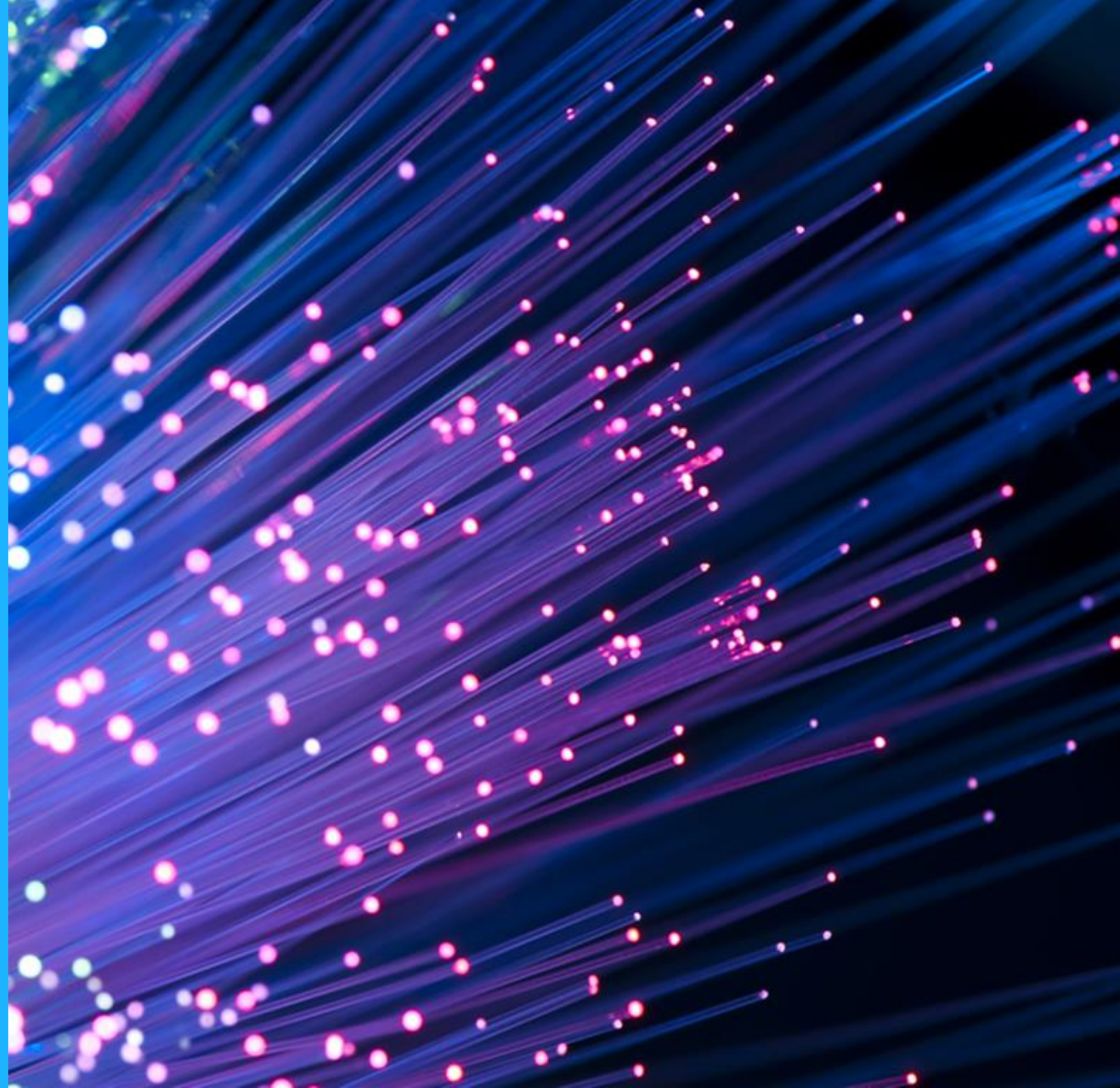
Trial Context

Summary of Charging Trials

Trial Timelines



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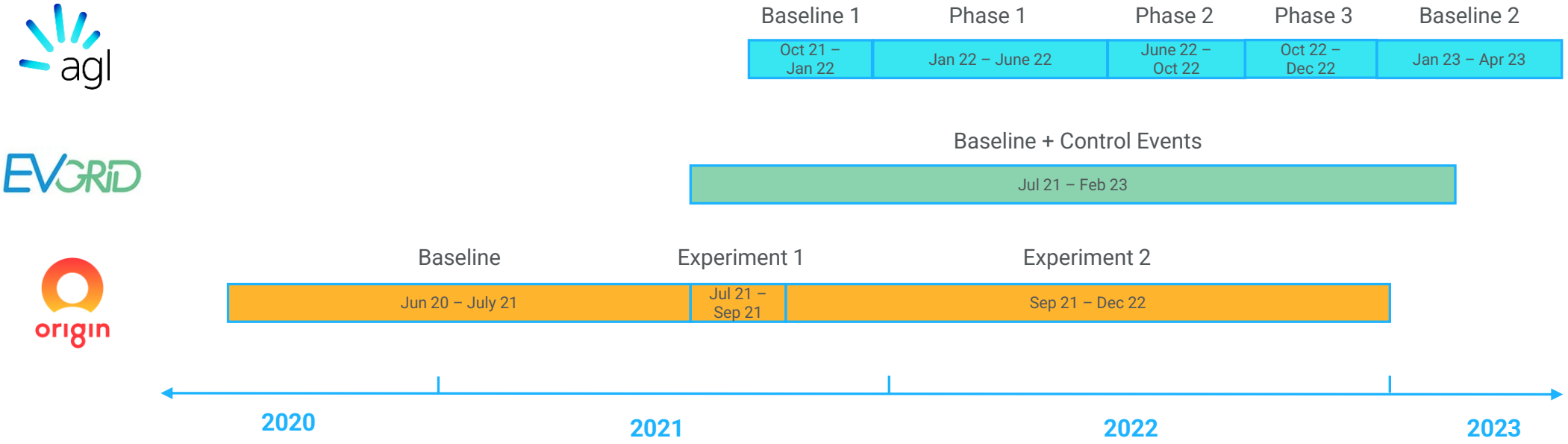
Summary of Charging Trials

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	Fixed (10am - 3 pm, 9pm - 5am)
Method of Management	Incentive	✓ Fixed ($/day)	✓ Fixed[2]	✓ 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] ad-hoc events, [2] 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

ARENA's Smart EV Charging Trial Timelines



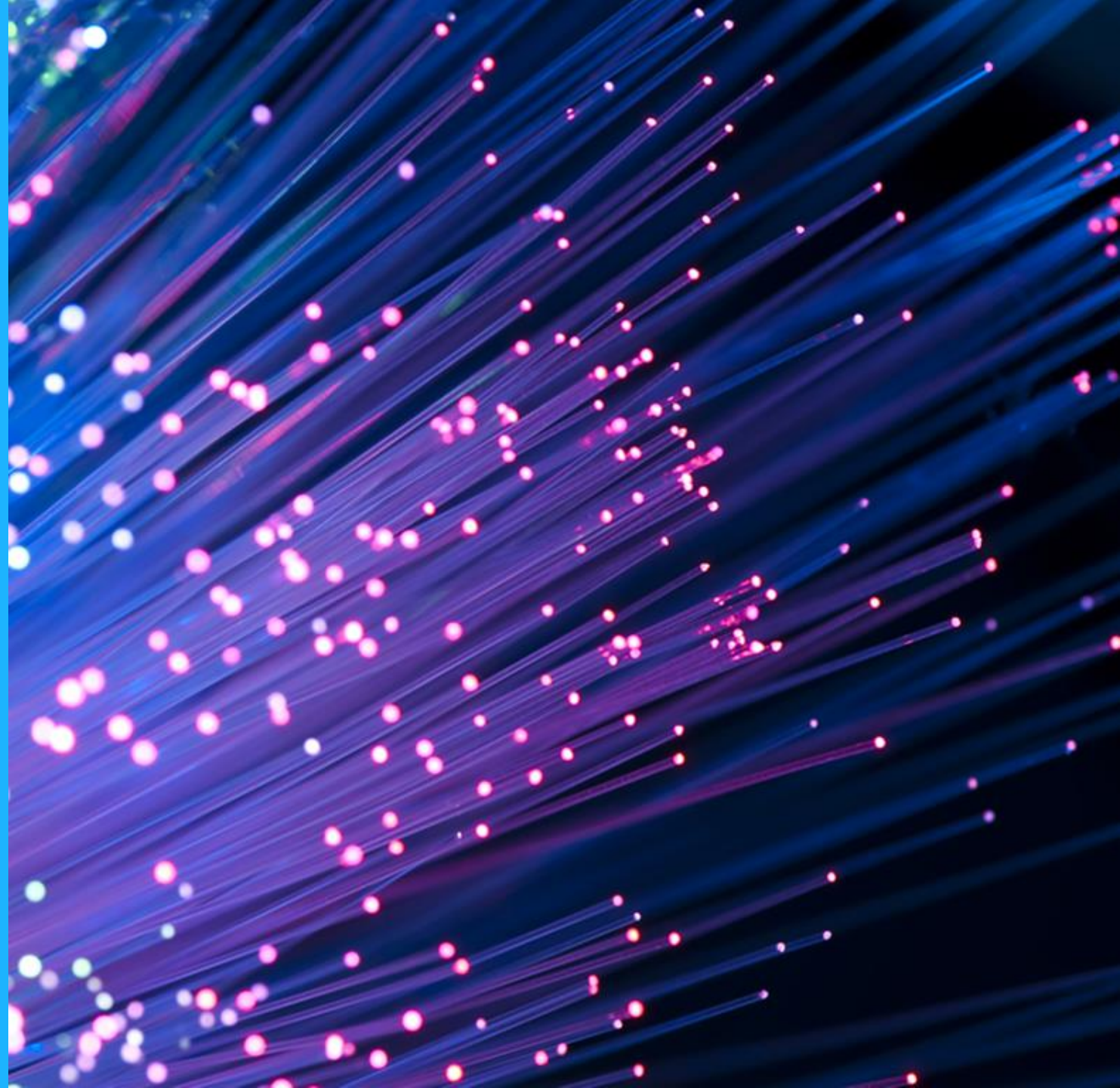
Source: AGL, EVGrid, Origin Energy

- Timelines of the trials conducted are outlined above
  - Each trial undertook a Baseline period of data collection, ahead of trial periods
  - EVGrid control events were conducted on single days throughout the trial
- COVID-19 lockdowns occurred during trials, to a varying extent
  - AGL elected to conduct a second baseline in 2023 to account for the impact

Key Insights

Unmanaged Charging

Smart Charging



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Unmanaged Charging

Unmanaged Charging by Trial

Average Profile over Time

Average Profile by Customer Characteristics

Average Profile by Vehicle and Charger Type

Impacts of COVID-19 on Unmanaged Charging

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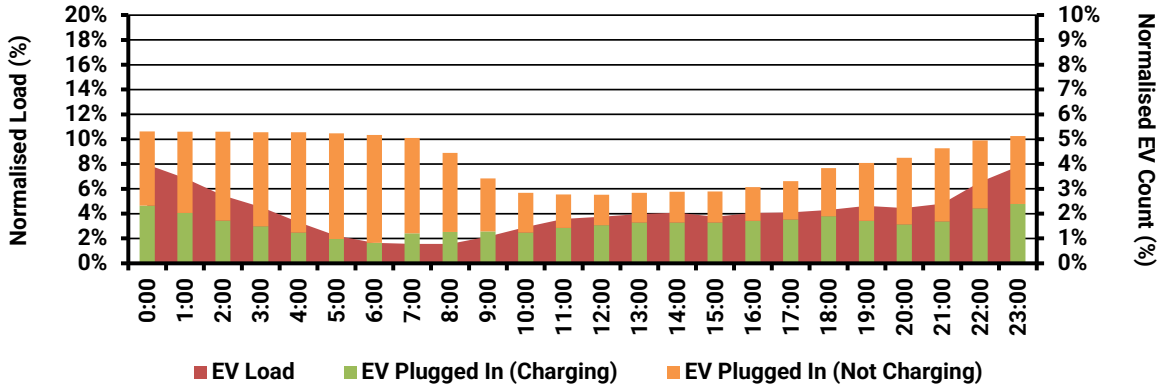
Average Unmanaged Hourly Charging Load Shape by Trial

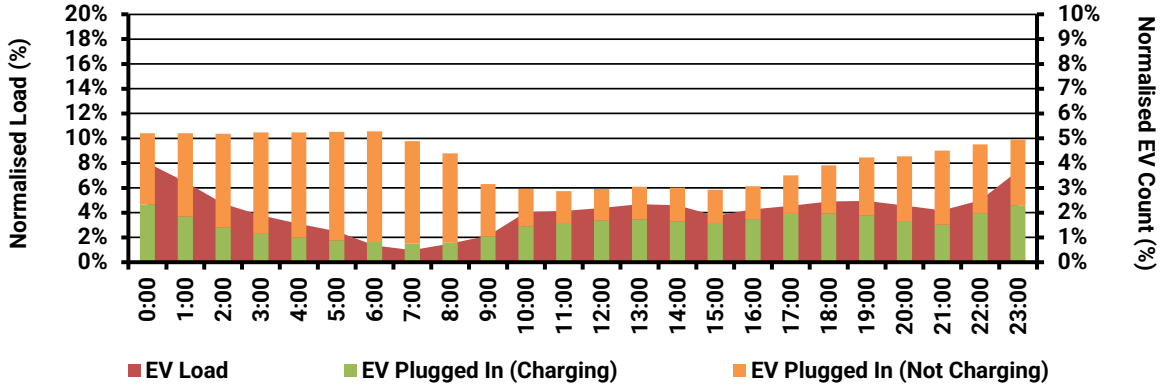
AGL



Source: AGL, Note: 125 customers

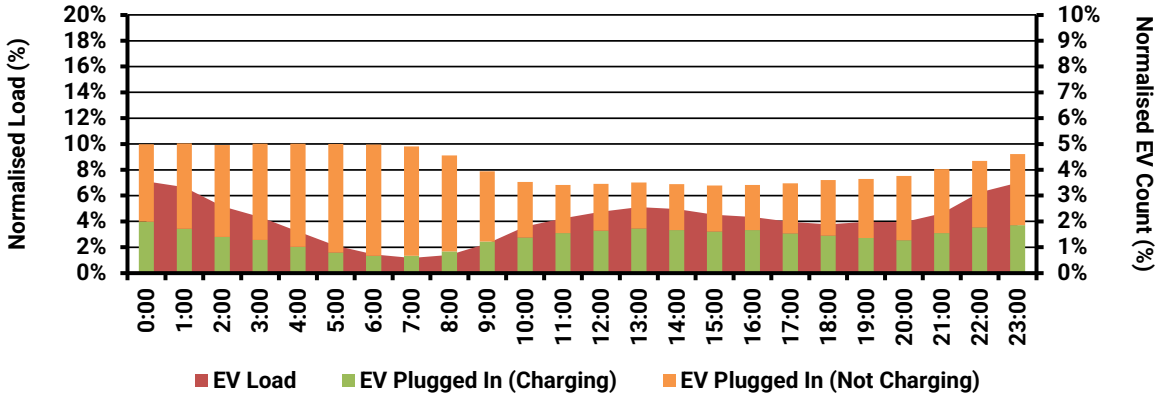
- Load normalisation on a kWh/day, count normalisation on total plug-ins/day
- Load increased when customers plug-in overnight, and is lowest in morning
- Increase in charging load in middle of the day suggests customers actively charged with solar PV
- No observable increase in load between 3-9pm, the 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

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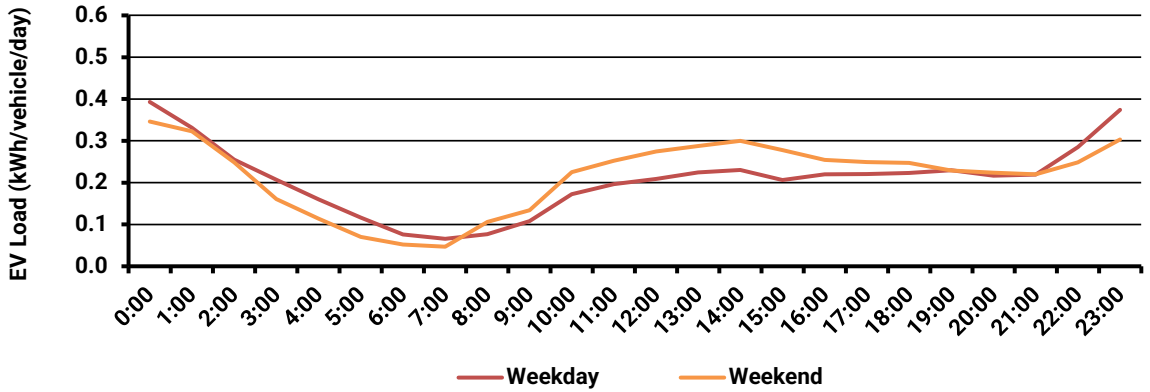
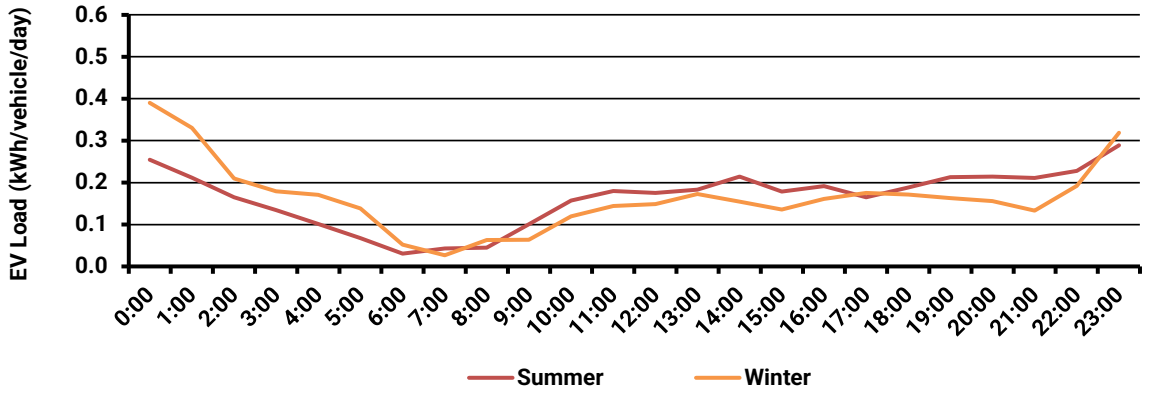
Average Hourly Charging Load – Time Variation

Weekday vs. Weekend



Source: Origin, AGL, Note: 67 Origin customers (period: Jun 20-Jul 21), 131 AGL customers (period: Jan 23-Apr 23)

Summer vs. Winter



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

- 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 are slightly 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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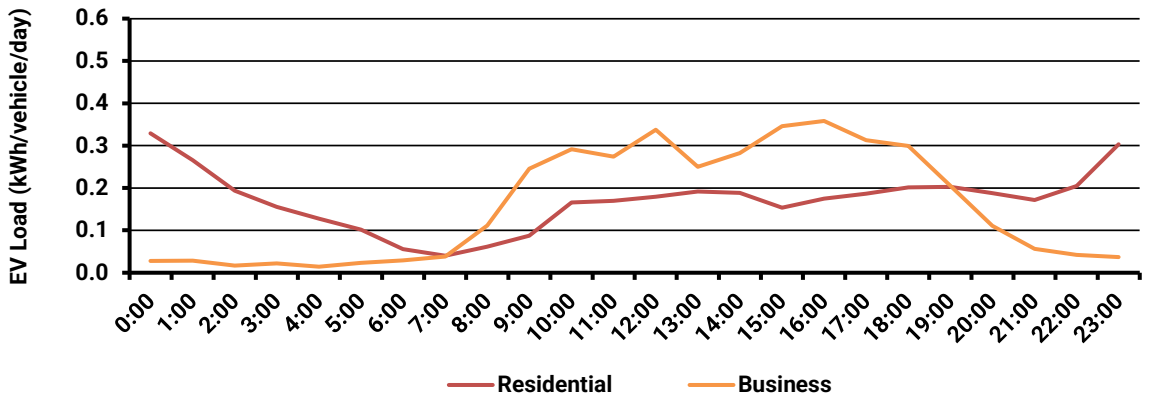
Average Charging Load Shape – Customer Variation

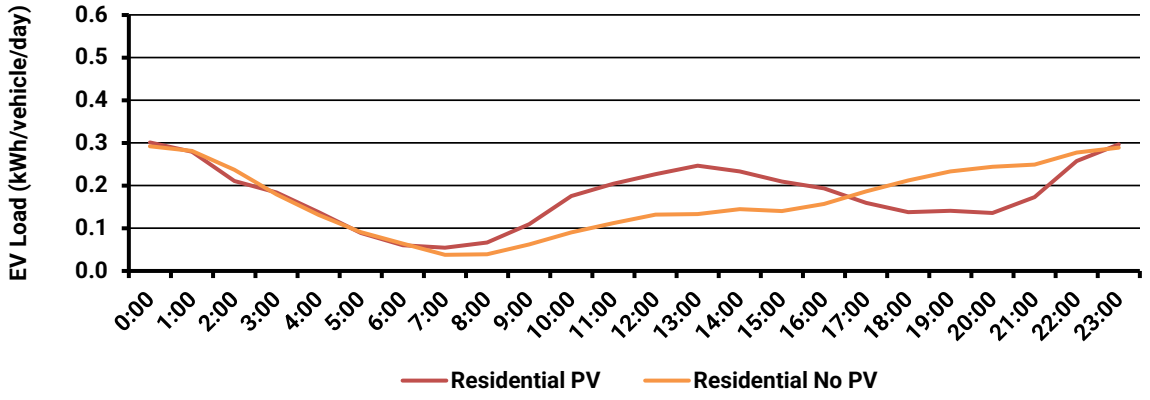
Residential vs. Business



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

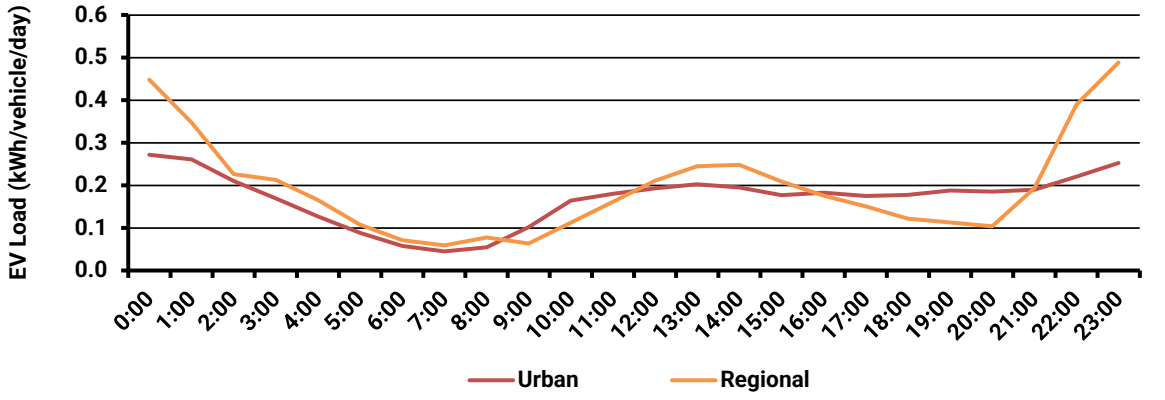
- Business participants contributed a small portion of the sample size collected, but have a distinct day time profile reflecting typical business hours
- Participants with rooftop solar PV were far more likely to charge in the daytime when solar production is highest
- Regional participant EVs had a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

Residential w/ vs. w/out Rooftop Solar PV



Source: EV Grid, Note: 119 w/ Solar PV, 44 w/out Solar PV

Urban vs. Regional



Source: EV Grid, Origin, Energeia, Note: 190 Urban, 40 Regional Customers

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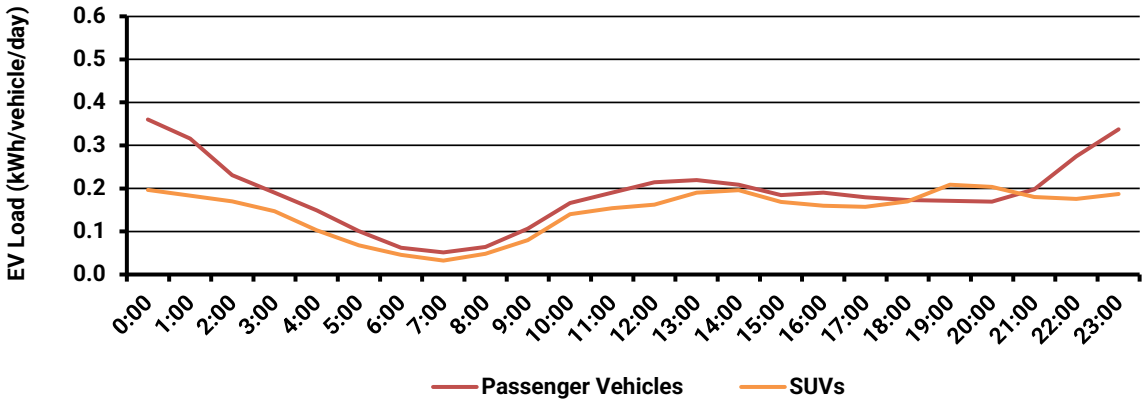
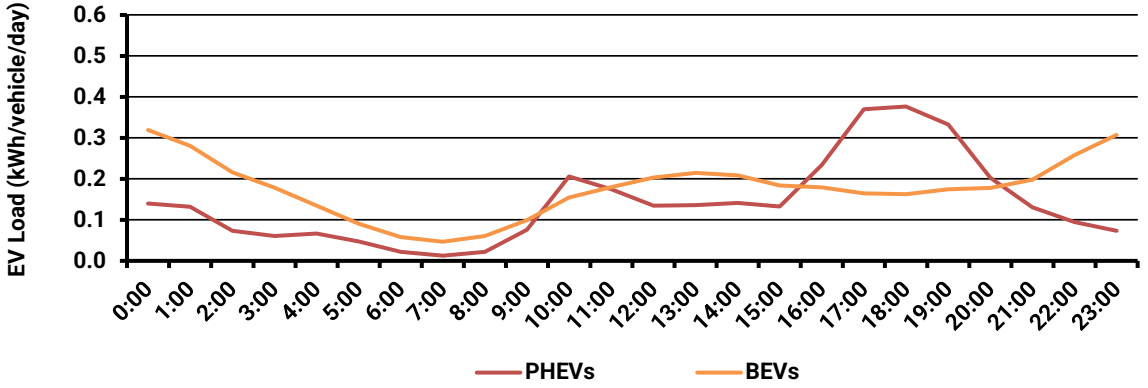
Average Charging Load Shape – Vehicle Variation

Passenger vs. SUV



Source: EV Grid, Origin. Note: 156 Passenger Vehicles, 66 SUVs

BEV vs. PHEV



Source: Origin. Note: 12 PHEVs, 218 BEVs

- 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

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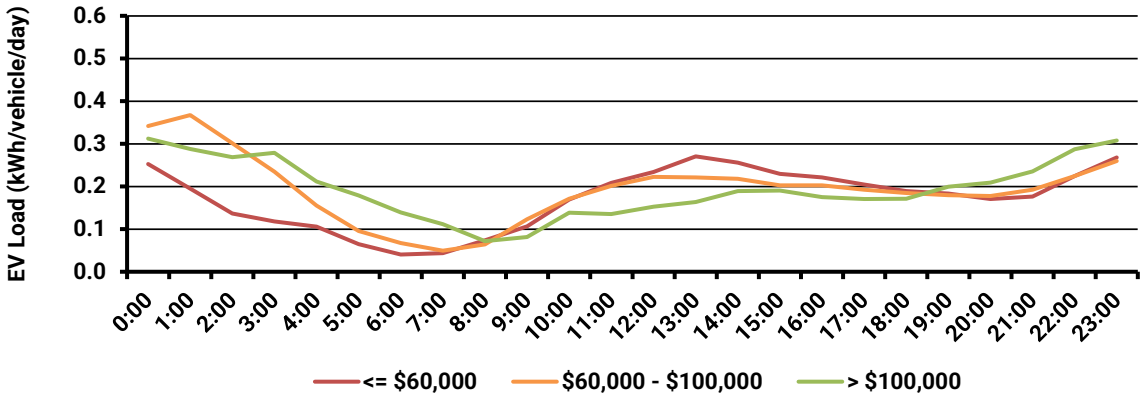
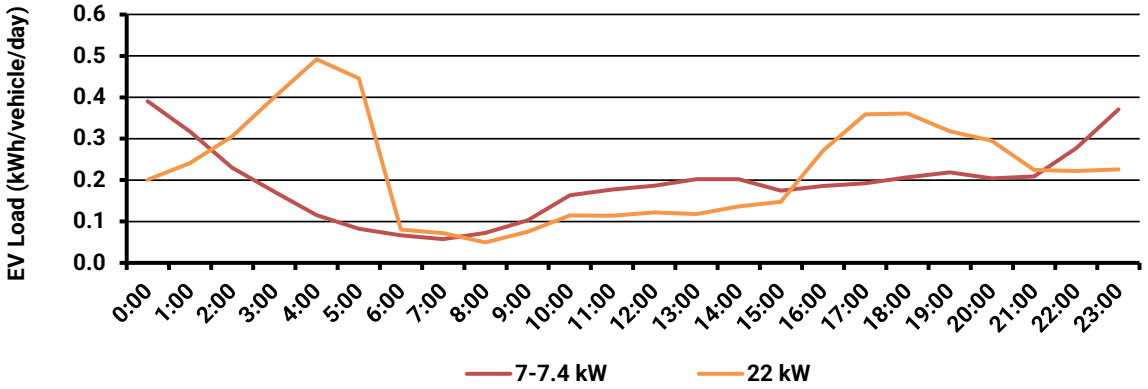
Average Charging Load Shape – Vehicle Variation

Vehicle Price Band



Source: EV Grid, Origin. Note: 108 low price band customers, 94 medium price band customers, 19 high price band customers

Vehicle Charger



Source: AGL, Origin, Note: 13 22kW chargers, 156 7-7.4 kW chargers. Early morning spike caused by single charger.

- The upper chart shows the load shape for vehicles split by price band
- The unmanaged profiles indicate that there is variation in charging times based on vehicle price
  - Higher priced vehicles appear to charge more at night
  - Lower price vehicles tended to charge more during the day
  - All have a similar charge rate during evening peak times
- The lower chart outlines charging profiles by charger power
  - 22 kW charging is predominantly from business customers, which potentially explains load shape

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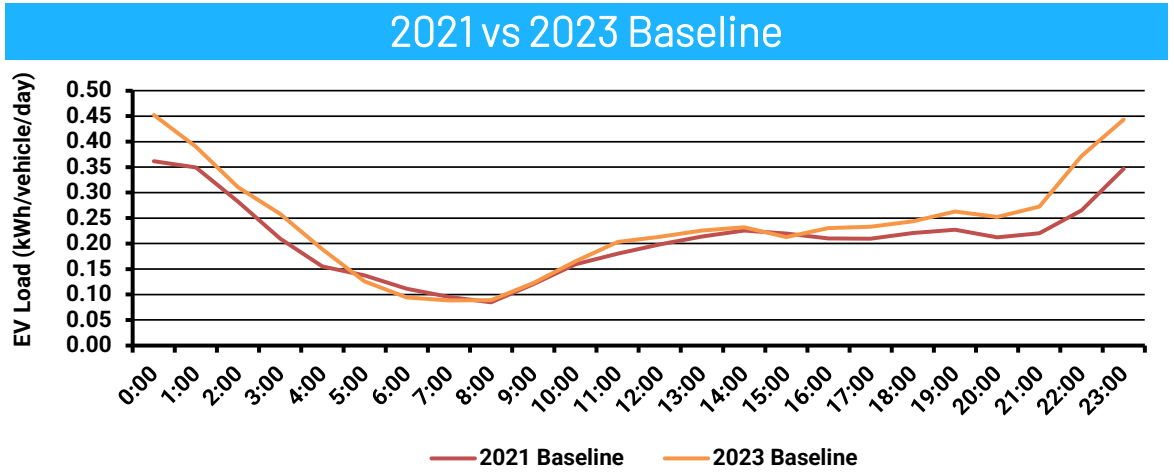
Updated BaU – AGL Baseline Data Re-Collection



Source: AGL. Note: 145 Baseline 2021 customers, 125 Baseline 2023 customers

- AGL re-collected unmanaged baseline charging data during the beginning of 2023
  - Aim was to collect baseline data not impacted by COVID-19 lockdowns
- Results show minimal difference in charge times during and after lockdowns
  - Suggests that charge time behaviours are robust against changes in frequency of vehicle usage
- Average daily EV consumption per vehicle varied during and post lockdowns with
  - 5.02 kWh per day during 2021 lockdowns
  - 5.68 kWh per day in 2023

Smart Charging – AGL

Load Shapes

Participation

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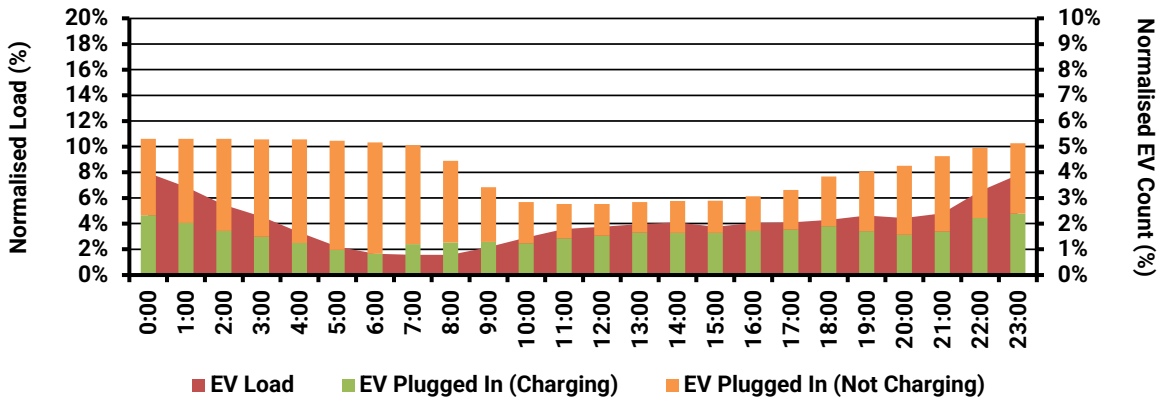
AGL – Unmanaged vs Smart Charging Profiles

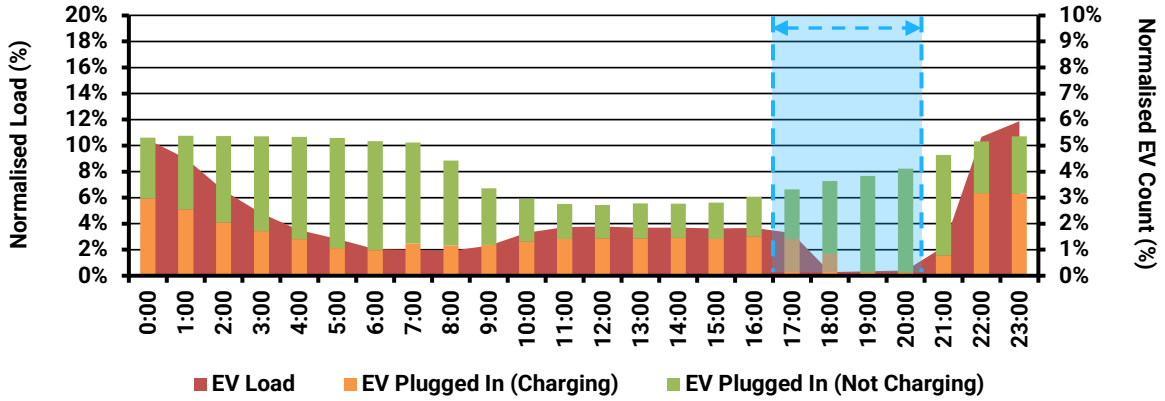
Unmanaged Profile – Weekday



Source: AGL, Energeia Analysis, Note: 125 customers

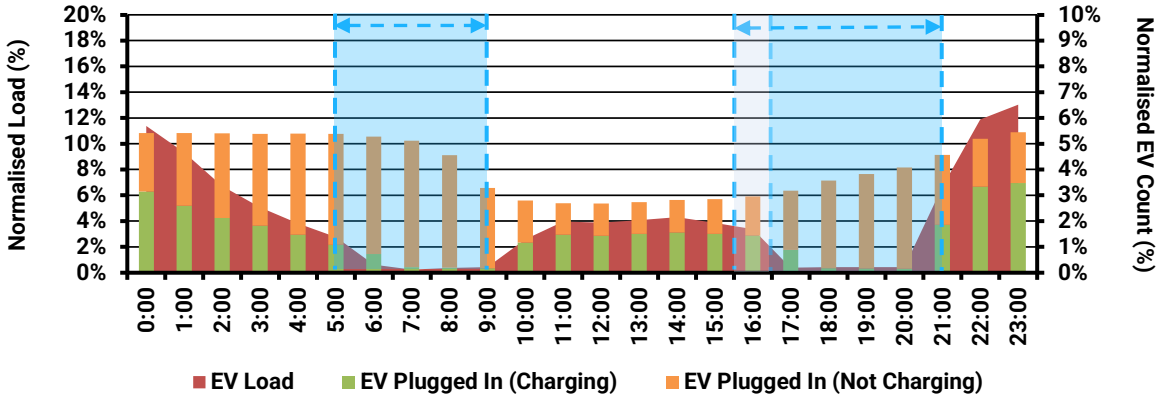
- The charts show unmanaged vs Phase 1 and Phase 2 of Smart Charging
  - **Phase 1**: Evening
  - **Phase 2 + 3**: Morning + Evening
- AGL conducted smart charging every weekday throughout the entire trial period
- Updated baseline data is used in comparison, to avoid impacts of 2021 COVID-19 lockdowns
- 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 overnight

Smart Charging – Phase 1 (Weekday)



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

Smart Charging – Phase 2 + 3 (Weekday)



Source: AGL, Energeia Analysis. Note: 148 customers. Period start and end time varies up to half an hour by state. Blue indicates smart charging period, where Phase 3 starts 1 hours earlier

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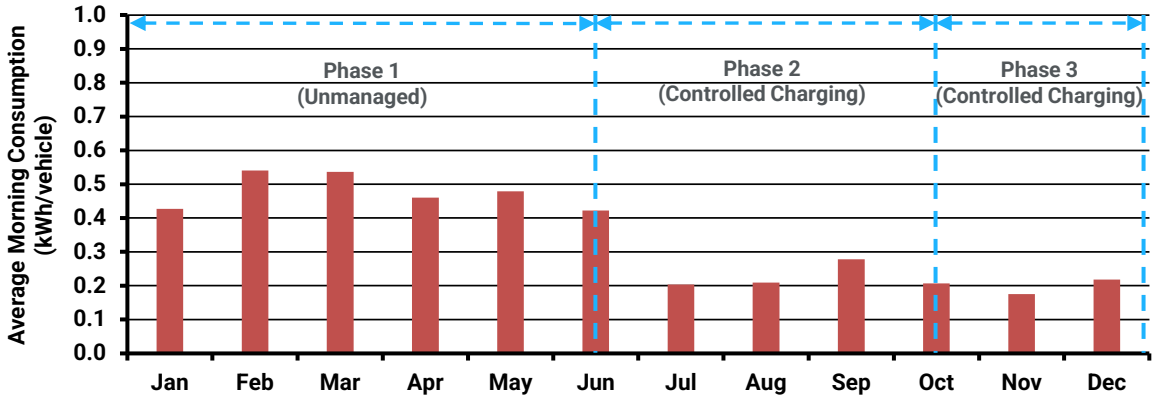
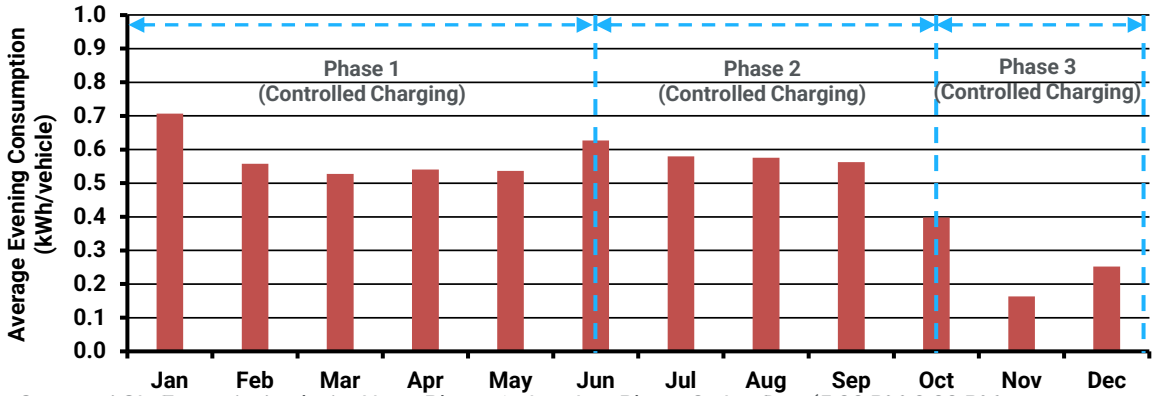
AGL – Smart Charging Opt-Out Behaviour

Morning Period Average Consumption



Source: AGL, Energeia Analysis. Note: Phase 2: Jun-Dec (5:30 AM-9:30 AM)

Evening Period Average Consumption



Source: AGL, Energeia Analysis. Note: Phase 1: Jan-Jun, Phase 2: Jun-Dec (5:30 PM-8:30 PM, to account for varying start times)

- The charts show customer average customer consumption during smart charging period across all months of the trial
  - Charts show fixed local time across all period of trial
  - Morning and evening period timing considered only hours where all states + phases overlap
- AGL trial aims to limit consumer energy consumption during the trial smart charging timeframes:
  - **Phase 1**: Jan – June, Evening
  - **Phase 2**: June – Oct, Morning + Evening
  - **Phase 3**: Oct – December, Morning + Evening (evening period shift)
- Findings show that controlling morning charging does not appear to impact how customers responded to evening charging control
- Evening control period experiences progressively lower consumption over the trial period – indicating lower opt-out rates
- Morning charging shows limited change in demand trends from the onset of control from late June onwards

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Smart Charging – EV Grid

Load Shapes

Participation

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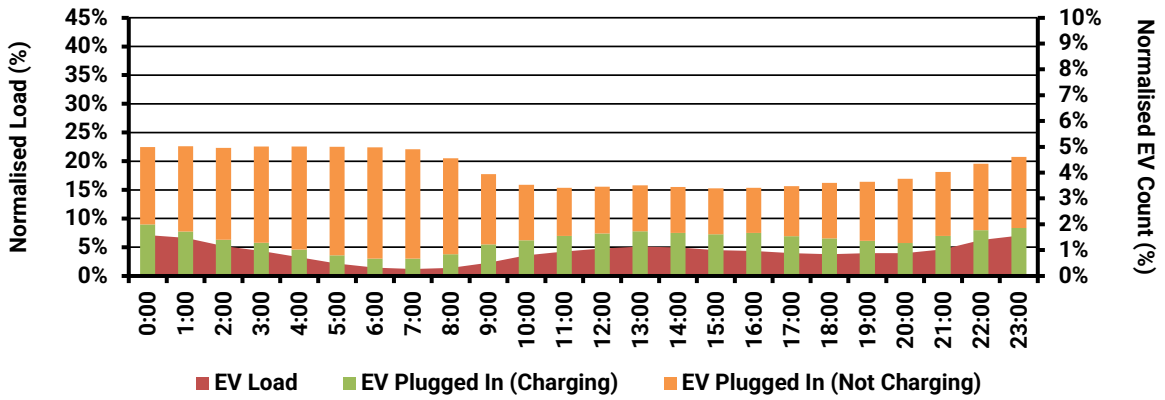
EV Grid – Unmanaged vs Smart Charging Profiles

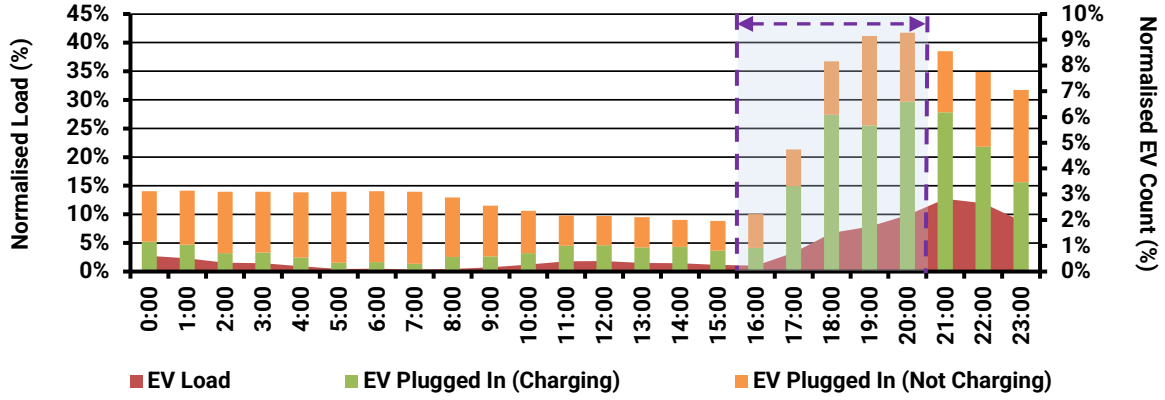
Unmanaged – Weekday



Source: EV Grid, Energeia Analysis

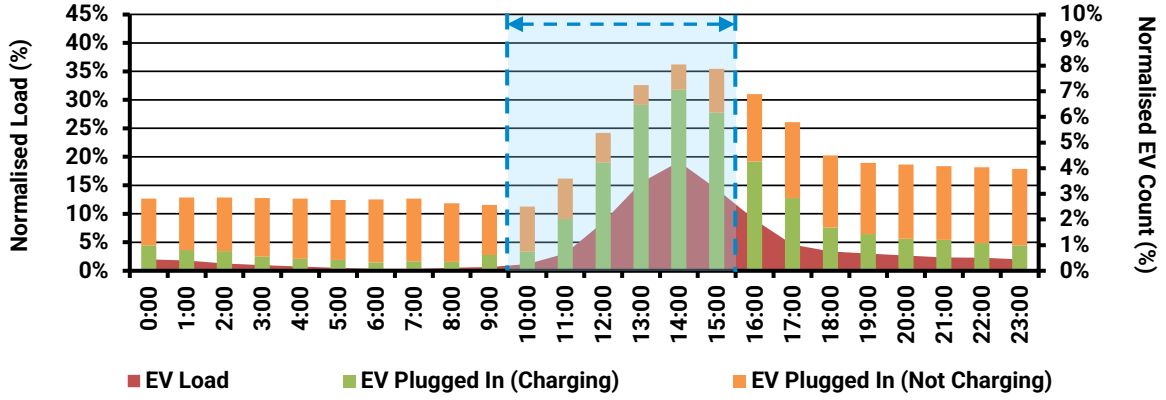
- The charts show unmanaged vs dynamic trials
  - **Demand Response**: 5 events, aimed to investigate ability to control demand in peak period
  - **Solar Soaker**: 5 events, aimed to incentivise demand during solar hours
- Trial figures contain all customers regardless of opt in/opt out
- Customers 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 period

Solar Soaker – Weekday



Source: EV Grid, Energeia Analysis. Note: Blue indicates incentive to charge

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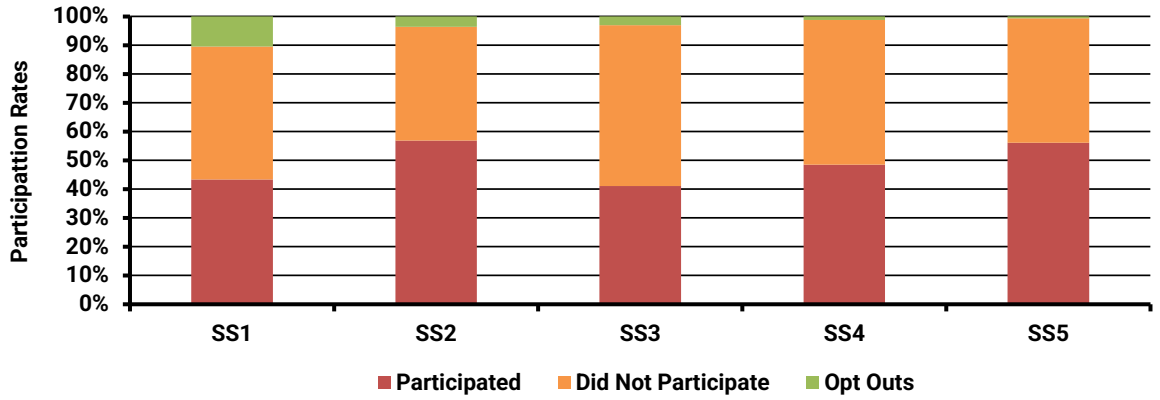
EVGRID

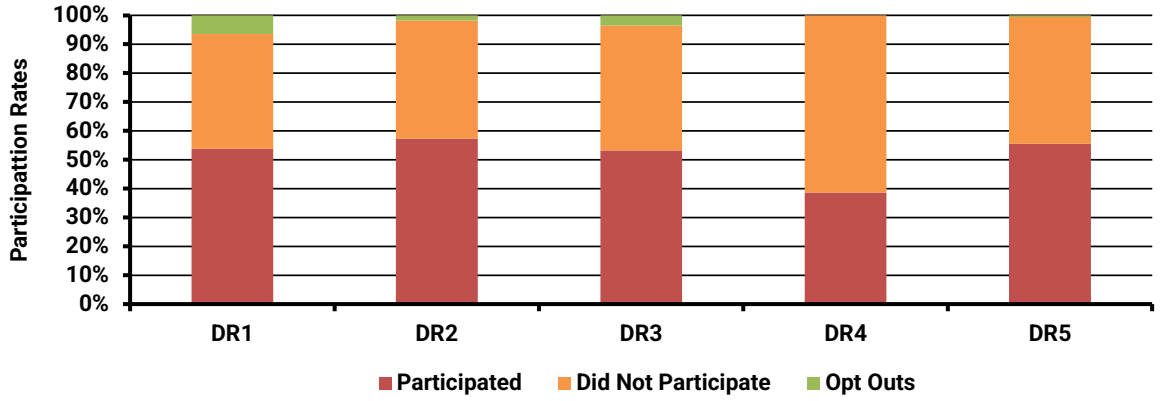
EV Grid – Smart Charging Opt-Out Behaviour

Solar Soaker Participation Rates by Event



Source: EV Grid, Energeia Analysis

Demand Response Participation Rates by Event



Source: EV Grid, Energeia Analysis

- EV Grids trials show relatively consistent participation rate over the entire trial
  - Participants were considered 'participating' if a vehicle was plugged into the charger at any point during the trial timeframe
- Opt-out rates where high upfront, with participants indicating that opt-out notifications where confusing
  - Opt-out rates decrease overtime with participants becoming increasingly familiar and prepared for trial process
- Around 50% of participants in each trial were offline, without opting out, with non-participation likely including:
  - Absent vehicles where opt-out process was not followed
  - Technical difficulties

Smart Charging – Origin

Load Shapes

Participation

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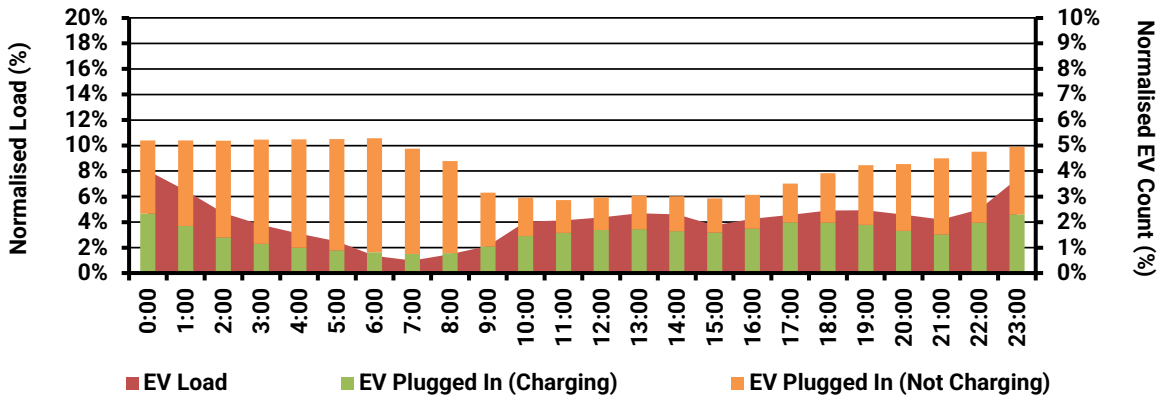
Origin – Unmanaged vs Smart Charging Profiles

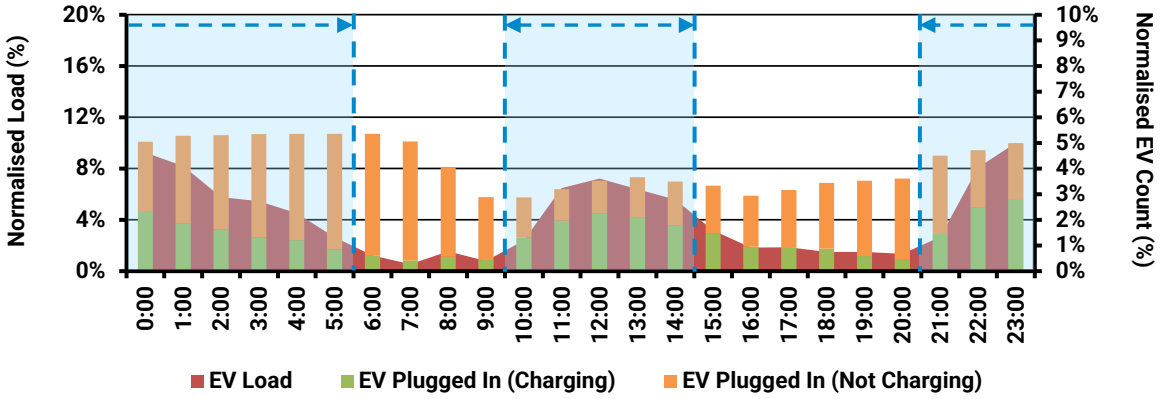
Unmanaged – Weekday



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

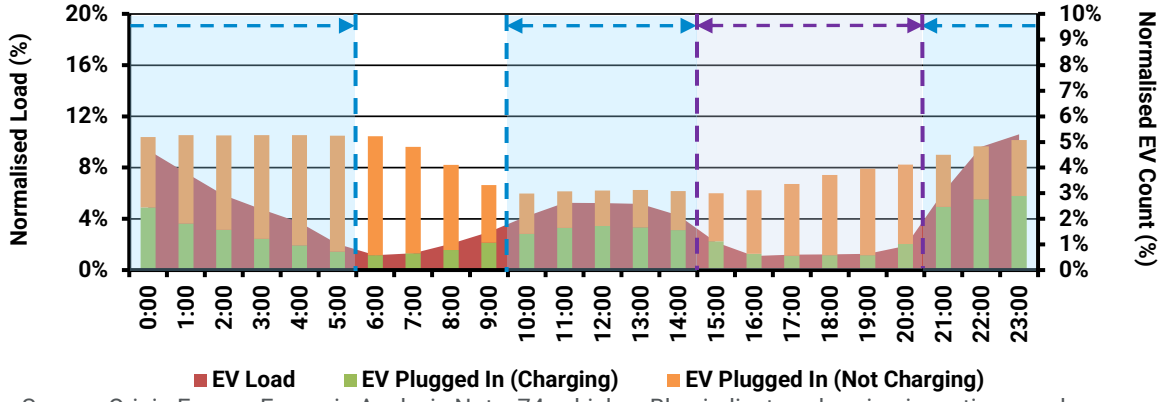
- The charts show Unmanaged vs experiments 1 and 2 across weekdays
  - **Experiment 1** – Off-peak smart charging incentive (10c/kWh midday and overnight)
  - **Experiment 2** – Additionally, a 3 - 9pm controlled smart charging period
- Impact of Experiment 1 significant, Experiment 2's impact more difficult 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. Blue indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Experiment 2 – Weekday



Source: Origin Energy, Energeia Analysis Note: 74 vehicles. Blue indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

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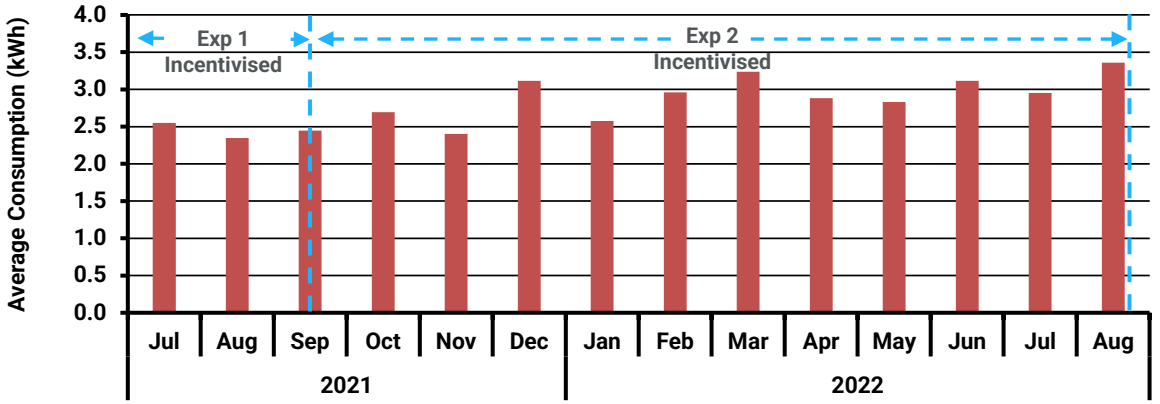
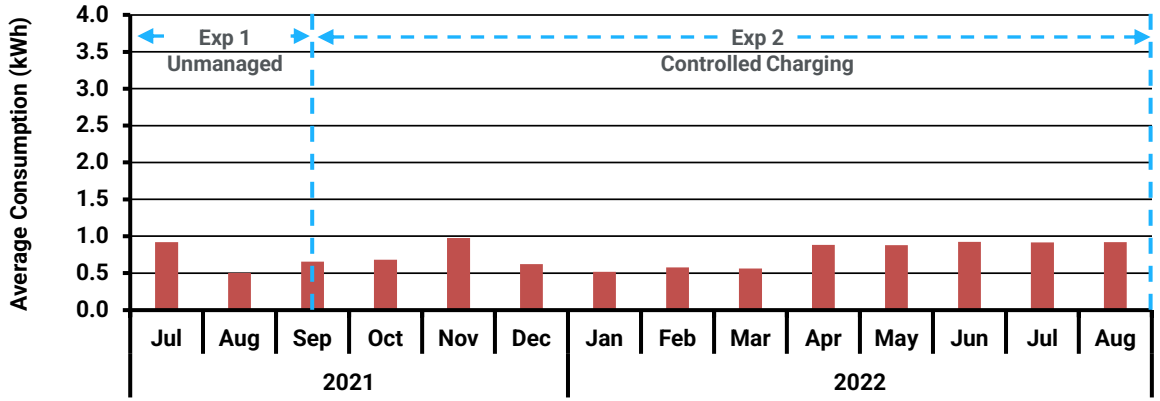
Origin – Smart Charging Opt-Out Behaviour

Avg Daily Incentive Period Consumption by Month



Source: Origin, Energeia Analysis. Note: Incentive period (10AM – 3 PM, 9PM – 5AM)

Avg Daily Control Period Consumption by Month



Source: Origin, Energeia Analysis. Note: Control period (3PM – 9PM)

- The charts show customer average customer consumption during incentive and smart charging period across all months of the trial
- Origin trial aims to both incentivise charging in off peak periods, and limit consumer energy consumption during the peak smart charging timeframes:
  - **Experiment 1**: Jul 2021– Sep 2021, Overnight and midday charging incentive
  - **Experiment 2**: Sep 2021 – Aug 2022, peak period smart charging suppression + Experiment 1 incentives
- Incentive period charging experiences a progressive growth in consumption over the trial period
- Control period charging appears to show a rebound effect, resulting in limited overall change in demand trends from the onset of control from July onwards
- Noting COVID lockdowns likely have an impact on the average charging volumes on the consumer in late 2021

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Industry Comparison

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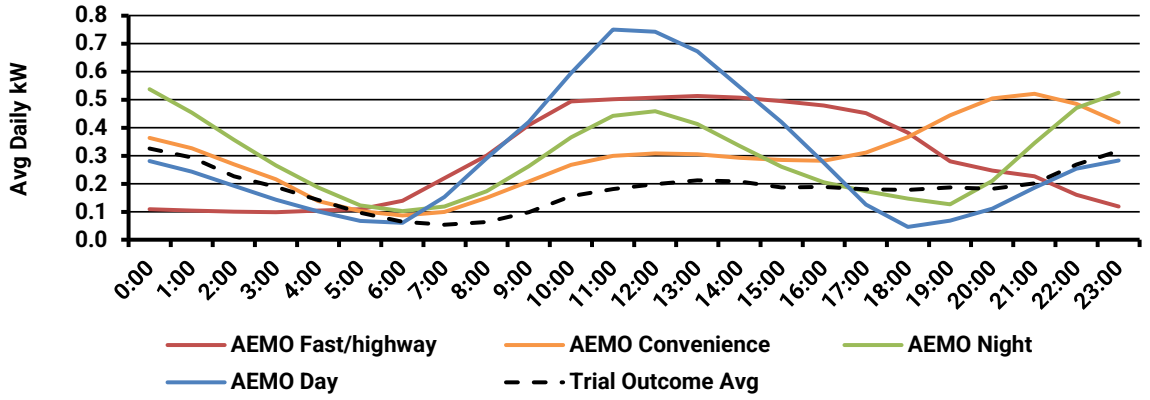
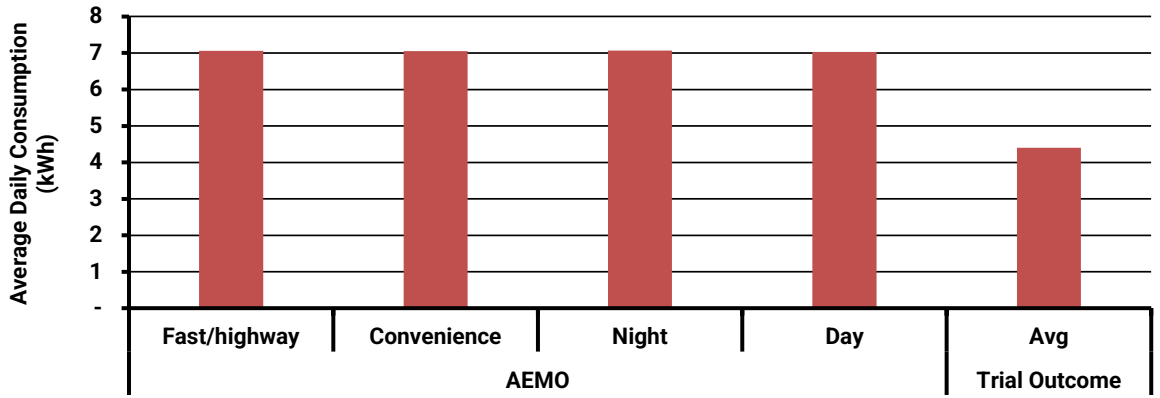
Charging Impacts

NEM ISP Modelling EV Charging Load Shape vs. Trial Data



Source: AEMO, EV Grid, Origin, AGL

NEM ISP Modelling EV Average Daily Cons vs. Trial Data



Source: CSIRO, EV Grid, Origin, AGL

- The charts show a comparison of the combined unmanaged profile of the 3 trials to the CSIRO modelling
- The trial data shows a daytime usage than the CSIRO profiles, which converges to the typical consumption of the CSIRO profiles overnight
- Comparison shows that the trial outcomes show close to half of CSIRO's modelled average daily consumption
  - The CSIRO's assumption arises from an average annual driving distance of 11,000 km/year
  - This implies that the trial vehicles do not entirely charge at home, or potentially also drive below the average annual driving distance

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Thank You!

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Appendix

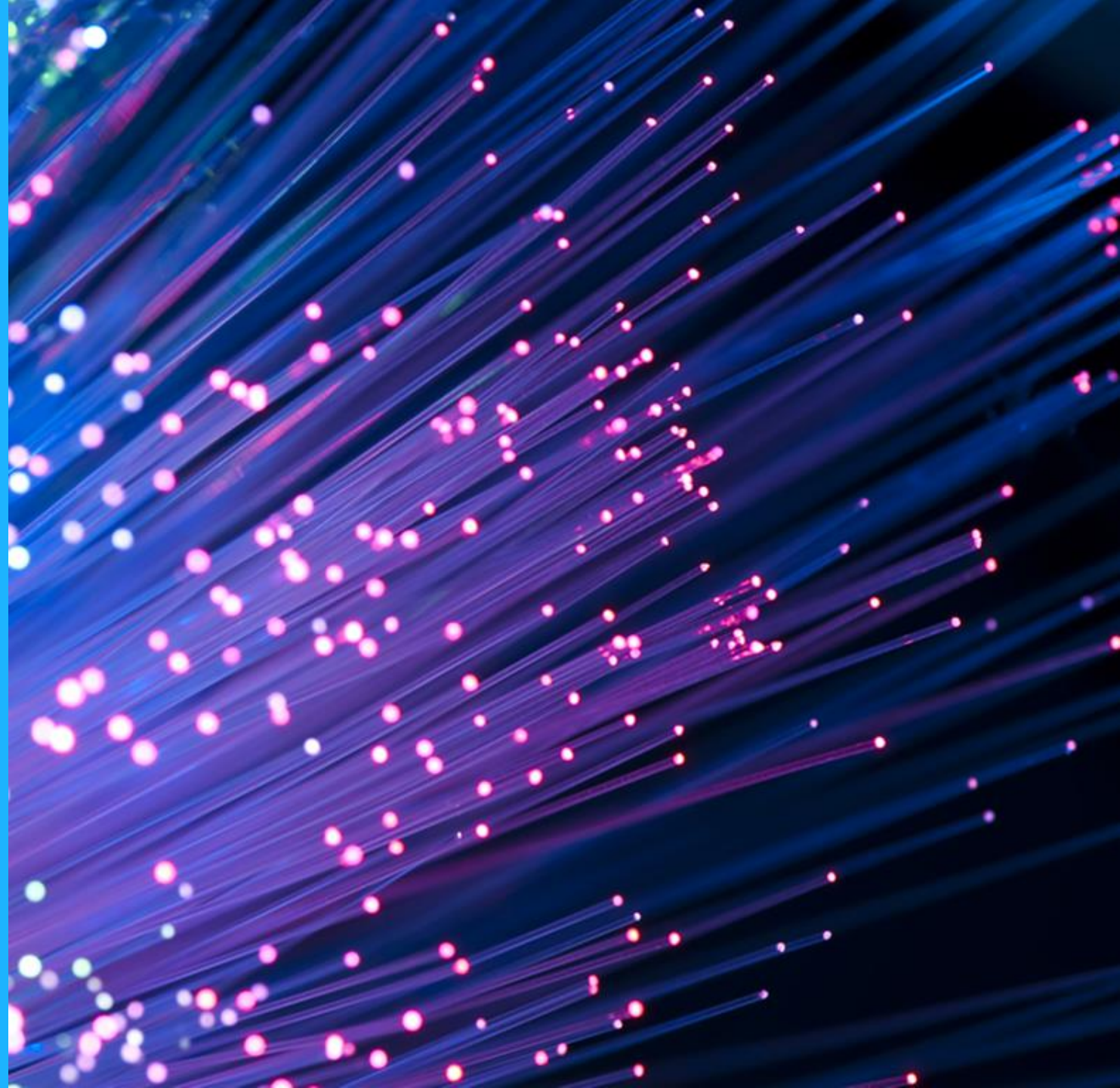
Data Received

Participant Characteristics

Unmanaged Charging – Current Industry Knowledge

Smart Charging – Detailed Findings

- AGL
- EV Grid
- Origin



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Data Received

Key Customer Characteristics

Participants and Observations

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Data Received – Key Customer Characteristics

Provider		Meter Data	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	✓	✓	✓	✓		✓	kW				
	To:	Dec-22											
EV Grid	From:	Jul-21	✓	✓	✓	✓	✓	✓	Amps		✓	✓	✓
	To:	Feb-23											
AGL	From:	Oct-21	✓						kW	✓			
	To:	Apr-23											

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	195	150	171
Participant IDs in meter data	171	146	163
Participant IDs Both Datasets	**171**	**146**	**163**
Smart Charging Event Days	253	341	10

Source: AGL, EV Grid, Origin

- Each provider has provided participants based on trial sign-ups to date
- Trials have a high data collection rate from active participants
- It is important to note that the EV Grid conducted 10 smart charging events

Participant Characteristics

Participants Involved by Location

Charger Power and Customer Driving Distances

Vehicle Price and Manufacturer

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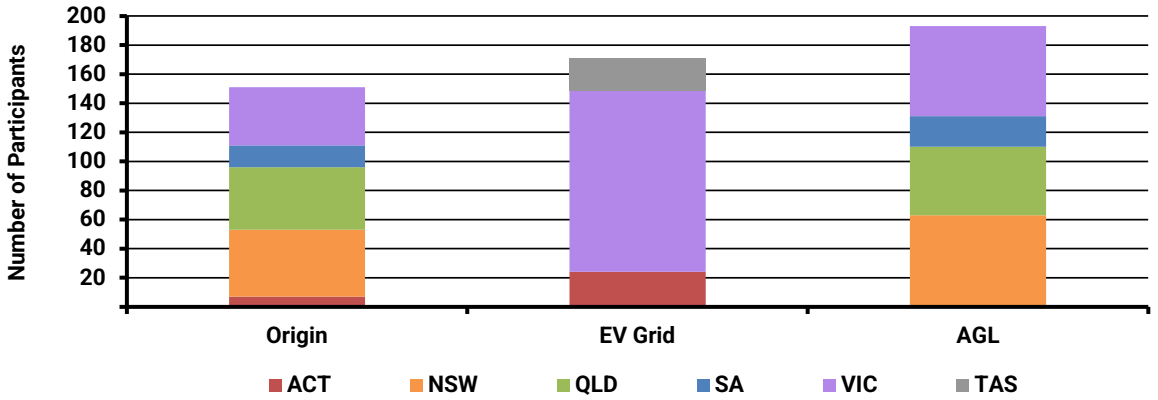
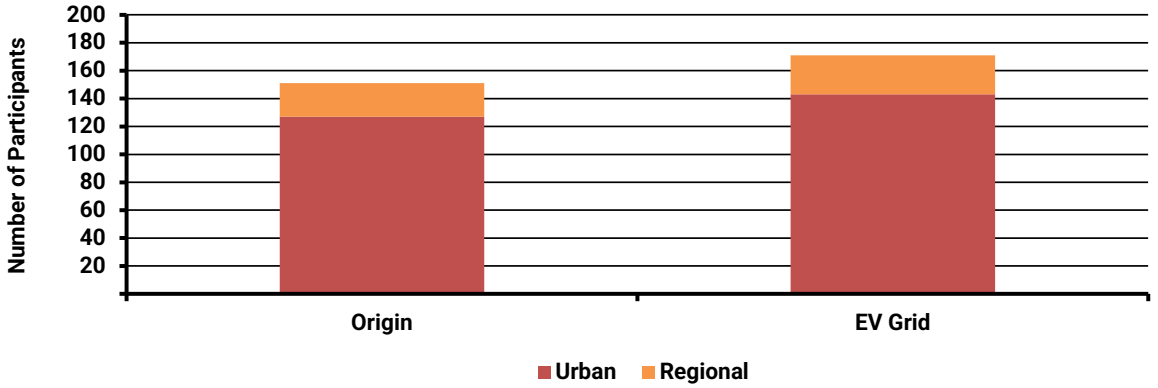
Participants Involved by Location

Participants by State and Provider



Source: EV Grid, Origin, Energeia

Participants by Location and Provider



Source: AGL, EV Grid, Origin

- 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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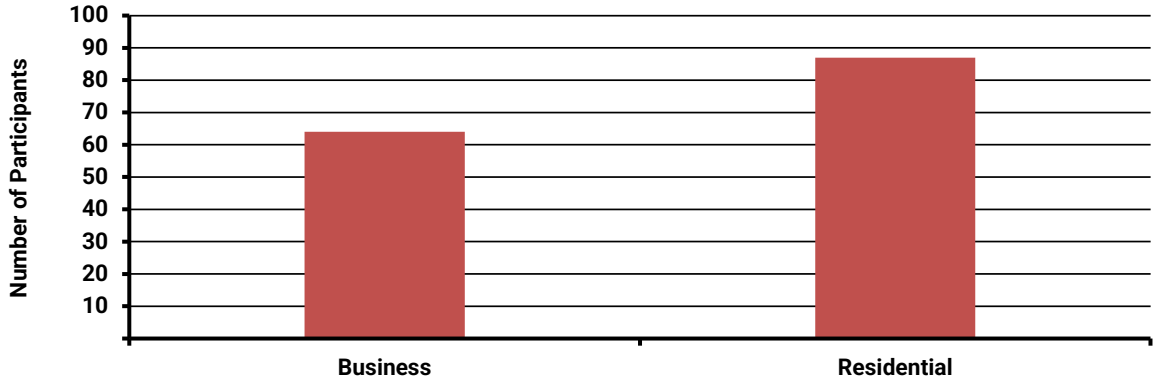
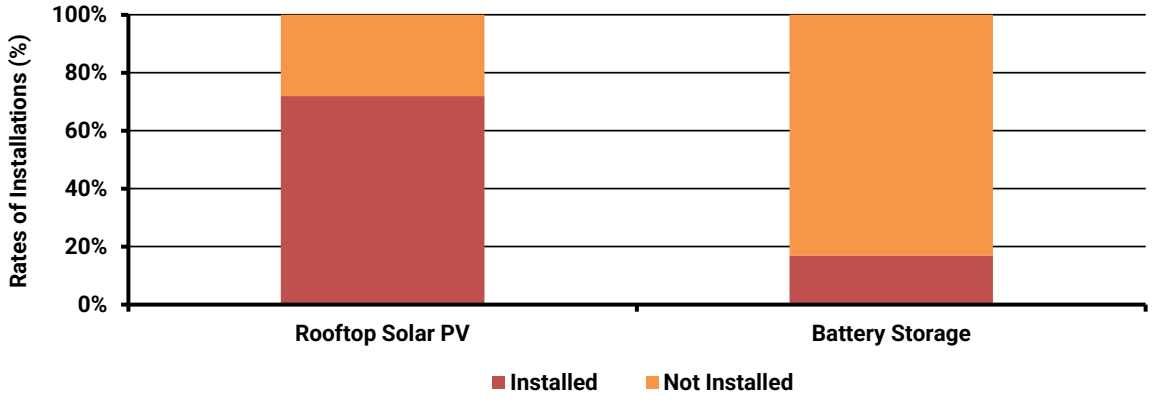
Participants by Customer Demographics

Premise Type



Source: Origin

Installed DER



Source: EV Grid

- The trials include customers with varying demographics
- Residential customers constitute:
  - 100% of customers in EV Grid and AGL trials
  - 58% of customers in Origin trial

- EV Grid collected data surrounding installed DER
  - Most trial participants have installed rooftop solar, at 72%
  - 17% of customers have installed battery storage
- EV Grid trial participants are an over-representation of prosumers

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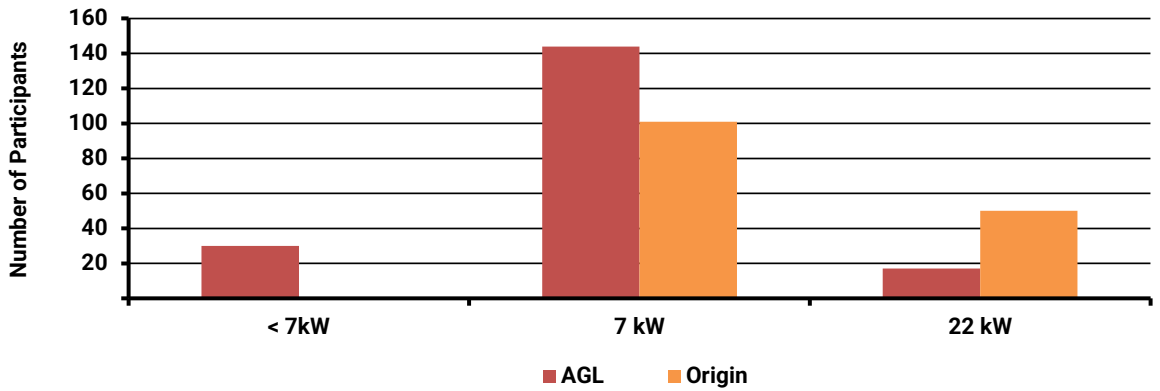
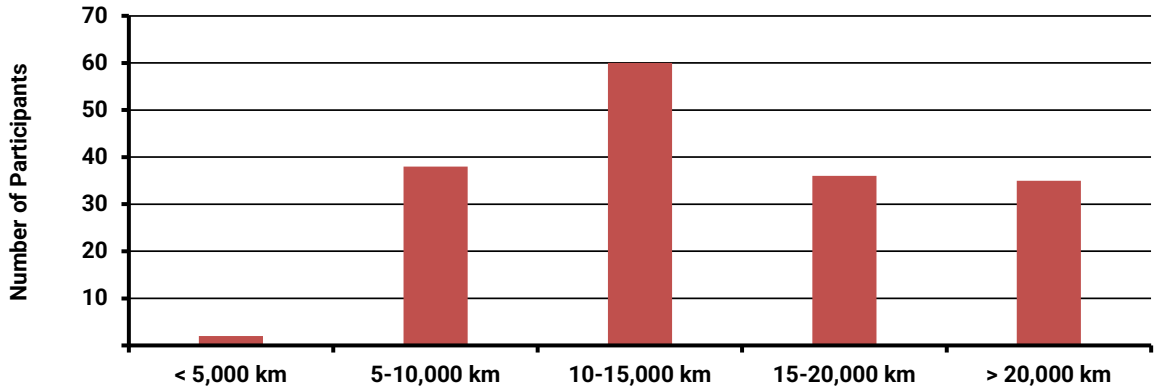
Charger Power and Customer Driving Distances

Level 2 - Charging Power



Source: EV Grid

Annual Distance Travelled



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

- 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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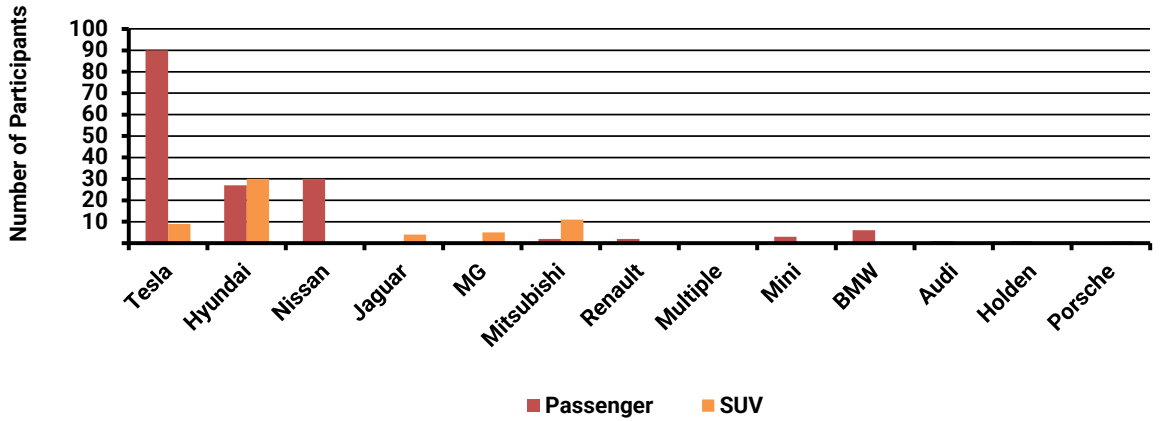
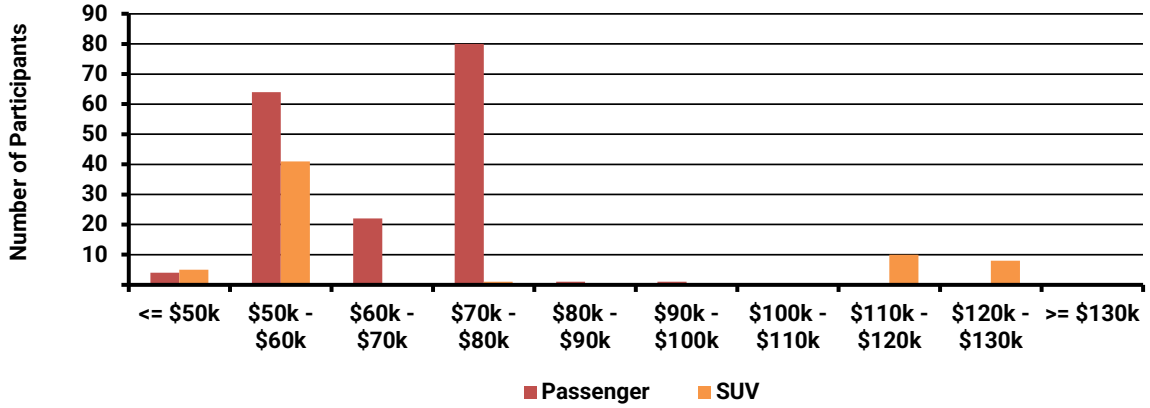
Vehicle Manufacturer and Price

Vehicle Manufacturer



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

Vehicles by Price Bands



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

- Vehicle manufacturer and price are shown where sufficient detail was available
- The most popular models within the trials included
  - Tesla Model 3 and X
  - Hyundai Kona and Ioniq
- Vehicle price band modelling assumes entry range models were purchased where further detail was not available
- The majority of vehicle were clustered between $50-80k, with very few vehicles above $100k

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Unmanaged Charging

Current Industry Knowledge

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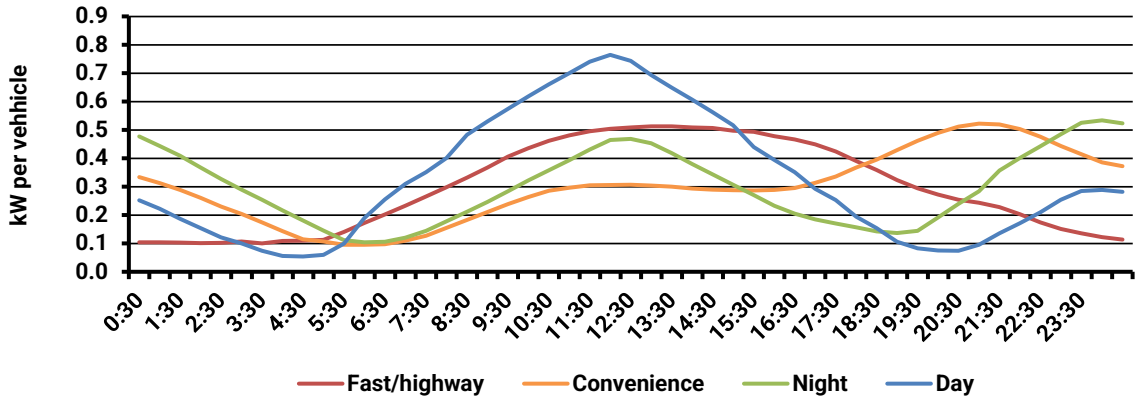
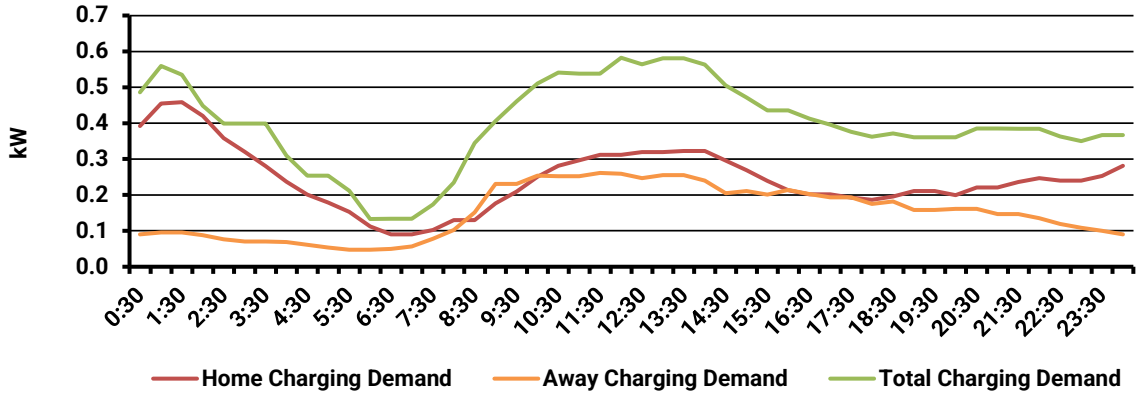
Current Industry Knowledge – Charging Profiles

CSIRO Report for AEMO (2022)



Source: CSIRO (2022)

EV SmartCharge Queensland (2023)



Source: Ergon and Energex (2023)

- Graphics to the left represent the current state of industry's PEV charging profile assumptions
- ARENA trials are intended to move the industry body of knowledge forward
- The following slides demonstrate the impact of the work in terms of industry understanding

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Smart Charging – AGL

Summary

Load Shapes

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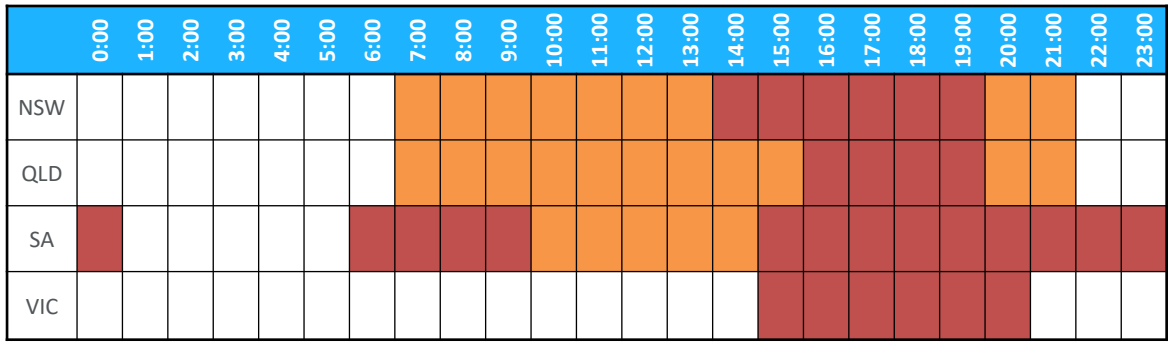
AGL – Summary of Trial

Summary of Key Trial Dates and Times

	Morning		Evening	
	Start	End	Start	End
BaU (Oct 21 -Jan 22)	None			
Phase 1 (Jan-Jun 2022)			4:30 pm-5:30 pm	8:30 pm-9:30 pm
Phase 2 (Jun-Oct 2022)	5:30 am	9:30 am	4:30 pm-5:30 pm	8:30 pm-9:30 pm
Phase 3 (Oct-Dec 2022)	5:30 am	9:30 am	3:30 pm-4:30 pm	8:30 pm-9:30 pm
Revised BaU (Jan – Apr 2023)	None			

Source: AGL. Note: Evening start and end evening times vary by state

Distribution of Tariff Incentives



Source: AGL. Note: **Red** = Peak Period, **Orange** = Shoulder Period

- AGL's trial implements two key phases:
  - **Phase 1**: Controlled charging during period in evening peak period
  - **Phase 2**: Controlled charging during period morning and evening peak periods
  - **Phase 3**: Slightly revised timing from Phase 2
- AGL's trial design aims to provide a single incentive time for all customers in all states, that aims to shift charging out the target periods
- Aligning periods to retail tariffs customers are exposed to reduces split incentives for consumers

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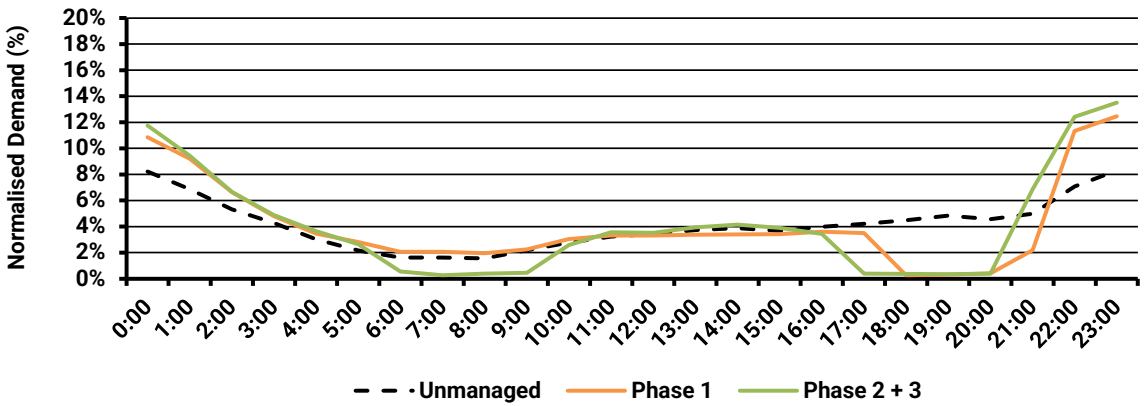
agl

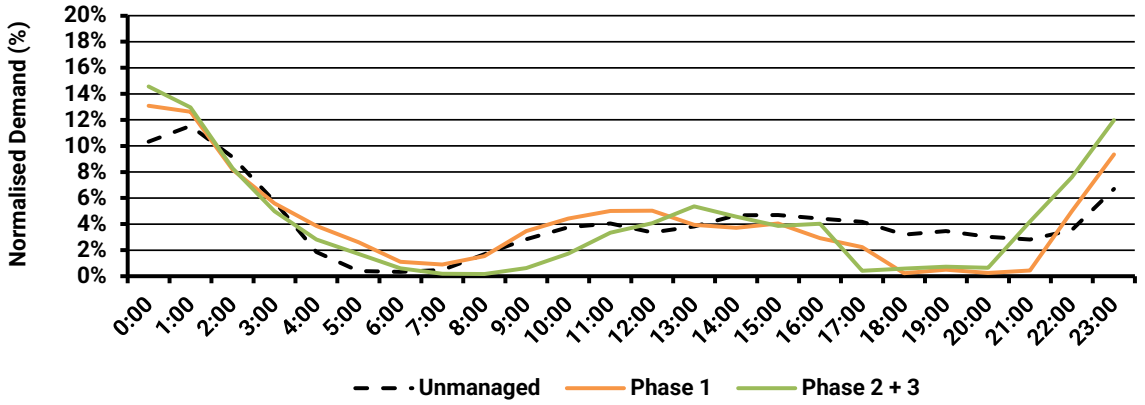
AGL– Smart Charging by Charging Power

Unmanaged vs Dynamic Events – 7 kW



Source: AGL, Energeia Analysis. Note: Unmanaged: 94 chargers, Phase 1: 110 chargers, Phase 2: 111 chargers. Evening period start and end time varies up to half an hour by state. Blue indicates smart charging period. Morning period occurs in Phase 2 only

Unmanaged vs Dynamic Events – 22 kW



Source: AGL, Energeia Analysis. Note: Unmanaged: 8 chargers, Phase 1: 11 chargers, Phase 2: 9 chargers. Evening period start and end time varies up to half an hour by state. Blue 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

Summary

Load Shapes

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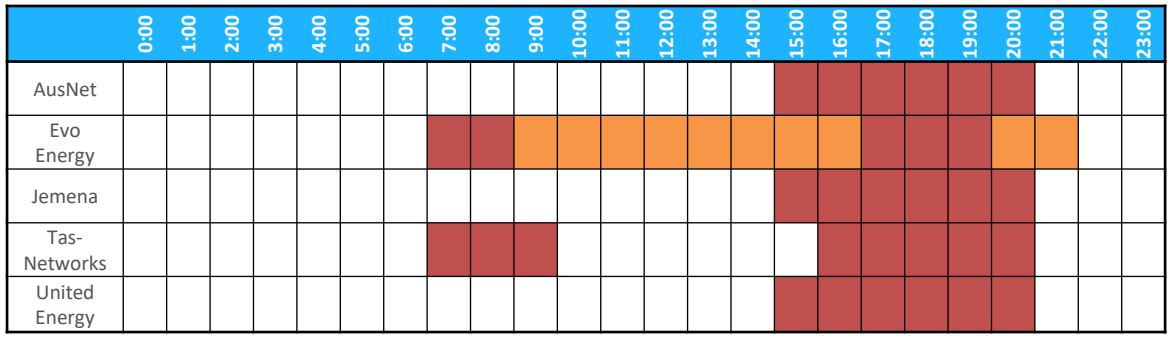
EV Grid – Summary of Trial Dates

Summary of Key Trial Dates and Times

Event Type	Event Name	Date	Start Time	Duration
Solar Soak	SS1	11 May 2022	12 pm	3 hrs
	SS2	9 Jul 2022	1 pm	2 or 3 hrs
	SS3	13 Oct 2022	10 or 11 am	3 hrs
	SS4	9 Nov 2022	11 am	3 hrs
	SS5	22 Jan 2023	12 pm	3 hrs
Demand Response	DR1	23 Jun 2022	6 pm	2 or 3 hrs
	DR2	24 Aug 2022	5 pm	3 hrs
	DR3	30 Oct 2022	5 pm	3 hrs
	DR4	21 Nov 2022	5 pm	3 hrs
	DR5	14 Jan 2023	4 or 5 pm	3 hrs

Distribution of Tariff Incentives

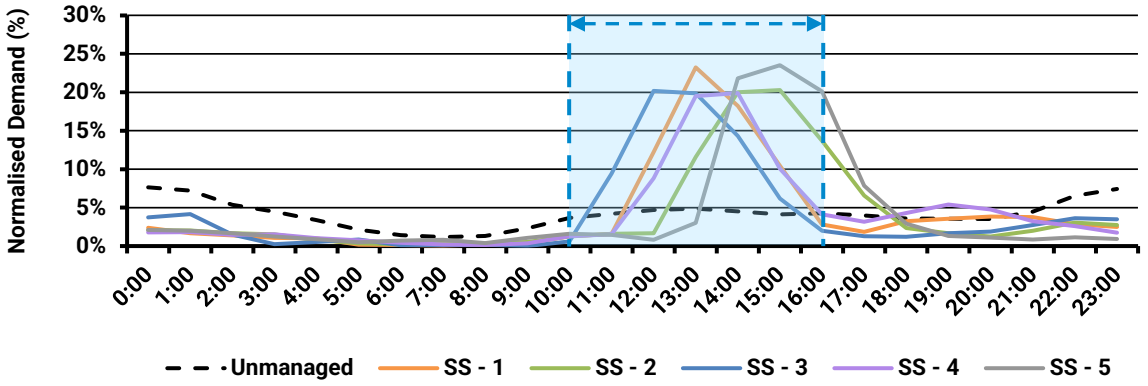


Source: EVGrid. Note: **Red** = Peak Period, **Orange** = Shoulder Period, Event Start times and durations could vary by network

- EV Grid's trial implements two key methods:
  - **Solar soak**: incentivised demand during period
  - **Demand response**: controlled charging during period in response to local network constraints.
- **Note**: controlled charging sets a variable EV charger consumption set-point with regards to the need in the local distribution network
- EVGrid's trial design aims to provide a single incentive time for all customers in all states, that aims to shift charging into the target periods
- EVGrid trial times are set to times of forecast need within the distribution network

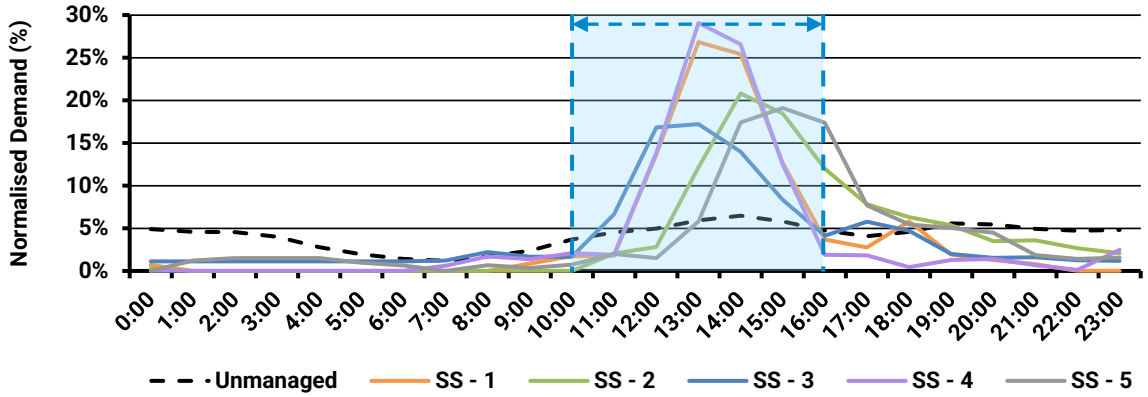
EV Grid – Solar Soak by Vehicle Type

Unmanaged vs Solar Soak Events – Passenger Vehicles



Source : EV Grid, Energeia , Note: Blue indicates incentivised charging. Unmanaged: 40 chargers, Demand Response: 35 chargers, Solar Soaker: 36 chargers.

Unmanaged vs Solar Soak Events – SUVs



Source: EV Grid, Energeia. Note: Blue indicates incentivised charging. Unmanaged: 117 chargers, Demand Response: 106 chargers, Solar Soaker: 106 chargers.

- The charts show the difference in total trial demand during each event
  - Note start time of events vary between 10 am – 1 pm by event
  - Later start times of SS 2 and 5 show demand continuing into the tariff defined peak demand periods

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

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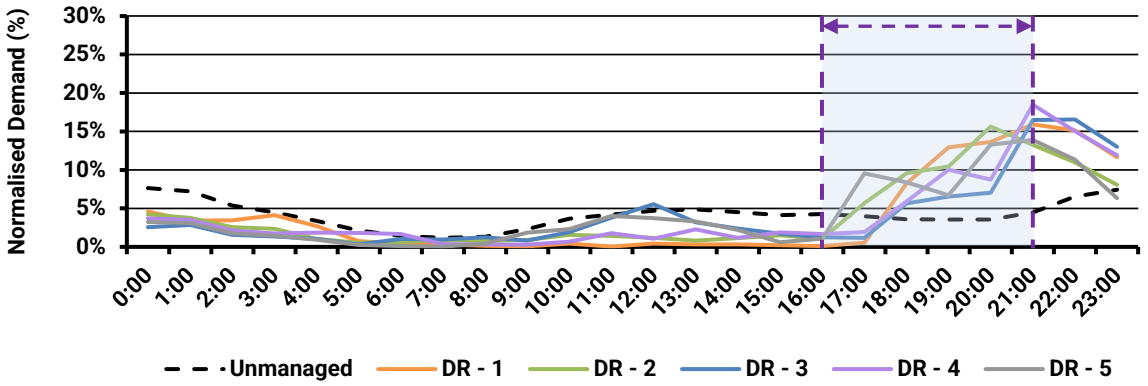
EVGRID

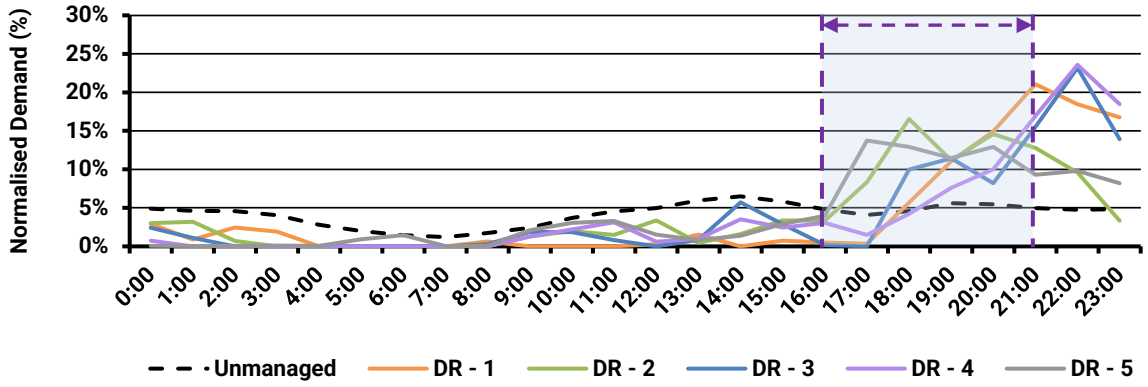
EV Grid – Demand Response by Vehicle Type

Unmanaged vs Demand Response Events – Passenger Vehicles



Source: EV Grid, Energeia. Note: Purple indicates controlled charging. Unmanaged: 117 chargers, Demand Response: 106 chargers, Solar Soaker: 106 chargers.

Unmanaged vs Demand Response Events – SUVs



Source : EV Grid, Energeia , Note: Purple indicates controlled charging. Unmanaged: 40 chargers, Demand Response: 35 chargers, Solar Soaker: 36 chargers.

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

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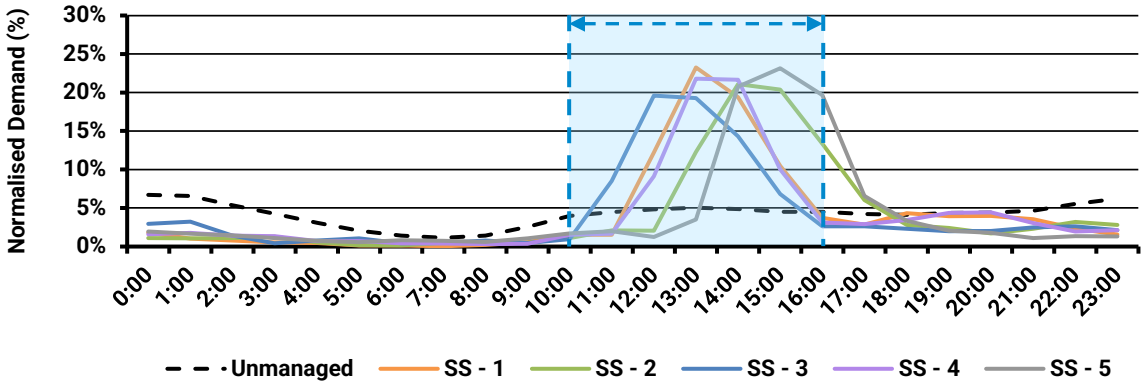
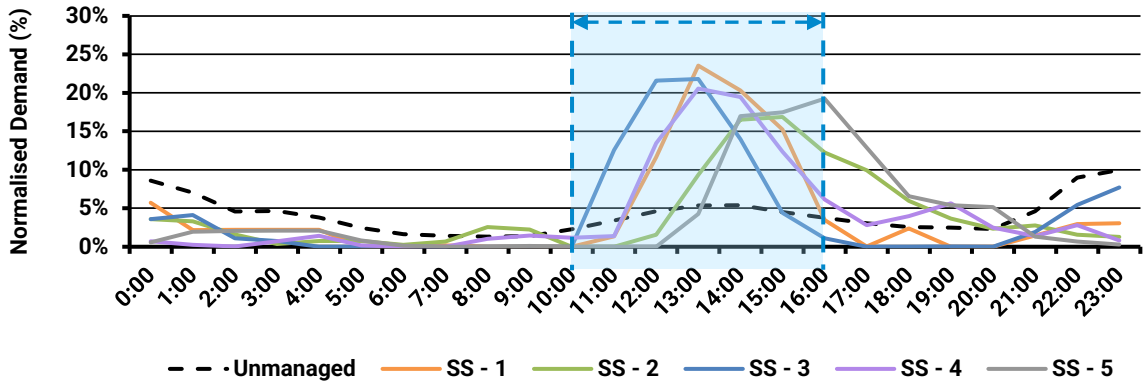
EV Grid – Solar Soak by Location

Unmanaged vs Solar Soak Events – Urban



Source: EV Grid. Note: Blue indicates incentivised charging. Unmanaged: 136 vehicles, Demand Response: 123 vehicles, Solar Soaker: 126 vehicles.

Unmanaged vs Solar Soak Events – Regional

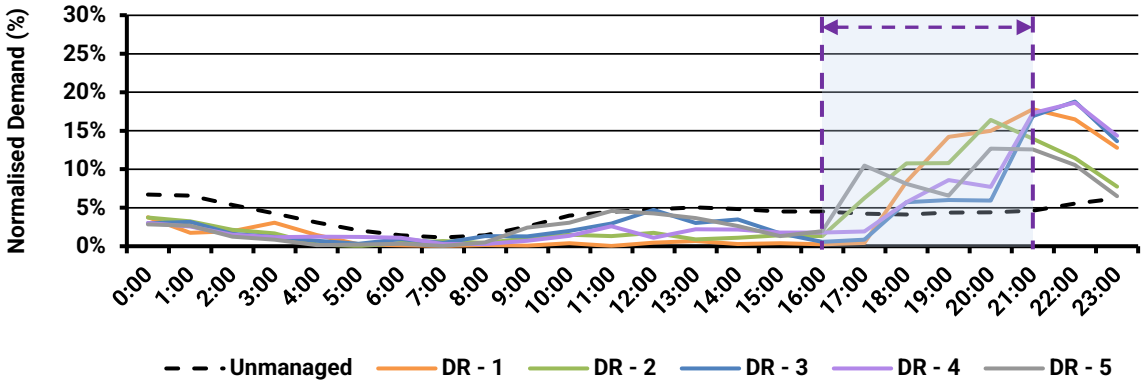


Source: EV Grid. Note: Blue indicates incentivised charging. Unmanaged: 27 vehicles, Demand Response: 23 vehicles, Solar Soaker: 21 vehicles.

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

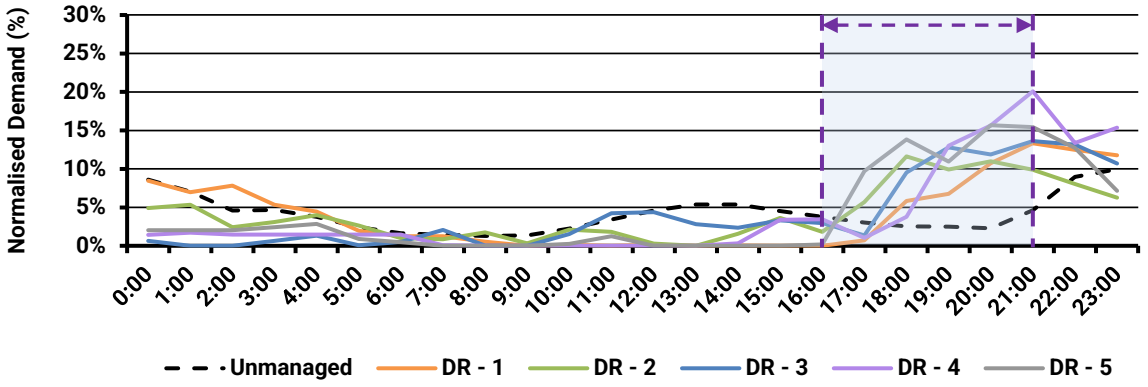
EV Grid – Demand Response by Location

Unmanaged vs Demand Response Events – Urban



Source: EV Grid. Note: Purple indicates controlled charging. Unmanaged: 136 vehicles, Demand Response: 123 vehicles, Solar Soaker: 126 vehicles.

Unmanaged vs Demand Response Events – Regional

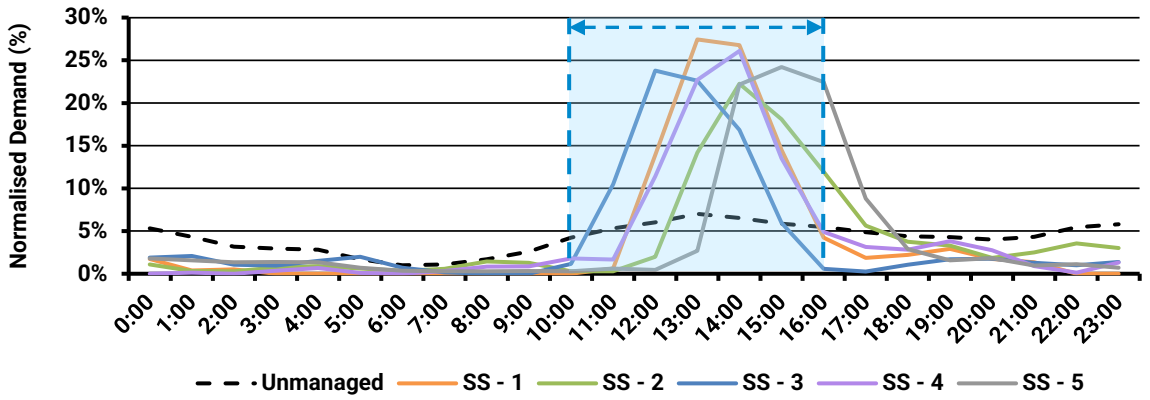


Source: EV Grid. Note: Purple indicates controlled charging. Unmanaged: 27 vehicles, Demand Response: 23 vehicles, Solar Soaker: 21 vehicles.

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

EV Grid – Solar Soak by Price Band

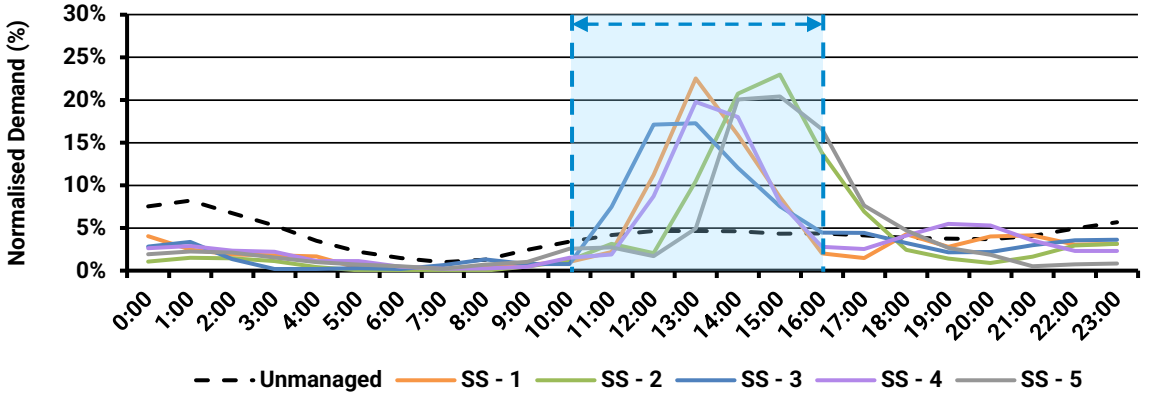
Unmanaged vs Solar Soak Events – Under $60k



Source: EV Grid. Note: Blue indicates incentivised charging. Unmanaged: 62 vehicles

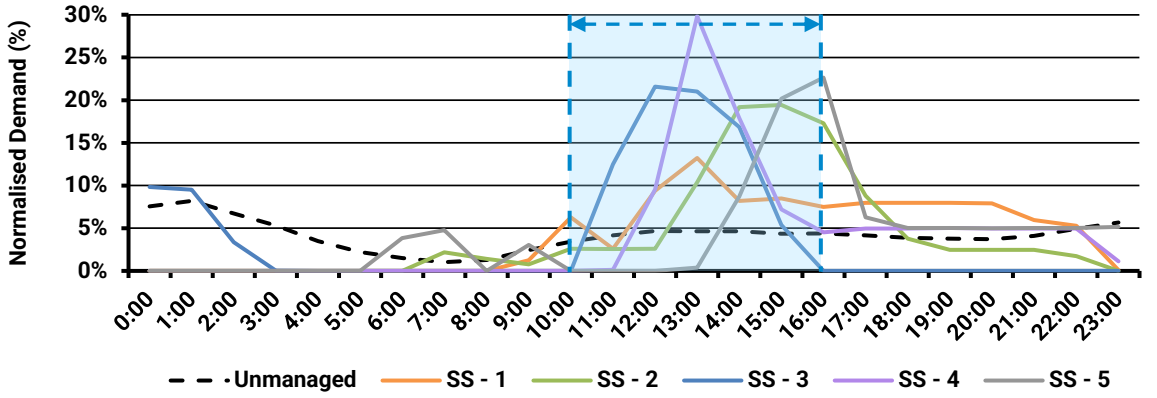
- Vehicles in all price bands had significant responses to incentivised solar soak charging
- Medium price bands participants had the lowest charging volumes in solar soak event
- Under 60k vehicles had the highest participation

Unmanaged vs Solar Soak Events – $60k – $100k



Source: EV Grid. Note: Blue indicates incentivised charging. Unmanaged: 77 vehicles

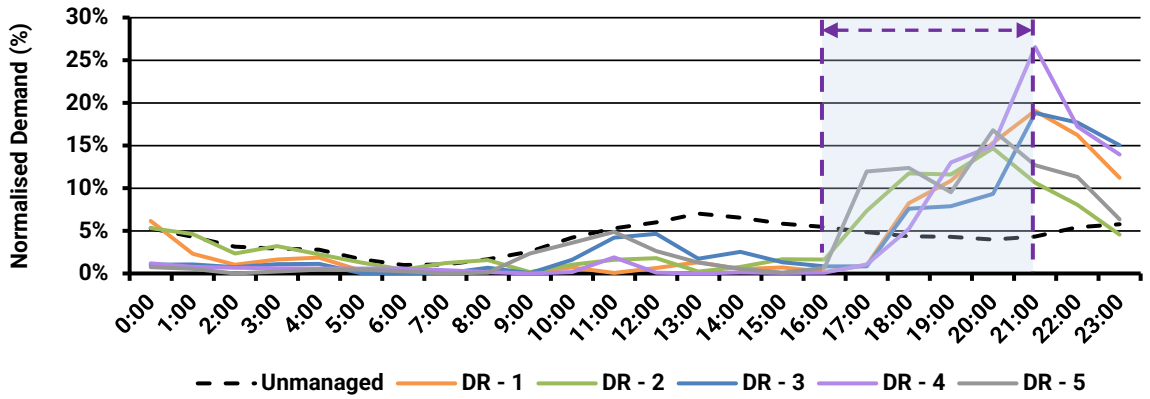
Unmanaged vs Solar Soak Events – over $100k



Source: EV Grid. Note: Purple indicates incentivised charging. Unmanaged: 18 vehicles

EV Grid – Demand Response by Price Band

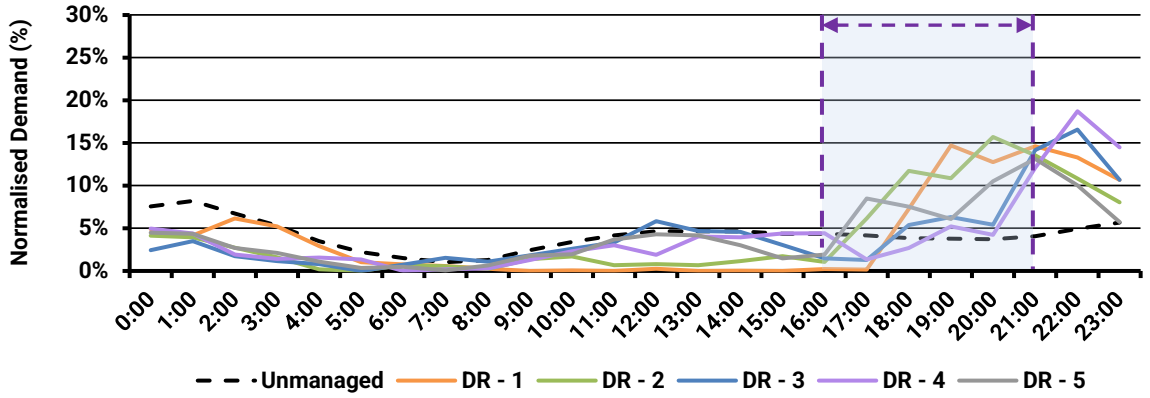
Unmanaged vs Demand Response Events – Under $60k



Source: EV Grid. Note: Purple indicates controlled charging. Unmanaged: 62 vehicles

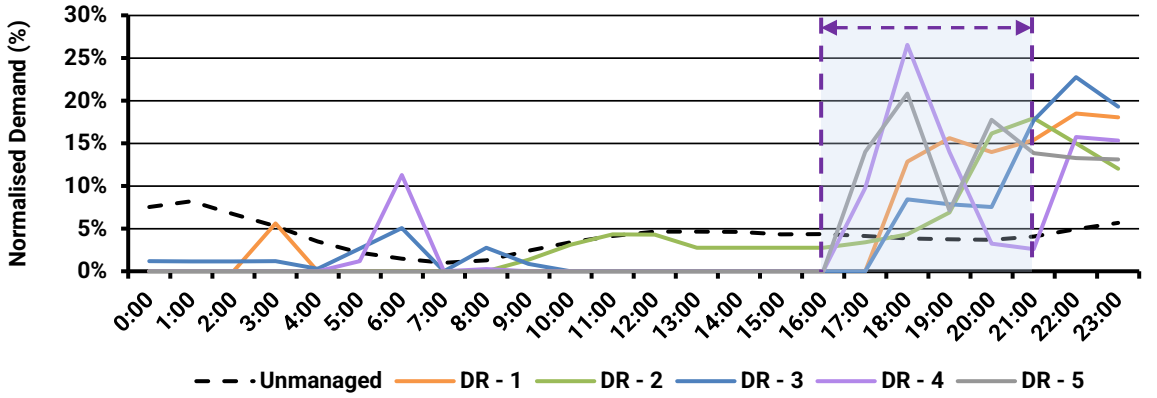
- As demand response charger set-points vary location-to-location, it is difficult to determine the cause of varied behaviour by vehicle price time

Unmanaged vs Demand Response Events – $60k – $100k



Source: EV Grid. Note: Purple indicates controlled charging. Unmanaged: 77 vehicles

Unmanaged vs Demand Response Events – over $100k



Source: EV Grid. Note: Purple indicates controlled charging. Unmanaged: 18 vehicles

Smart Charging – Origin

Summary

Load Shapes

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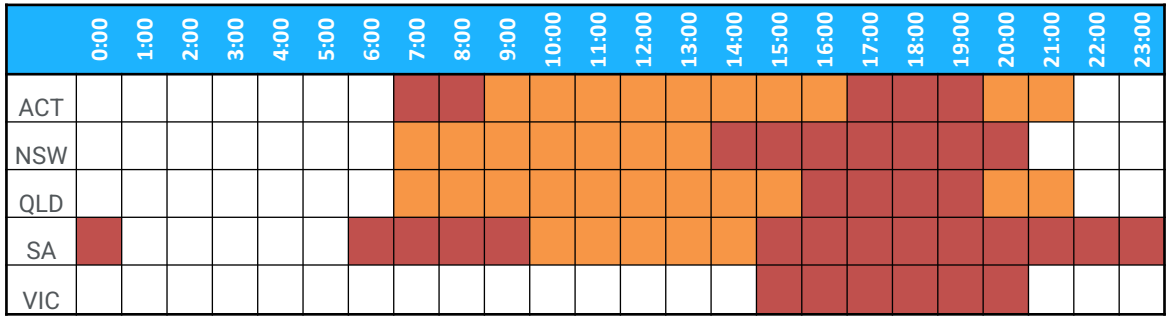
Origin – Summary of Trial

Summary of Key Trial Dates and Times

	Daytime		Evening		Overnight	
	Start	End	Start	End	Start	End
BaU (Aug 20-Jul 21)	None					
Experiment 1 (Jul 21-Oct 21)	10 am	3 pm			9 pm	5 am
Experiment 2 (Nov 21-Aug 22)	10 am	3 pm	3 pm	9 pm	9 pm	5 am

Source: Origin

Distribution of Tariff Incentives

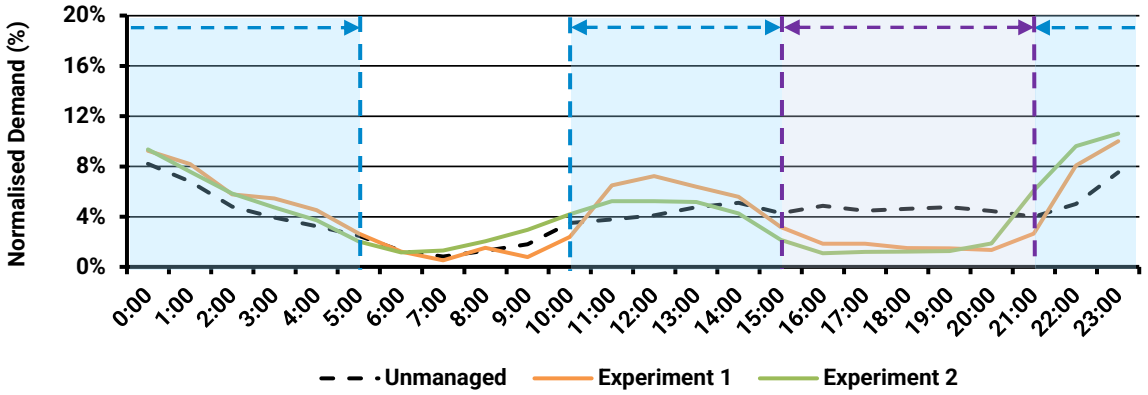


Source: Origin. Note: **Red** = Peak Period, **Orange** = Shoulder Period. Note: NSW assumes AusGrid network region

- The table shows a summary of the key trial timing
  - **Experiment 1** – Off-peak smart charging incentive (10c/kWh midday and overnight)
  - **Experiment 2** – Additionally, a 3 - 9pm controlled smart charging period
- Origin's trial timing aims to provide a single set of incentives to all customers in all states, aligning the different peak and off-peak periods by state

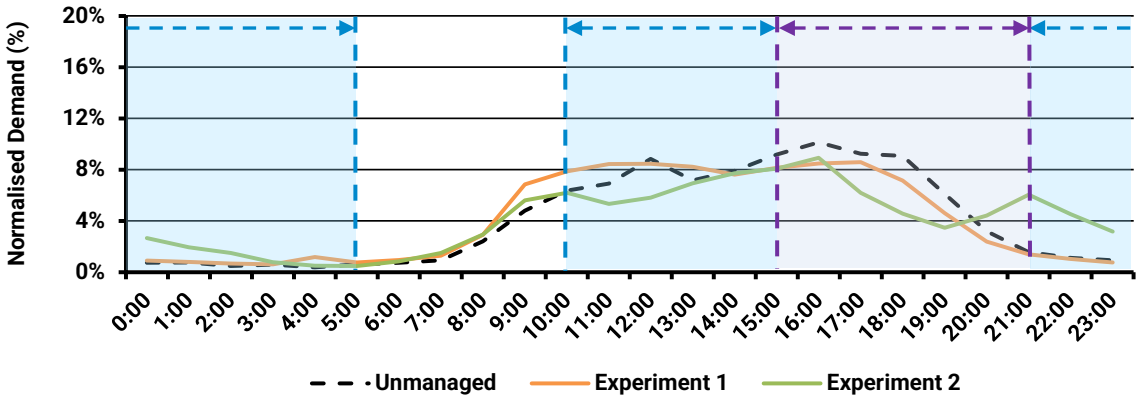
Origin – Smart Charging by Customer Class

Unmanaged vs Experiments – Residential



Source: Origin, Energeia Analysis. Note: Unmanaged: 67 vehicles, Exp 1: 68 vehicles, Exp 2: 74 vehicles. Blue 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: 55 vehicles. Blue 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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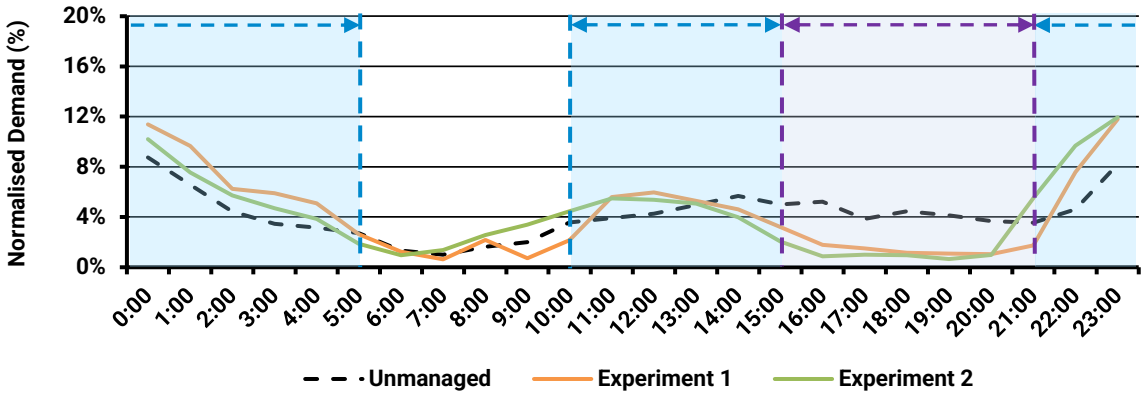
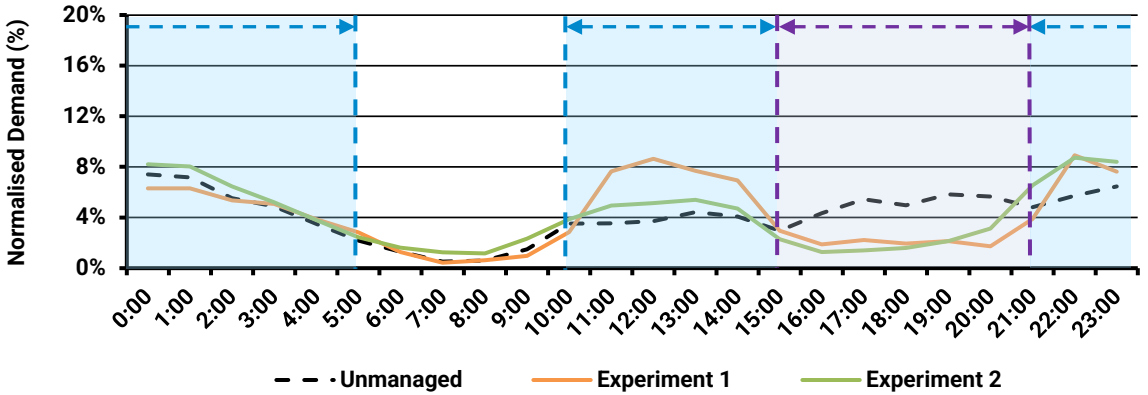
Origin – Smart Charging by Vehicle Type

Unmanaged vs Experiments – Passenger Vehicles



Source: Origin, Energeia Analysis. Note: Unmanaged: 39 vehicles, Exp 1: 40 vehicles, Exp 2: 44 vehicles. Blue 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: 27 vehicles. Blue 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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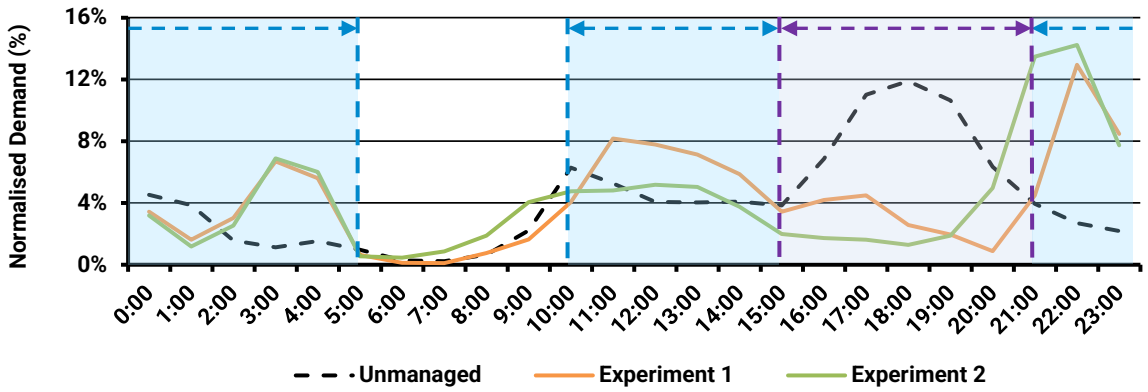
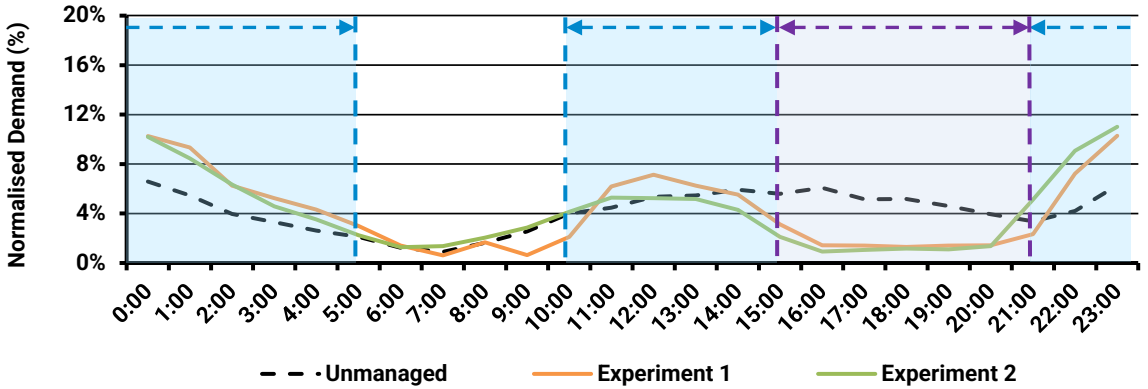
Origin – Smart Charging by Electrification Type

Unmanaged vs Experiments – PHEVs



Source: Origin, Energeia Analysis. Note: Unmanaged: 8 vehicles, Exp 1: 8 vehicles, Exp 2: 8 vehicles. Blue 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. Blue 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
- BEV charging shifted from overnight; middle of the day charging did not shift upwards, indicating saturation, potentially due to PV soaking

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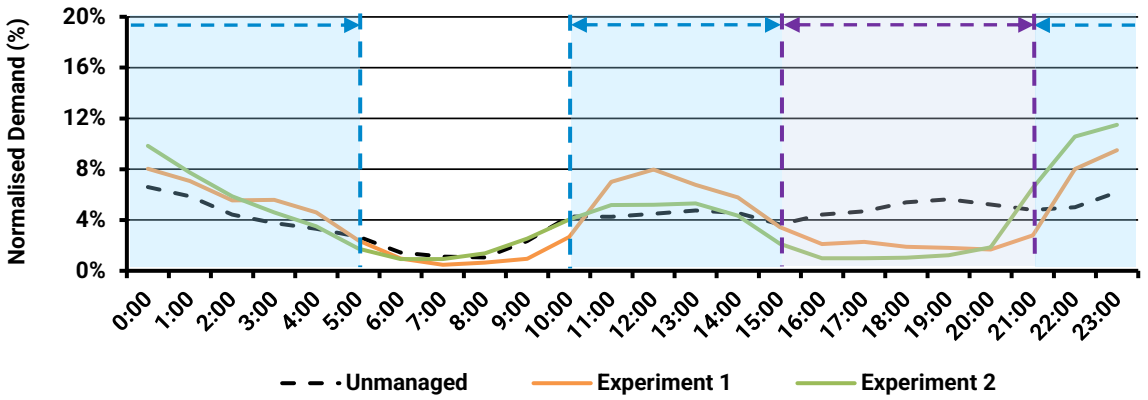
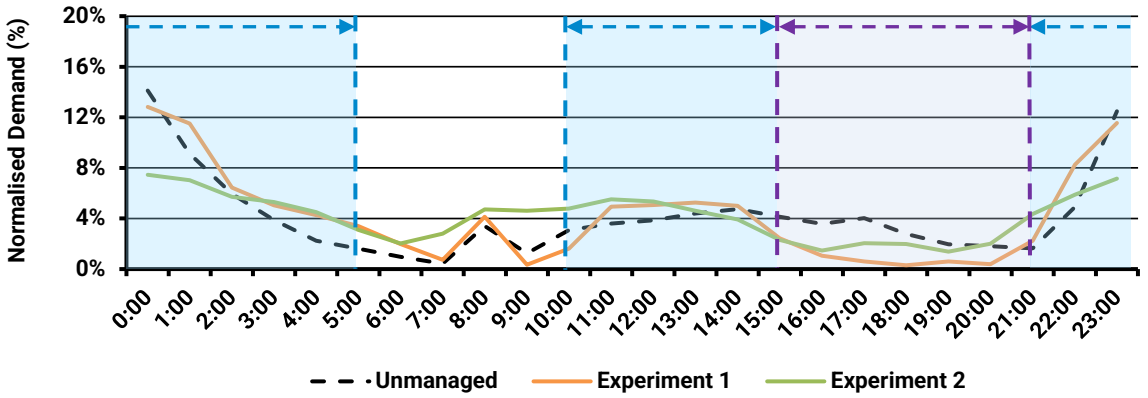
Origin – Smart Charging by Location

Unmanaged vs Experiments – Urban



Source: Origin, Energeia Analysis. Note: Unmanaged: 54 vehicles, Exp 1: 55 vehicles, Exp 2: 60 vehicles. Blue 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: 14 vehicles. Blue 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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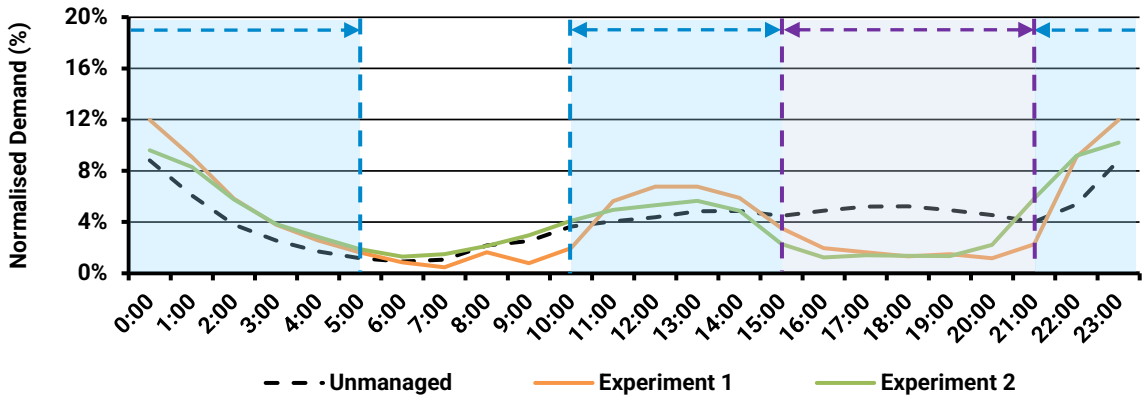
Origin – Smart Charging by Price Band

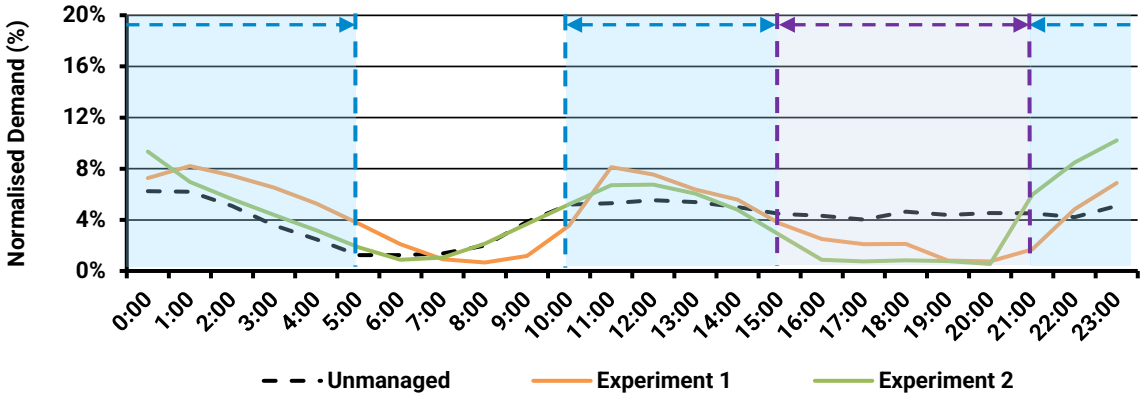
Unmanaged vs Experiments – under $60k



Source: Origin, Energeia Analysis. Note: Unmanaged: 46 vehicles, Exp 1: 45 vehicles, Exp 2: 47 vehicles. Blue indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

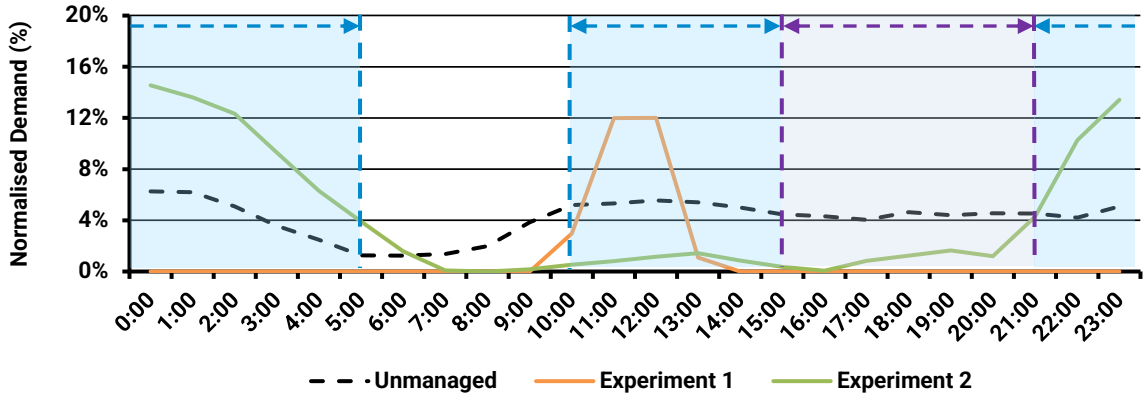
- Low and medium price bands had similar charging profiles for both experiments, indicating minimal difference in responses to price incentives
- Low price band shows minimal close to no change between Experiment 1 and 2 during the control period, indicating that charging incentives was sufficient to unlock optimal behaviour
- High price band only involved one customer

Unmanaged vs Experiments – $60k – $100k



Source: Origin, Energeia Analysis. Note: Unmanaged: 17 vehicles, Exp 1: 19 vehicles, Exp 2: 22 vehicles. Blue indicates charging incentive, purple indicates controlled charging (Experiment 2 only)

Unmanaged vs Experiments – over $100k



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

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origin