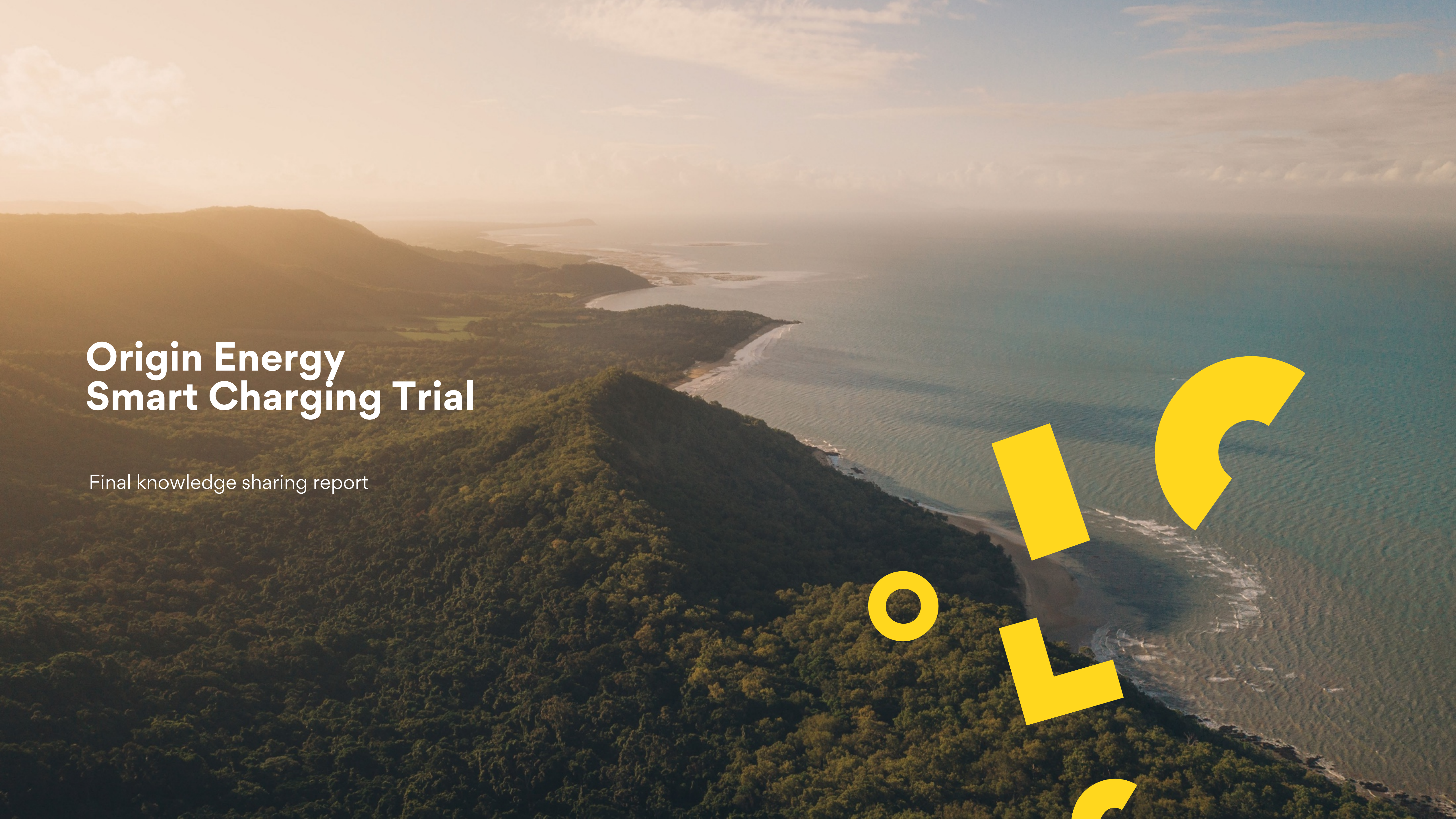


Origin Energy Smart Charging Trial

Final knowledge sharing report

Acknowledgement & 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.

Contents

1. Executive summary

Executive Summary

The Smart Charging Trial (the Trial) is an ARENA-funded project that seeks to collect insights into the charging behaviour of EV drivers across residential and commercial applications as well as the effectiveness of smart charging to optimise EV charging in response to signals from the electricity system.

The Trial commenced in August 2020 and involved connecting 200 EV smart chargers of residential and commercial participants onto Origin's Virtual Power Plant ("**Loop**"). Over the course of the 28-month Trial period, Origin collected valuable insights into:

- The recruitment process to enrol participants onto the Trial;
- The charger installation and commissioning process;
- Baseline EV charging behaviour across private and fleet EV use cases;
- The responsiveness of EV charging to price signals and smart charging experiments;
- The value of smart charging to the wholesale electricity market and distribution networks;
- Customer motivations and sentiments towards smart charging.

The Smart Charging Trial successfully demonstrated the effectiveness of smart charging in managing the charging of EVs across residential and commercial applications and delivered on the project objectives outlined below:

1. **Determine whether smart charging can help shift charging to periods of high renewable energy supply and reduce demand during peak periods to help manage network and wholesale market constraints**
2. **Improved understanding of customers' willingness to allow the management of the charging of their EVs and satisfaction with managed charging**
3. **Progress towards the commercialisation of smart EV charging**

Key findings against Project Objectives

Project Objectives	Key findings
Understanding the potential of optimised charging of EVs to: 1. Shift energy to periods of high renewable energy supply; 2. Reduce demand during periods of peak demand or low renewable energy supply to relieve network and wholesale market constraints 3. Minimise the cost of charging	• The combination of price signals and smart charging controls were effective in reducing charging during the evening peak by 79% and shifting this load into the midday and overnight charging periods • Estimated value created from smart charging is approximately $75 per annum. This is calculated as the wholesale energy and network cost of the Baseline Charging profile compared to the Smart Charging Profile. • The charging profiles observed in the Trial is skewed towards behaviours of early adopters who were already actively managing the charging of their Evs to optimise their solar generation and / or time of use tariff. • Using the CSRIO's convenience charging profile as the proxy for the baseline charging profile in a mass adoption scenario, the smart charging value increase to $170 p.a. • Trial participants were happy with the incentive received to reduce the cost of EV charging
Understanding customers' willingness to allow management of the charging of their EVs and customer experience and satisfaction with managed charging	• Participants were already familiar with managing charging behaviour to drive different outcomes. Reflective of a highly engaged cohort. • Participants were comfortable with smart charging. There were exceptions where the participant required instant charge and required to opt out. It was apparent that customer choice was important to the adoption of smart charging.
Progress towards the commercialisation of smart EV charging through an enhanced understanding of the business case for the control of EV charging	Based on insights from the Trial, Origin has designed and launched an EV Energy Plan that provides attractive price signals to encourage midday and overnight charging with five hours of free energy between 10am to 3pm and off-peak rates between 1am and 6am everyday. Origin is also retailing smart chargers that are enrolled onto Loop from which customers can select a range of smart charging schedules. Customers who are on the EV Energy Plan can elect for their Origin smart chargers to be optimised according to the times of the EV Energy Plan.

2. Smart Charging Trial Design

What is Smart Charging and why does it matter?

Smart charging is the ability for an EV charger to accept instructions from someone or something. These instructions could be designed to achieve objectives such as:

- Scheduled EV charging to allow for cheaper charging based of tariffs
- Smart EV charging to maximise local renewables or renewables in the market
- Sharing and allocation of load between chargers to stay within maximum capacity levels at a particular boards or site
- Reducing maximum load at any given day to stay within network constraints.

There are different ways to undertake smart charging including via a smart meter, a smart charger or via the electric vehicle itself.

Notes

Customers may experience issues or confusion when multiple methods of smart charging are configured at the same time. For example, the charging schedule configured in the car may differ to the schedule configured in the charger.

Smart Charging via the meter

Communications can be sent via a 3rd party that will energize/deenergize anything connected to that circuit. Traditionally this has been control load for hot water systems and pool pumps where power is made available for a certain number of hours but can also be used for EV chargers.

Smart Charging via the EV charger

Communications can be sent directly to the EV charger via ethernet, wifi or 4G. Instructions can also be more intelligent than what is available via the meter. Typically the industry uses a standard called OCPP to ensure all chargers are talking the same language.

Smart Charging via vehicle

Communications can be sent directly to the EV either via APIs or via the onboard settings. A standard feature allows drivers to set timers so that the car starts charging at certain times. The availability of this differs between car manufacturers and typically does not allow 3rd party access. 3rd party access can only be enabled via APIs and are not standardised across car manufacturers.

Smart Charging Trial Timeline

Sep 2019

Participant recruitment & installs

Origin commence promotion of the Trial to residential and fleet customers.

Eligible participants are enrolled onto the Trial and Origin arranges for a smart charger to be installed at their premises.

June 2020

Baseline

Origin collects charging data from connected chargers to understand charging behaviour without intervention from the smart charging platform.

July 2021

Experiment 1

Origin conducts its first experiment to test the effectiveness of price signals to change charging behaviour.

Nov 2021

Experiment 2

Origin conducts its second experiment which combines price signals with automatic controls of EV chargers to make it easy for participants to respond to the price signals.

Sep 2022

End of experiments

Origin completes smart charging experiments but continues to collect charging data to observe charging behaviour once price signals and smart charging controls are no longer present.

Dec 2022

End of trial

3. Residential participants

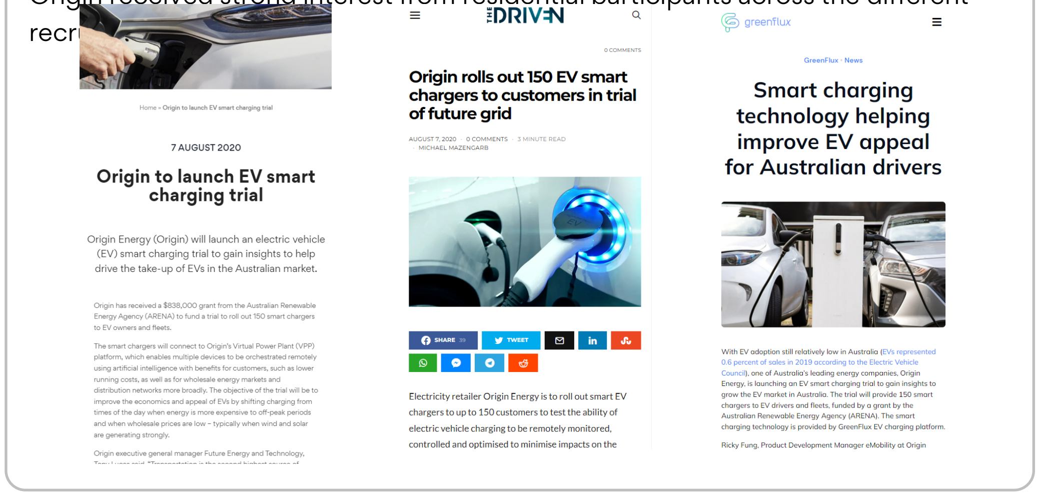
Recruitment process

Origin was targeting to enrol at least 150 EV chargers onto the Smart Charging Trial with the objective to have this split roughly half from each of the fleet segment and the retail segment and across Victoria, NSW, Queensland and South Australia.

In recruiting residential participants, Origin employed the strategies below:

- Mass media and social media promotions of the Smart Charging Trial to drive awareness
- Promoting the Trial at point of EV purchase via Hyundai and Nissan dealership channels

Origin received strong interest from residential participants across the different recr



Home » Origin to launch EV smart charging trial

7 AUGUST 2020

Origin to launch EV smart charging trial

Origin Energy (Origin) will launch an electric vehicle (EV) smart charging trial to gain insights to help drive the take-up of EVs in the Australian market.

Origin has received a $838,000 grant from the Australian Renewable Energy Agency (ARENA) to fund a trial to roll out 150 smart chargers to EV owners and fleets.

The smart chargers will connect to Origin's Virtual Power Plant (VPP) platform, which enables multiple devices to be orchestrated remotely using artificial intelligence with benefits for customers, such as lower running costs, as well as for wholesale energy markets and distribution networks more broadly. The objective of the trial will be to improve the economics and appeal of EVs by shifting charging from times of the day when energy is more expensive to off-peak periods and when wholesale prices are low – typically when wind and solar are generating strongly.

Origin executive general manager Future Energy and Technology,

THE DRIVEN

0 COMMENTS

Origin rolls out 150 EV smart chargers to customers in trial of future grid

AUGUST 7, 2020 · 0 COMMENTS · 3 MINUTE READ · MICHAEL MAZENGARB

SHARE 39 TWEET

Electricity retailer Origin Energy is to roll out smart EV chargers to up to 150 customers to test the ability of electric vehicle charging to be remotely monitored, controlled and optimised to minimise impacts on the

greenflux

GreenFlux · News

Smart charging technology helping improve EV appeal for Australian drivers

With EV adoption still relatively low in Australia (EVs represented 0.6 percent of sales in 2019 according to the Electric Vehicle Council), one of Australia's leading energy companies, Origin Energy, is launching an EV smart charging trial to gain insights to grow the EV market in Australia. The trial will provide 150 smart chargers to EV drivers and fleets, funded by a grant by the Australian Renewable Energy Agency (ARENA). The smart charging technology is provided by GreenFlux EV charging platform.

Ricky Fung, Product Development Manager eMobility at Origin

Origin uncovered some key learnings during the residential participant recruitment process. Most notably the following:

1. Technical aspects and details of residential EV ownership.

Detailed technical knowledge of the vehicles and EV ownership was very important when serving participants. This required understanding of facets such as maximum charge rates, connector types and speed of charging. This information assists in getting customers comfortable with EVs and the charging experience. For future trials, it is recommended that dedicated training sessions are conducted to better serve participants.

2. Smart charger being offered for free as part of the Trial

Origin noted that residential participants tended not to be as responsive in the installation process for the free charger as compared to when they are paying for a product. In some cases, unexpected additional costs even if quite relatively small to the value of the charger being installed, did result in participants pulling out of the trial.

Expressions of interest

Origin received expressions of interest from 388 residential participants, which were distributed all around the nation. There was particularly strong demand from QLD, NSW, and VIC, which made up around 75% of the total participants.

Many of the potential participants expressed interest in just helping industry advance.

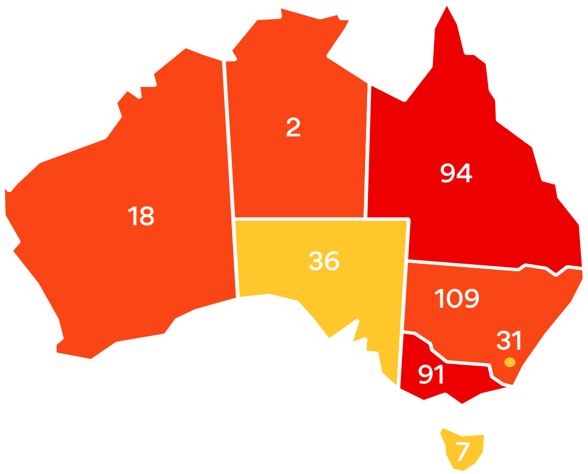
73 residential participants were selected to be part of the trial based on eligibility criteria including:

- Dwelling type (e.g. freestanding houses or townhouses).
- Off-street parking to install chargers.
- Being an Origin Energy electricity customer.
- Willingness to participate in surveys, interviews, and experiments over the period of 2 years.

Majority of interest came from Tesla and Hyundai drivers, reflecting the market share at the time.

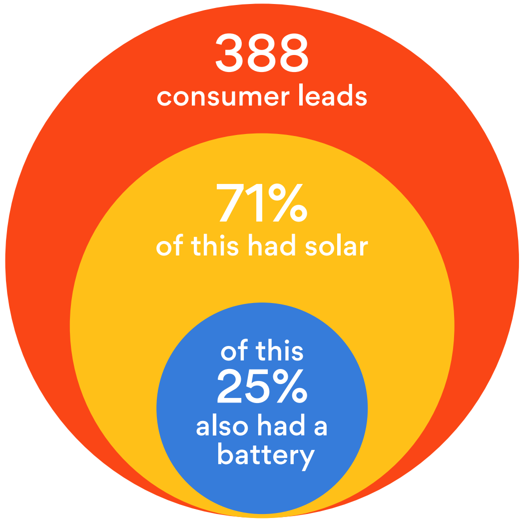
Interest from businesses varied as many of the customers did not have their EVs just yet. Businesses were considering chargers as part of infrastructure requirements but having subsidised chargers were not a strong incentive for switching to EVs.

Participants are already largely engaged with energy, many of them having solar and batteries.



388 people were interested in participating in the trial across Australia

Majority of those interested already had rooftop solar and many also had a home battery



Installation process

Following receipt of the expressions of interest from residential participants Origin undertook a process to qualify participants for their eligibility to be enrolled onto the Smart Charging Trial based on:

- Availability of off-street parking to enable the installation of smart chargers
- Ownership of premises
- Existing Origin customers.

The Smart Charging Trial subsidised chargers and installation up to $3,000. This amount was sufficient to cover most of the cost of supply and installation at residential premises for a large proportion of the installations.

Following the qualification process, residential participants are enrolled onto the trial and Origin arranges for a smart charger to be installed at their premises. Key learnings during the installation process included:

Physical factors

Photos from customers were key to gain a better understanding of the site requirements before an installer arrives on site. However, some physical factors were still not visible or not obvious, sometimes resulting in variation costs.

Customer preferences

The location of an EV charger was an important consideration to participants, particularly those who own multiple cars. It was important to ensure that it was possible to park the EV near the charger if the charging cable was not long enough.

Cost

Although the charger and a standard installation was at no cost to the participants, some sites required additional variation costs. This included factors such as cable run from switchboard to charger location, trenching and existing switch board capacity.

Performance of hardware and software

The combination of Schneider hardware and the GreenFlux smart charging software platform performed in-line with expectations:

- Although the EV charger configuration process has been relatively straight forward for installers to repeat, following initial training. The commissioning process for installers could be made more user centric. Origin's experience with other connected devices such as VPP batteries etc. suggest that installers have minimal experience in configuring network settings.
- There have been relatively few issues connecting to the smart charging platform.
- EV chargers may go offline intermittently and require a hard reset to bring them back online.
- This has resulted in successful implementations of smart charging at group and single user levels.

For a cloud-based solution, reliability of connection is important to ensure stable transfer of data, instructions and servicing of hardware.

Although rare, Origin has found instabilities with certain areas of the 4G network causing a lack of connectivity, interruptions, and delays in data transfer. This may limit the effectiveness of smart chargers at larger scales. Wi-Fi was considered as an alternative; however, this introduces other complexities as reliability falls onto the customer to ensure the network is maintained and secure.

Table 2: Connectivity options considered

Technology	Pros	Cons
4G	• Connectivity not impacted by customer • Allows remote diagnostics of connectivity problems	• Relies on telco network coverage i.e., subject to blackspots • Most expensive
Wi-Fi	• Cheapest and easiest option	• Relies on customer's Wi-Fi coverage and security to the garage/carport/driveway • Connectivity breaks if network configuration changes or if customer gets a new router or if customer moves • Cannot remotely fix or diagnose connectivity problems
Ethernet	• Most stable connection once wiring has been implemented	• Relies on customer's home security • Can be expensive due to threading cables from the router to the EV charger • Cannot remotely fix or diagnose connectivity problems • Connectivity breaks if network configuration changes or if customer gets a new router or if customer moves

Who are our participants?

The participants in our trial were highly engaged and knowledgeable about EVs and or energy.

This was reflective in many surveys and interviews that we conducted with our participants. Many were leveraging additional apps to help with managing charging and driving.

Our trial participants have shown to seek and engage communities and have self selected to be part of the trial.

It's important to acknowledge this as outcomes and opinions are skewed towards the innovators and early adopters.

Despite 66% of participants being comfortable with charging from a standard power socket, many participants wanted to join the trial for the free charger. Some had a charger already and wanted to participate to support the advancement of the technology.

"I try to charge using solar to ensure it's renewable and cheaper"

90% participants are over 35yo

66% were comfortable with charging via a standard power socket

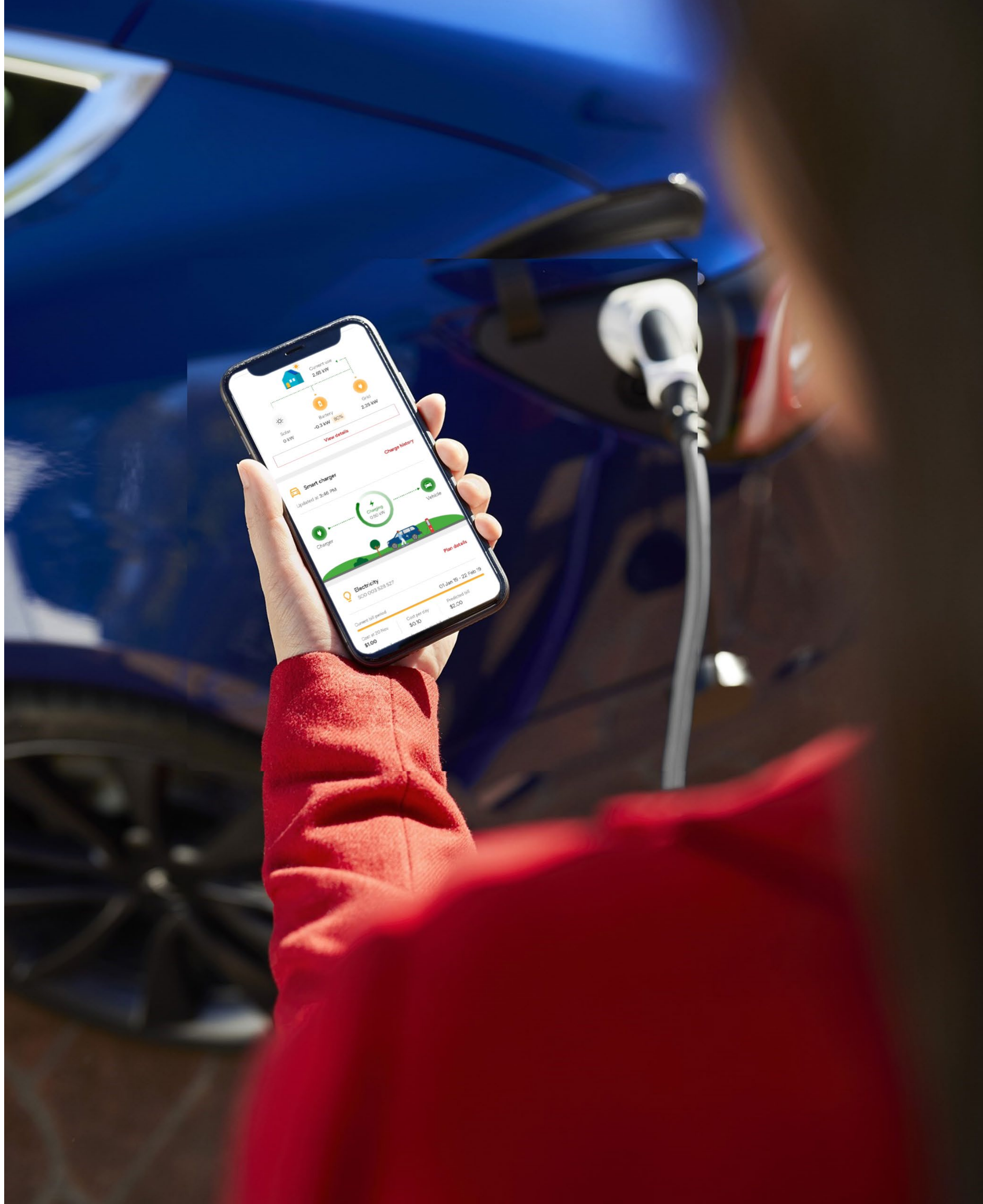
3 : 1 Male : Female split as primary contact

Baseline – Charging behaviour

Participants were well educated on how their energy is typically managed. Many had already been optimizing their charging to take into account solar production.

In some instances, participants were on legacy feed in tariffs that worth up to 60c per kWh. In these scenarios, participants chose to actively not charge at these periods in order to maximise return.

Many Tesla drivers use their in-built vehicle charging schedulers to start charging during off-peak periods.



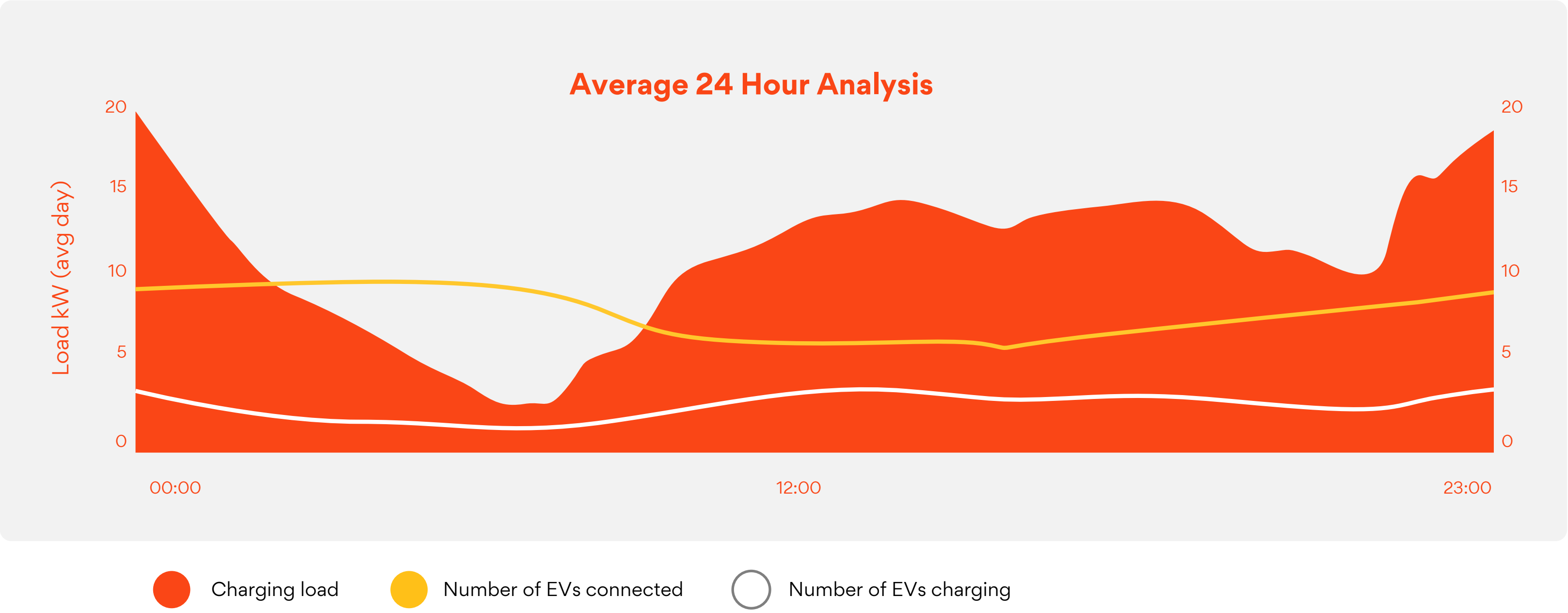
Baseline

Baseline charging behaviour

Baseline data capture occurred over 13 months from first install in 2020 to the beginning of experiment 1 in 2021.

What were the results?

This data showed Overnight Charging behaviour was popular. Equally as popular was charging in the middle of the day to maximising solar usage. Participants were already self optimising either manually plugging and unplugging or using timers in the cars.



Experiment 1

The incentive

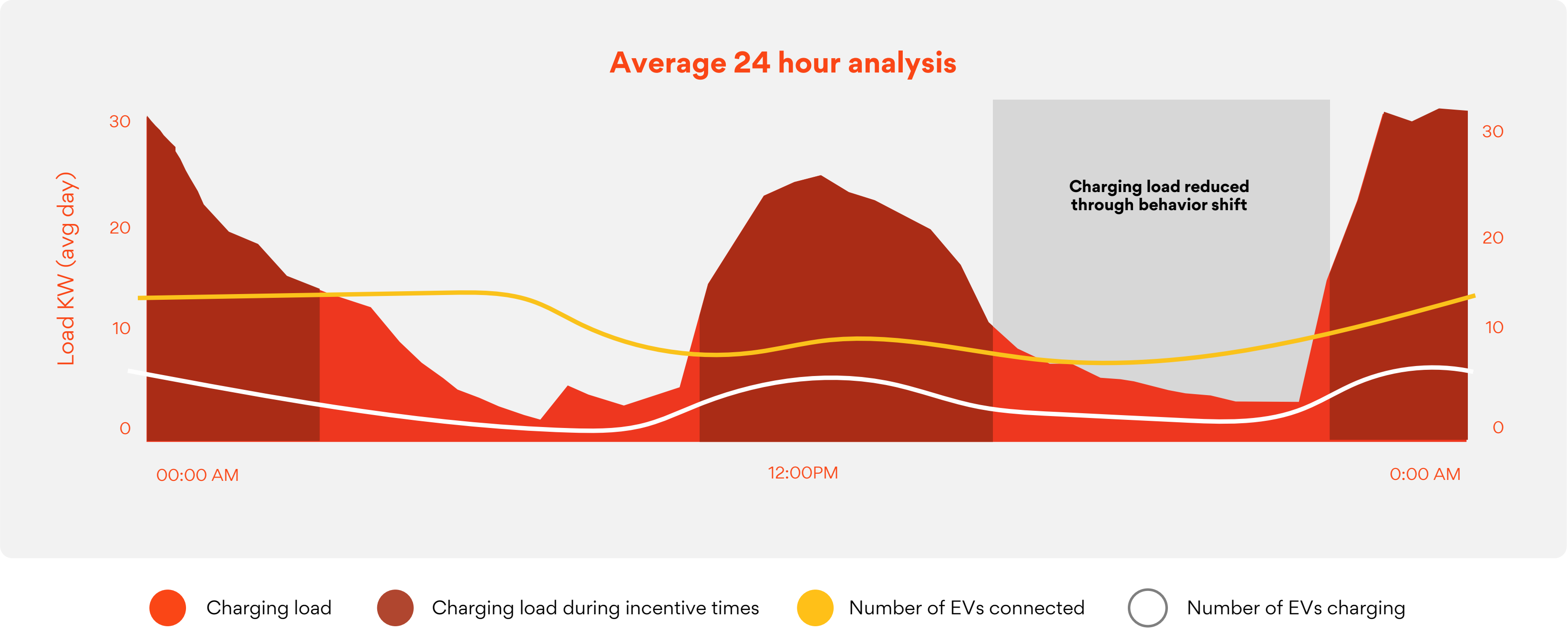
Experiment 1 consisted of Origin implementing a variable reward to test a monetary incentive-based approach to charging.

The variable component consisted of a 10c per kWh reward for charging between the times of 10am – 3pm and 9pm – 5am. Charging outside of these pre-defined periods did not yield a reward. Rewards would accumulate and be paid to customers via credit on their energy bill monthly.

What were the results?

Compared to baseline charging data, we found that participants responded strongly to the incentive. Charging outside of peak periods (3pm-9pm) increased from 70% during baseline periods to 90% during the first experiment.

It was noted that participants shifted their charging to the 10am – 3pm period where charging increased by 6% and the midnight period where charging further increased by 17% suggesting that overnight charging was more flexible in their circumstance.



Experiment 2

The incentive

Experiment 2 consisted of Origin controlling charging for a small window rather than relying on participants to control their charging.

Origin implemented a fixed and variable reward mechanism to incentivise control.

The fixed component consisted of a 25c per day reward if participants allowed Origin to curtail their charging between 3pm and 9pm. Furthermore, participants would also receive a variable component of 10c per kWh reward for charging between the times of 10am – 3pm and 9pm – 5am to further shape charging habits.

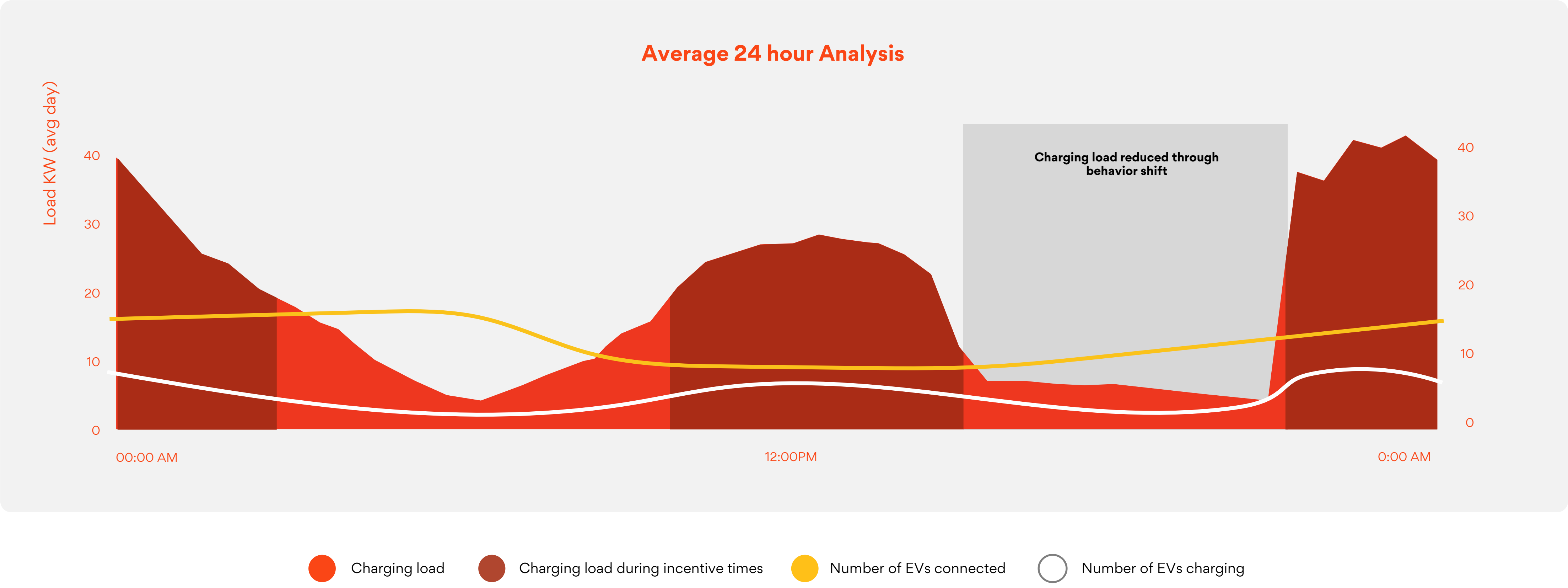
Noting that participants that may want to override this, Origin provided functionality in the Origin mobile app to override any settings (Figure 4). We found that participants valued this feature as it provided flexibility and control when needed.

What were the results?

Compared to baseline charging data, we found that participants responded strongly to the incentives. Charging during the peak periods reduced by 22% when compared to baseline charging patterns and 4% compared to experiment 1 (Figure 5). It was noted that participants further shifted their charging to the 10am – 3pm period where charging increased by 3% compared to baseline and a decrease of 3% compared to Experiment 1. Lastly, we noted changes in the overnight period where charging further increased by 14% compared to baseline and 4% increase compared to experiment 1.

Although this approached provided only a 4% benefit when compared to Experiment 1, this is also a significant result as it indicates participants responded well to controlled charging in comparison to an incentive-based mechanism. This observed behaviour could be explained by the convenience factor of having to “plug and forget” for the participants rather than having to think daily about charging (and not charging) in specific time periods.

Experiment 2



Experiment 2 – Analysis of Daily Curtailment Opt Out

Participants rarely opted out of the daily 3pm – 9pm curtailment.

It was noted that only 44 of the 73 residential chargers ever opted out of the 3pm – 9pm curtailment over the almost 11 month period.

Of the 44 that did opt out at least once, on average, there were 11 opt outs per charger.

However it is worth noting this was largely skewed by one charger that opted out 108 times and another two that opted out 55 and 42 times respectively.

The participant who opted out 108 times (driving a PHEV) provided the following insight behind why they opted out so often "car came home at 4pm, and needed to be charged for next morning or even later that night. Usually there was some sun left, so wanted to charge from the solar while I could".

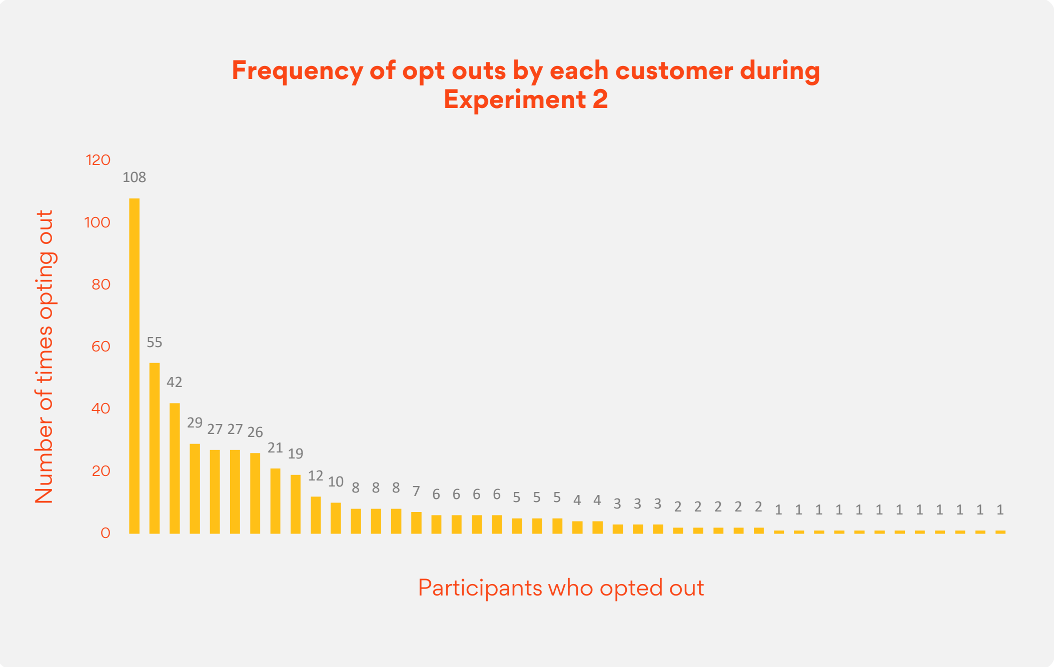
We also saw a large number of opt outs from a driver who was driving a particular vehicle. This was due to the driver implementing scheduled charging within the vehicle's scheduler to optimise for off-peak rates (start charging at 10pm, 1 hour after the 9pm curtailment ended) the vehicle BMS would not resume smart charging if the schedule was enabled, leading to the driver opting out more often to enable that schedule and charge as desired.

8 other participants formed a large proportion of the opt outs, the remaining cohort choosing to opt out a handful of times or less.

In total, of the 342 day of experiment 2, across the 73 residential chargers, there was a 24,966 opportunities to opt out.

We saw a total of 485 opt outs, representing an approximate opt out rate of 1.9%

This is significant as it shows that there is available flexibility in Electric Vehicle charging that can be used to support the grid's demands.



Post Experiments Baseline

The incentive

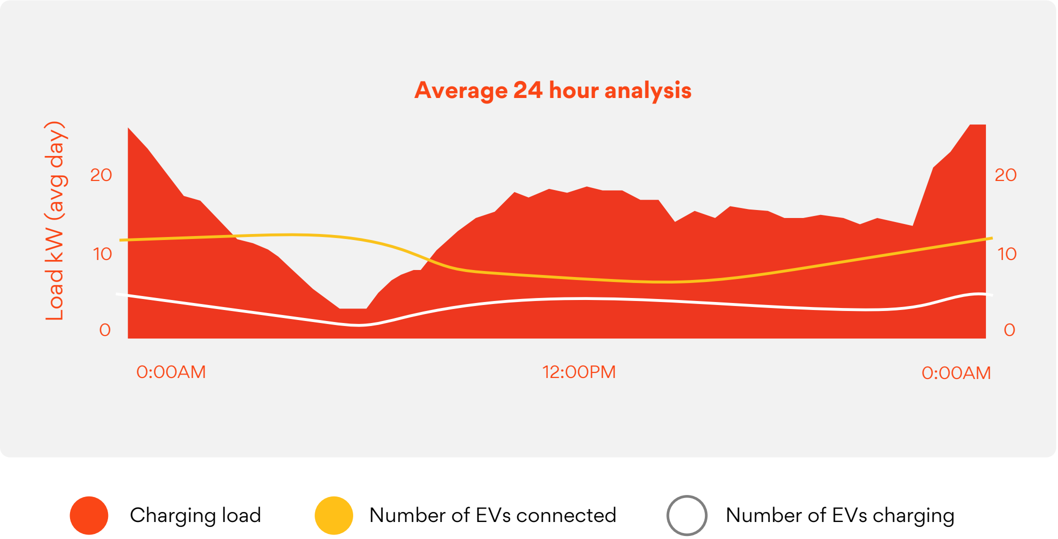
There were no incentives during this period. Following experiment two, over a 3 month period, no curtailment was in place and no incentives were on offer, and the same charging data was collected to understand if there was any lasting effect of the experiments on participant behaviour without the incentives in place.

What were the results

Compared to baseline charging data, we found that participants responded were showing minor changes to the behaviour in their charging patterns.

Charging during the peak periods was reduced by 4% when compared to baseline charging patterns, up 14% compared to experiment 1 and up 18% compared to experiment 2. It was noted that participants had shifted some of their charging away from peak to other periods in the day by 1-2%.

This indicates that charging patterns trended towards returning to baseline over time without the presence of incentives or active curtailment periods.



Assessing the value of Smart Charging

Origin assesses two value streams as approximates for the value of Smart Charging:

1. **Value to the wholesale energy markets; and**
2. **Value to the distribution networks.**

Wholesale energy value

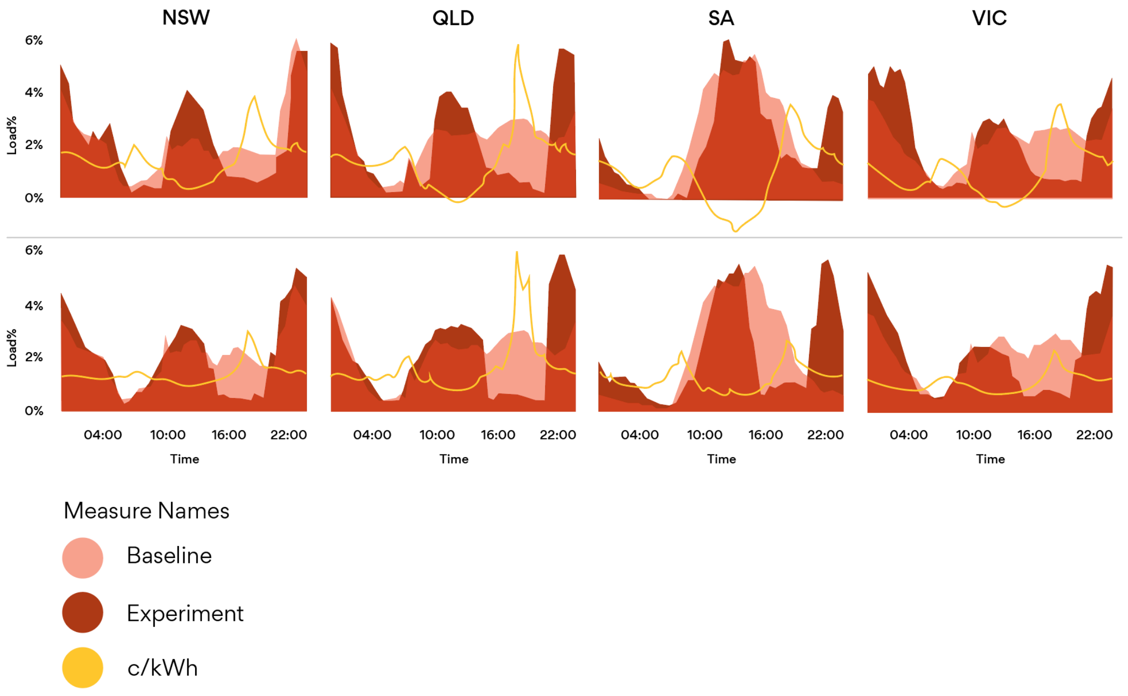
To assess the wholesale energy value created from Smart Charging, the charging profile under Experiment 2 were overlayed against the Baseline charging profile.

The wholesale energy value from Smart Charging is then calculated as the reduction in the wholesale energy cost of the Baseline charging profile compared to the cost for Experiment 2.

There are slight variations across the states, but the result can be broadly summarised as:

- Charging during peak period (3pm – 9pm) incurred peak wholesale energy prices from $0.14 to $0.38/kwh
- With Smart Charging, charging during peak period reduced by 79% under Experiment 2 compared to the Baseline
- Charging previously done during the peak period was shifted to the midday period (10am – 3pm) with average cost of $0.11 – 0.13/kwh and overnight period (9pm-6am) with average cost of $0.13 – 0.20/kwh

The average wholesale energy cost of the Baseline charging profile is $330. This is reduced to $286 under Experiment 2. This results in an approximate wholesale energy value of Smart Charging for $46 per EV per annum.



Assessing the value of Smart Charging

Value to the distribution networks

Origin worked with Ausgrid, Powercor / CitiPower / United Energy and Energy Queensland (Energex and Ergon) during the Smart Charging Trial to share data and analyse the potential value of smart charging to these networks.

Each network suggested a different approach to estimating the potential value of smart charging.:

Powercor / CitiPower / United Energy

The network value can be approximated from time-of-use (TOU) network tariffs which have had a peak rate about 10-12 c/kWh higher than the off-peak rate depending on the network. The source of this value is the potential to defer network investment.

In addition, smart charging in Victoria should be assessed relative to a customer on a TOU tariff since the Victorian Government's intent is that every customer with a smart charger should be on a TOU network tariff, and the Origin Smart Charging trial showed that TOU tariffs are effective in getting customers to charge in off-peak times.

If Origin assumed that:

- the network TOU tariff is cost-reflective
- in the absence of control, 30% of convenience charging would occur at peak pricing times
- 100% of controlled charging would occur at off-peak times

the network cost saving would be about $80 per year per EV.

Assessing the value of Smart Charging

Ausgrid

The potential value of smart charging can be informed by the Ausgrid network's long run marginal cost and any local network constraints. The trial findings showed that customer incentives and managed charging were seen as effective strategies to reduce electricity demand from EVs at network peak times and increases electricity demand from EVs at network minimum demand times. These responses both help to lower network costs and so reduce long-term costs to consumers.

Ausgrid explored the potential value of smart charging on avoided or deferred network investment. LV distributor capacity constraints could result in EV charging limitations or reduced reliability for all customers.

As part of Ausgrid's CER integration model, Ausgrid isolated the impacts of EV charging and were able to compare the Ausgrid base case to the findings from the Origin Smart Charging trial.

Ausgrid's model indicated that the percentage reduction in EV demand (kW) at peak times (3-9pm) achieved in the trial could support up to $12m in avoided or deferred network investment, if similar EV charging behaviour was replicated across all residential EV users to 2029.

Ausgrid did additional analysis with trial data on case study areas of the network. This showed that managed charging can have unintended outcomes due to coincident responses to price signals, resulting in a local secondary peak after the traditional peak demand period.

The trial reinforces the importance of tariff design and improved customer access to retail products that support efficient utilisation of network assets and reduce long term customer costs.

Energex and Ergon Energy Network

Energex and Ergon Energy Network combined the finding from the Smart Charging Trial with their own EV SmartCharge Trial to assess the impact of charging on the distribution networks. Both Trials supported the finding that EV charging is a flexible load and EV charging tariffs and incentives can be effective in influencing behavioural change.

Customers demonstrated the ability to move their EV charging between different periods of the day to satisfy their charging preferences including to self-consume their solar generation in the day time and make late (non peak) overnight charging prominent.

In terms of assessing the value of smart charging to the networks, they outline this will be informed by long run marginal costs, constraints at a point in time, relative size and spatial dimensions.

Additionally, Energex and Ergon Energy Network highlighted the role that retailers such as Origin Energy in helping EV charging to match network needs.

They have produced a report: "EV SmartCharge Queensland" to share insights from their Electric Vehicle study. This is available at: https://www.energex.com.au/home/control-your-energy/smarter-energy/electric-vehicles/ev-insights.

Value of Smart Charging using Time of Use (TOU) network tariff

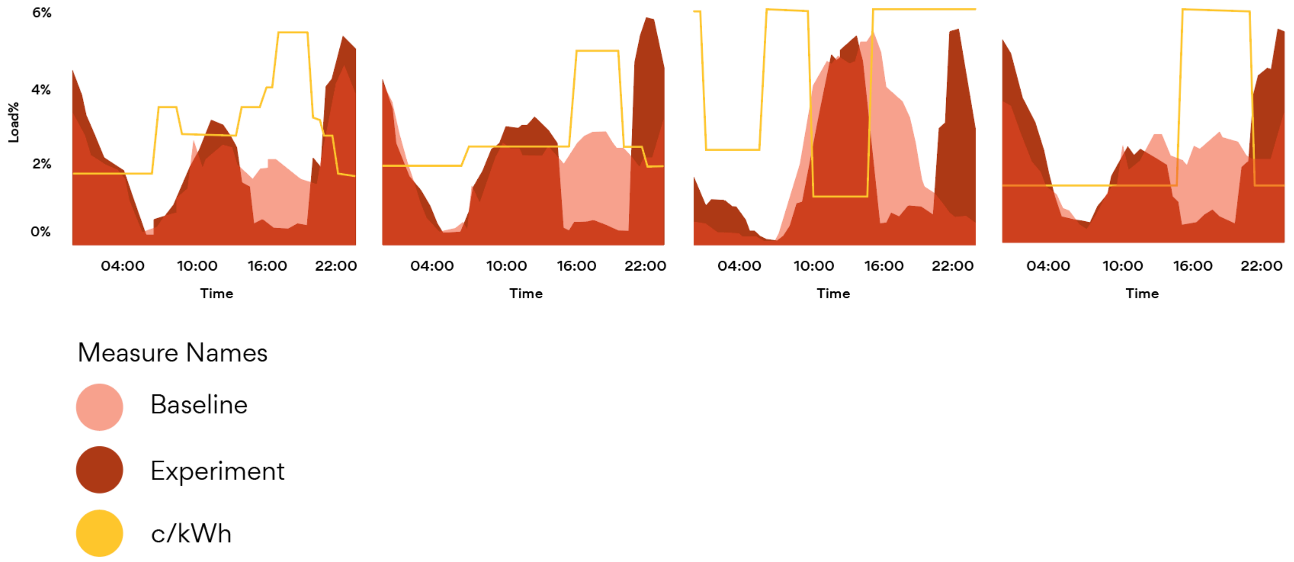
In using the Time of Use (TOU) network tariff as a proxy to calculate the value of smart charging, Origin calculates the network cost of the Baseline charging profile and compared this to the cost of the charging profiles under Experiment 2.

While the DNSPS have different tariff structures, the following can be observed:

Network tariffs during peak periods ranged from $0.11/kwh to $0.28/kwh. The common time period where these peak tariffs occurred across the DNSPs were between 3pm - 9pm

Off peak tariffs ranged from $0.03/kwh – $0.07/kwh. The common periods when these off peak tariffs occurred across the DNSPs were between 9pm – 6am or 9pm - 3pm (overnight).

The average network cost of the Baseline charging profile was $135. This is reduced to $107 under Experiment 2. This results in an approximate network value of Smart Charging of $28 per EV per annum.



Factors impacting the value of Smart Charging

There are a number of factors that influence the wholesale energy value and the value to the distribution of networks from Smart Charging

Shape of the wholesale energy price

Due to increased volatility in the wholesale energy markets during Experiment 1 and 2 the wholesale energy prices during the midday and overnight charging periods were higher than expected, resulting in lower savings from shifting charging into these periods.

Baseline charging profile

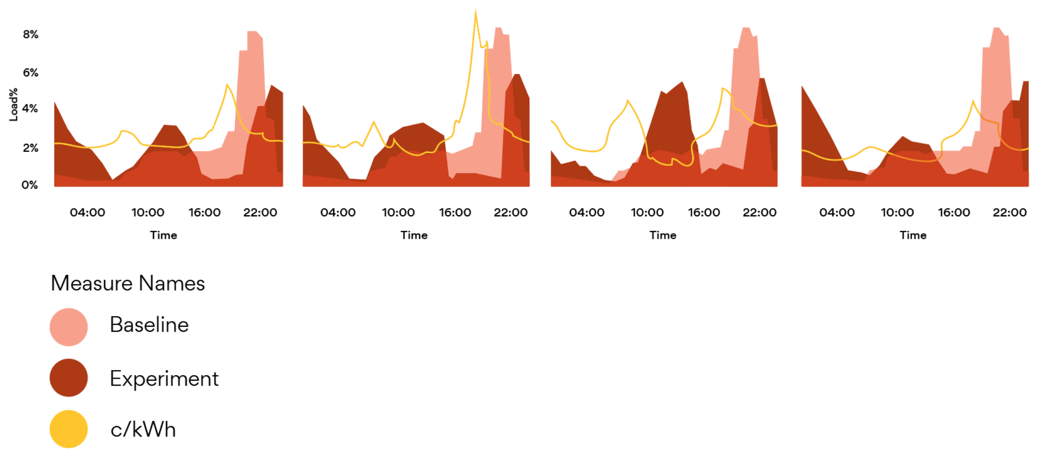
The Trial participants were from the early adopter cohort and were highly engaged in managing their energy and charging consumptions. The Baseline charging profile already reflected a level of optimisation by Trial participants with large proportion of the charging already done during the midday period to maximise solar consumption and overnight period to take advantage of existing time of use tariffs. Therefore the difference wholesale energy cost and TOU network costs of the Baseline charging profile and the profiles under Experiments 1 and 2 were less what would be expected under charging profiles where more of the charging would be undertaken during the peak period (mass market uptake).

The baseline charging profile also reflects the maximum demand placed on the distribution network during the peak period. As the maximum demand during the peak period under Baseline under the Smart Charging Trial is lower than would be expected under mass uptake scenarios, this will also underestimate the increase in peak demand from EV charging and the investment required to accommodate this increase without Smart Charging.

To understand what the value of Smart Charging could be under normalised charging profiles expected under mass uptake scenarios, Origin replaced the baseline charging profile from the Trial with the Convenience charging profile in CSIRO' Electric Vehicle Projections 2021 report.

The Convenience charging reflects the expected scenario where EV drivers come home from work and plugs their EVs from 5pm which coincides with the evening peak period.

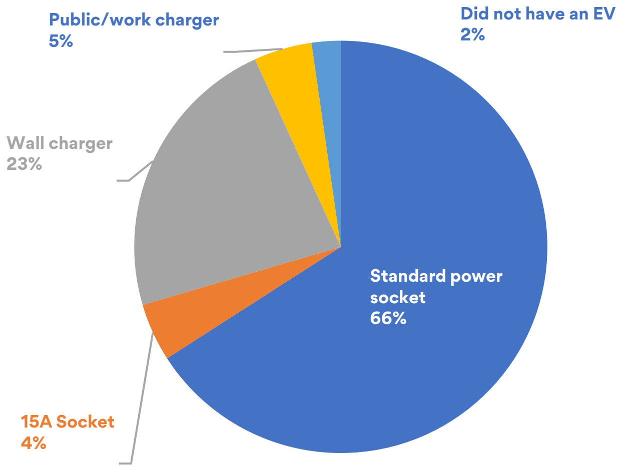
The difference in the wholesale energy cost and network TOU tariff cost for the Convenience charging profile and the profiles under Experiment 2 is $170 p.a. which can be a proxy for the value of smart charging under a mass uptake scenario. This compares to the value of smart charging calculated against the Baseline profile under the Smart Charging Trial of $76 p.a.



Insights

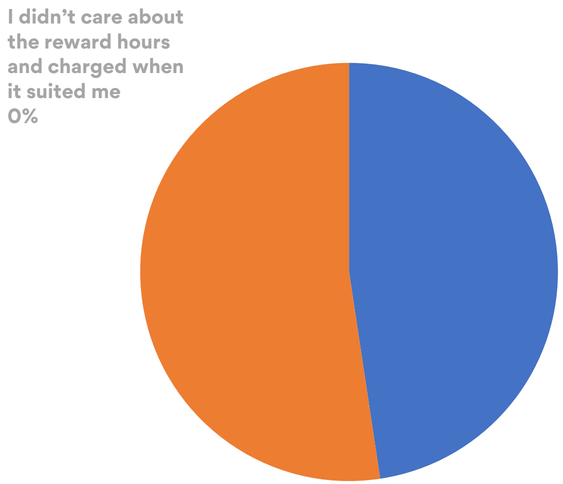
Customer sentiment & attitudes

How did participants charge before the start of the trial?



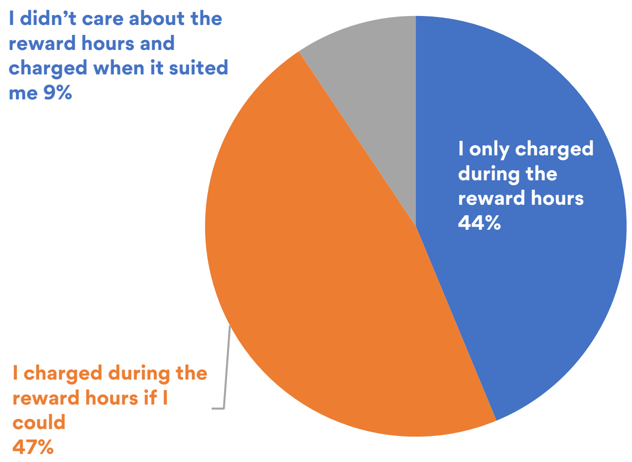
Insight: *Most EV owners start out using just a low-speed portable charger*

During experiment 1, how did your behaviour change?



Insight: *Small per kWh cash rewards influenced almost half of users to charge during reward hours*

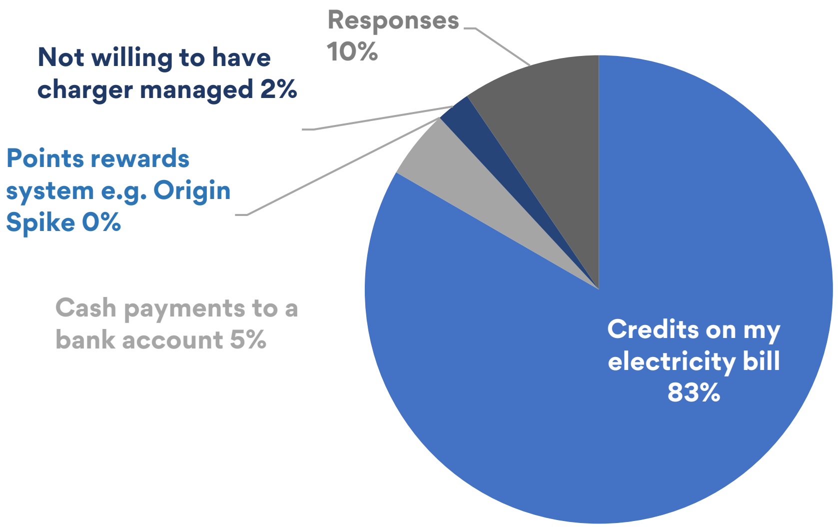
How did your charging behaviour change during experiment 2, compared to before experiment 2?



Insight: *An additional daily curtailment did not dramatically impact driver's charging behavior on top of the small per kwh cash reward*

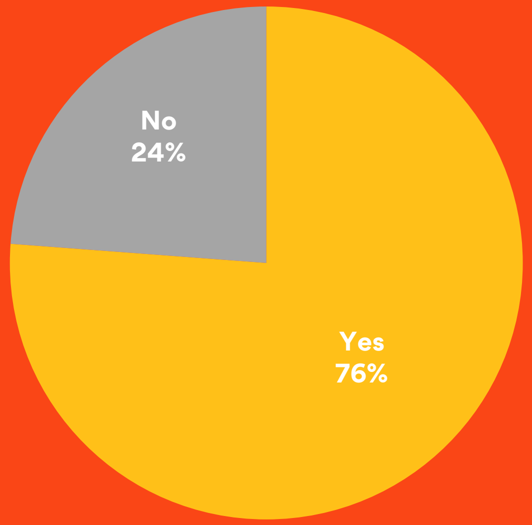
Customer sentiment & attitudes

What format of incentives do you believe would most likely make you change your charging behaviour?



Insight: *Credits on customer electricity bills are the most desirable form of incentives for customers*

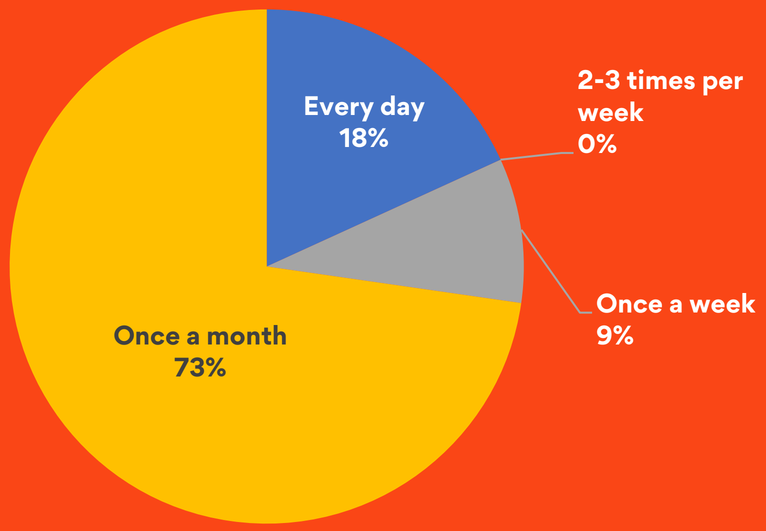
During Experiment 1 was the 10c per kwh reward during the specified hours enough incentive to change your behaviour?



Insight: *10c per kwh (in some cases an almost 50% discount on the price of the electricity) is largely acceptable as an amount for incentivizing customer behavior*

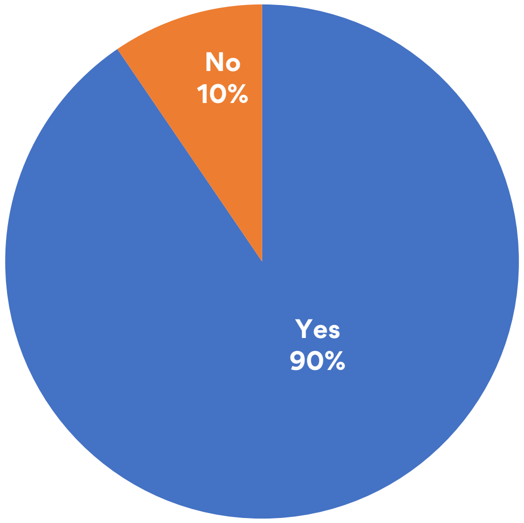
Customer sentiment & attitudes

During experiment 2, how often (on average) did you opt out of curtailed charging between 3pm and 9pm?



Insight: *Drivers rarely opted out of curtailed charge between 3pm and 9pm, indicating it was not negatively impacting their life.*

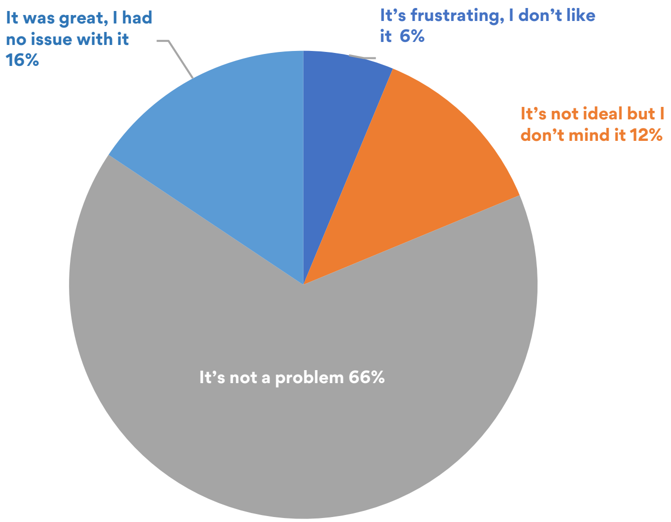
Would you sign up to an electricity plan that rewards you to charge during off peak periods (i.e. middle of of day and overnight)?



Insight: *Customers are strongly interested in electricity plans that incentivize them to charge at certain times of day, indicating that changing behaviors may be achieved simply through ToU plans.*

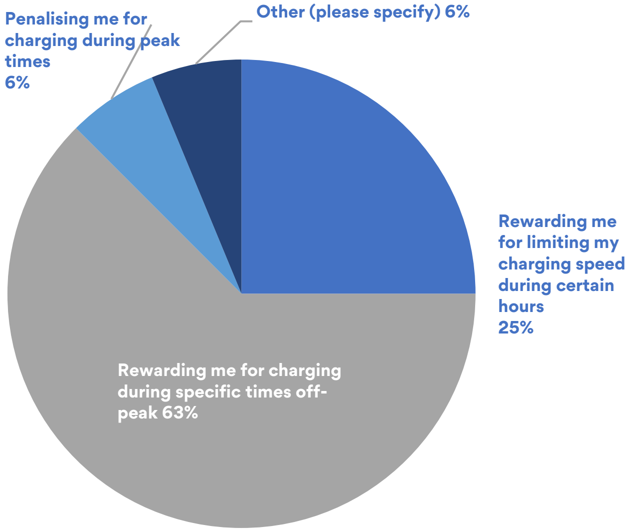
Customer sentiment & attitudes

When your charging speed is being limited, how do you feel about it?



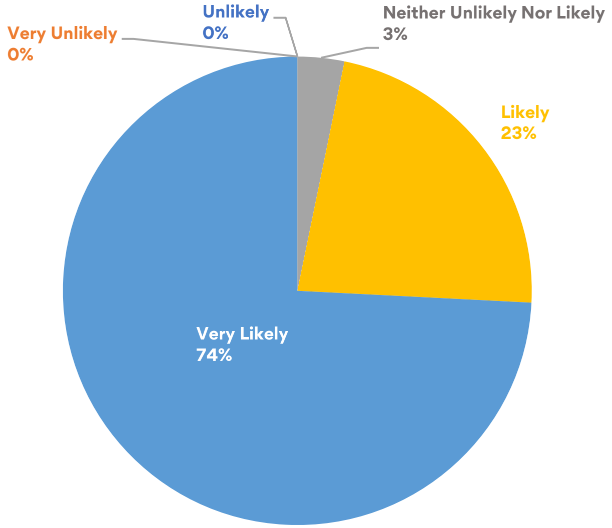
Insight: *Participants did not feel that curtailing charge between 3pm and 9pm was a major impost*

Which of these would most likely change the time when you charge?



Insight: *Customers like the idea of being rewarded for the right behaviors over penalizing them for the wrong behaviors.*

If we continued to run Experiment 1 or 2 in an ongoing manner, how likely would you stay on it?



Insight: *Customers are happy to continue their involvement in a program like this!*

Meet Peter

Peter is a sales person from Sydney, NSW. Peter and his family live in a house with solar and 2 vehicles; a Tesla Model 3 and a petrol SUV.

"We use the Model 3 as our primary car, if we look change our SUV, it will be for a Model Y. Petrol car only kicks in when we need 2 cars. It's more expensive [the SUV] and more fun to drive the Tesla"

Peter drives on average 150km per week.

"A typical day is dropping off my daughter at childcare which is 10km away or when I'm not working from home 20km to airport for work."

Peter

Peter likes technology and getting solar had made him more engaged with energy. Peter was familiar with changing hits habits to earn more rewards.

“Solar makes you really aware of consumption in general. Now I think about what I do at night, and charging has accelerated that even further. So I think about what’s on while I charge. I think about how much the sun’s out relative to it.”

The importance of having an dedicated EV charger

Peter values the speed and piece of mind it. “What is has given me more than anything, is a piece of mind that I won’t have enough charge. You can rely on the car to be ready to go when you need it. If you forget to charge and you only have a wall socket, you’re in trouble.”

On reward and curtailment, Peter was already familiar with the concept due to Origin’s Spike program.

I thought it was quite reasonable. Because it was a peak time anyway, not necessarily a time you would be charging the car. Sometimes I would be using the car.

I get it, I’m on that Spike* thing as well, same premise, you’ve got busy hours you’re trying to stop. I’ve probably claimed $150 worth of Uber Eats vouchers.

> “My rule is…if the sun’s out – start doing stuff. Do the washing, dishwasher, charge the car, things like that.”

Opting out of Smart Charging

“There were definitely times where I needed to opt out and just needed a quick charge immediately.

Future developments with using vehicle to grid

“What is has given me more than anything, is a piece of mind that I won’t have enough charge. You can rely on the car to be ready to go when you need it. If you forget to charge and you only have a wall socket, you’re in trouble.”

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Meet Pam

Pam is an Uber driver from Canberra, driving a Hyundai Kona Electric living in a house with Solar installed. Pam is on a legacy feed in tariff so does not try to maximise her solar use by using things during offpeak.

“I normally start at around half past 7 come home at 5:30 to 6. I set the car to start charging at 10pm. On weekends I charge all day because it’s offpeak”

Pam drives on average 1,250km per week most because she is an Uber driver however she also like to drive more often because of its low costs.

“I’ve done 115,000km in the past 2 years but I can’t compare it to a petrol car. I wouldn’t have done that many k’s if it was a petrol car.” I have driven from here to Gungahlin which is about 40kms away to look at buttons. I wouldn’t have done that if I had a petrol car, I would have gone online. But because it’s electric, I go wherever I want, whenever I want.”

Pam

Range anxiety is a common occurrence for ICE and new EV drivers. Pam regularly travels long distances without breaking a sweat.

"I've been to Melbourne, I've been to Newcastle, I go to Wagga all the time, come back to Gundagai, charge it just enough – maybe about half hour to get back here [Canberra]. It's a really nice way to travel, I like to have some lunch instead of coffee, have a walk around. For some people it doesn't suit them."

"When I got my car I told I was going to get 360km to a range. I drive around what I call 'Old Mole' mode so I get 450km. I've been told that 90km/hr is the optimum amount where I get the most efficiency."

"When I got my car I told I was going to get 360km to a range. I drive around what I call 'Old Mole' mode so I get 450km."

Using the car as a battery in the future

"Not sure, it's a bit technical for me, not sure how it would work. I'm not sure how that would work for me as I am always driving."

On Origin's control of the EV charger during the trial,

"I didn't even know about the Smart Charge thing. I didn't notice the credits."

We asked Pam whether she would continue with now knowing what we were doing with the trial.

If it mean I didn't have to set it everyday, that would be great if I could do that. If you could do that and I just plug it in, that would be really good.

4. Fleet participants

Recruitment process

Leveraging Origin Energy's relationships with commercial and industrial organisations, focus was placed on identifying organisations with strong CO^2 reduction commitments who were actively seeking to trial/pilot EVs as a way of reducing transport related emissions.

One on one briefing sessions were held with organisations to explain how the trial would be run, how smart charging worked (as well as potential benefits to the grid and organisations) and to assess interest.

Once customers indicated interest in participating in the program, Origin would work with the customer to understand the scope of their requirements and would undertake detailed site assessments to understand the existing infrastructure at site and the most optimal installation process.

In the process numerous stakeholders would be engaged with from sustainability managers, facilities managers as well as contracting/procurement stakeholders as contracting of the electrical works was negotiated.

Trial participants came from a range of industries including:

- Local Government
- Aged care
- Managed services providers
- Water Authorities
- Education

It was noted that participants decision-making process tended to be longer when compared to residential participants, this was due to the multiple stakeholders and approvals required to purchase EVs and install chargers.

Origin noted several key findings relating to business participants:

Technical aspects and details of business EV ownership and operation.

There was major focus by businesses to ensure the compatibility of chargers and how that related to the EVs they already owned, or how it might impact future choice of EVs. Similarly, to residential participants, Origin noted that educating businesses on the specifics of charging times and charger types was important to participation in the trial.

How smart charging would impact fleet operations.

Business participants were interested to understand how smart charging could help optimise the spend associated with powering their fleet, and whether smart charging could lower demand charges (i.e., by blocking charging during peak demand periods)

Business participants exhibited a level of concern around how the trial's 'charging events' may impact business operations. Questions were also raised about the amount of notice they would receive prior to events occurring and who in the organisation (either fleet managers or drivers) would be best to make decisions on whether to opt-out of smart charging or not. This concern was particularly noticeable in instances where it was a pool vehicle and not dedicated to a particular driver.

Installation cost

As part of the trial Origin proposed to subsidise the installation and commissioning of EV chargers to the value of $4,000 (Ex-GST) per charger for each BEV/PHEV the organisation had within their fleet.

One of the key learnings of the trial was that installation costs could vary significantly at commercial premises due to a range of factors which included:

- Existing capacity at site (and whether a load management system was required to limit EV charging demand)
- Existing electrical infrastructure (and whether upgrades were required such as switchboards)
- Cable run distances (distance from switchboard to charger location)
- Requirement for civil works (ie trenching to run cables to charger locations)

As part of the trial installation costs, the $4,000 rarely fully-subsidised the installation and commissioning of chargers, with more complex sites having costs closer to $10,000 per charger. At more complex sites, this included items such as load management systems and in some instances provision for future electrical works (ie pre-wires to reduce charging costs in the future).

Baseline charging behavior

Within trial participant cohorts, the implementation of EVs was predominantly the first EV within the fleet. To mitigate risks around range anxiety, vehicles were typically pool vehicles to simplify charging requirements (ie overnight charging at the office), pool vehicles also provided the opportunity for multiple stakeholders across the business to drive the EV.

Vehicles were typically driven during traditional business hours and charged in the evenings, with the logic that vehicles would be fully-charged for the next days' business activities. AC chargers provided piece of mind that the vehicles would be sufficiently charged in a timely manner.

Whilst a few companies were keen to optimise charging to leverage excess solar generation during daylight hours, not much thought was taken into account to optimise charging spend by charging during off-peak periods.

When initiating conversations around smart charging, customers were hesitant to undertake any activities that may have impacted the operational needs of the business. There was a fear from some customers that smart charging may result in scenarios where vehicles didn't have enough charging during periods where the vehicle was earmarked to be driven.

Participation in smart charging

Whilst smart charging provides the opportunity for organisations to reduce the cost of powering fleets and associated demand charges (particularly for large C&I electricity accounts). There are a few barriers that need to be addressed before wide adoption of smart charging occurs in particular:

- Businesses having confidence that smart charging wont impact operational requirements. This is particularly challenging for the first EVs within fleets where concerns around range anxiety are heightened. As the majority of vehicles in the trial were pool vehicles, where utilisation can vary widely, static smart charging schedules can be problematic. A solution to this may be to link schedules to pool vehicle booking systems so that dynamic smart charging schedules can be developed based on the travel requirement in the upcoming 12-48 hours. This however doesn't account for last minute trips that employees need to make.
- When discussing the benefits of smart charging, one of the key challenges was identifying the best stakeholder in the business to approve proposed smart charging schedules. Whilst numerous stakeholders saw the benefits of smart charging, there was a risk vs reward approach by businesses, with most organisations believing that greater flexibility justified any premiums in costs.

The area where smart charging did have resonance

- Capacity constrained sites: Where sites didn't have enough capacity to charge vehicles, smart charging was seen as a way of effectively reducing the capital costs associated with increasing energy capacity at site.
- Excess solar generation: For organisations with excess solar generation, maximising charging during daylight periods was seen as a cost-effective solution. This particularly worked well for pool vehicles which weren't driven on weekends. Excess generation during the weekend could top up the electric fleet for the upcoming week.
- Impacts to energy bills: In some instances our analysis indicated that EV charging would impact capacity and demand charges on a customers energy bill at a rate much higher than the over increase in energy demand. Using smart charging to limit/optimise spikes in demand charges was seen as an effective strategy. This only had resonance when talking about future fleet when EVs were at scale as opposed to a few EVs for trialling purposes.

5. Key learnings

Incentivising the right people at the right time

As referenced several times in this report, the participants of this trial are early adopters and as such, exhibited behaviours that may differ to mass market EV drivers in the future.

Although our insights showed that 74% of participants would stay on an incentive program post trial – the customer needed to be offered a free charger to participate in the first place. In the absence of mandates, part of the challenge will be to:

1. **Convince the customer to choose a smart EV charger over a basic EV charger**
2. **Convince the customer to enrol into a smart charging incentive program**
3. **Participate in specific curtailment events**

From a business customer perspective, there was concern on our smart charging would impact operations. Due to this reason, smart charging was on an opt in basis, only 10 of 30 business customers had opted into smart charging due to these concerns. The reward for smart charging could not outweigh the operational risks.

Additionally, simple incentive structures and control may lead to secondary or alternative peak demand.

Getting the right data

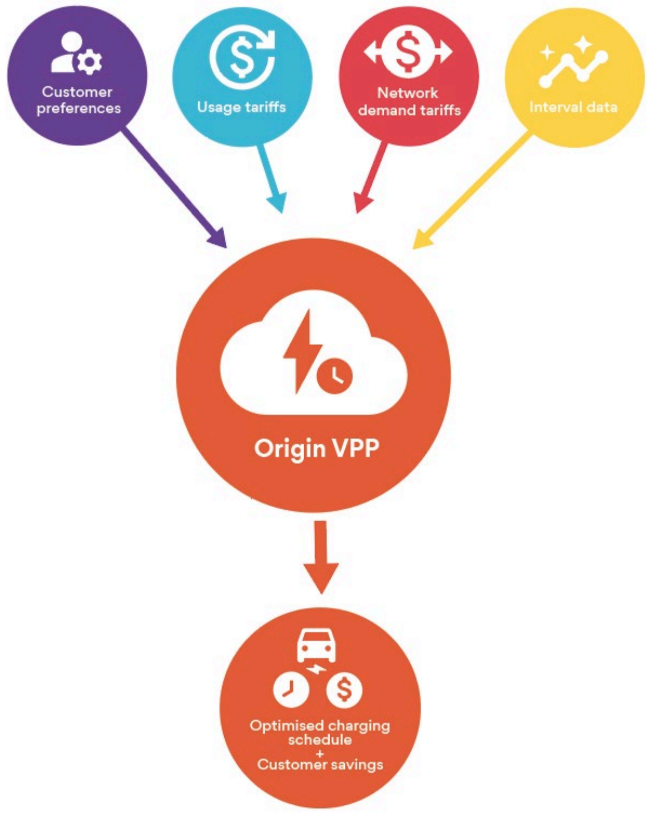
Access to data is crucial to provide value back to the customer. This data includes, interval data, tariff pricing and data from any local assets such as solar or batteries.

Origin currently provides optimisation of value via it's Virtual Power Plan (VPP) and is typically straight forward when customers are an Origin electricity customer. Origin has worked with customers previously to provide significant savings by reducing network demand charges and charging off-peak.

For the trial, one of the constraints that Origin experienced was access to these data points specifically with business customers who were not Origin electricity customers.

The process would require business customers to make time and find people with access to the relevant data, seek approval and find a secure way to provide the data. Given the number of EV chargers that were involved, businesses were not motivated to provide the data for the potential benefits that could be gained.

Customers start thinking about more sophisticated charging strategies once EV charging becomes business as usual and make up a larger proportion of the energy bills.



The importance of a standardised ecosystem for EV charging

Investigating smart charging technology and communication approaches between chargers and networks can be a relatively simple exercise. The effort is typically spent on agreeing with an approach as opposed to finding the right technology that fits our needs.

In a commercialised model where multiple parties have different ways of talking to an EV charger, circuit or vehicle downstream and even more ways to communicate to different networks upstream, the ecosystem becomes complex and costly to maintain.

In addition to this, the requirements on smart charging might differ based on state or network whilst metering requirements of charging is vague.

Learnings from a parallel industry - IoT & Matter

Customers installing IoT devices such as smart lights, doorbells, sensors etc bare the brunt of a fragmented eco systems. Many of these manufacturers have created an alliance to build an open interoperability standard named Matter.

Applying a similar approach between utilities, networks, devices and the market operator may help simplify the eco system.

6. Commercialisation of smart charging

Origin’s EV Energy Plan and Smart Charging Program

The results from the based on the findings from the Smart Charging Trial suggests that when EV adoption moves beyond the early adopter phase into the mass adoption phase, EV charging may have the potential to increase peak demand during the evening peak period and smart charging can be effective in managing this charging away from the evening peak period.

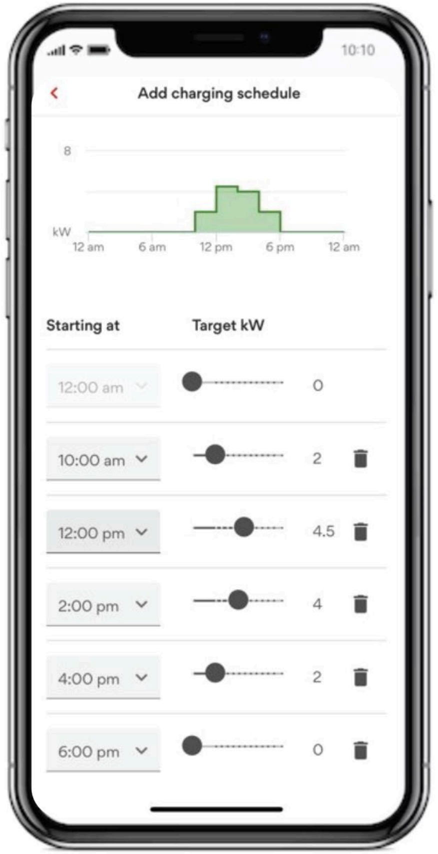
Based on this finding, Origin has launched an EV Energy Plan combined with a Smart Charging Program to encourage EV drivers to optimise the charging of their EVs.

The EV Energy Plan provides EV drivers with attractive price signals to encourage charging during the solar period and overnight period with:

- Five hours of free energy from 10am to 3pm;
- Off peak rates from 1am to 6am;
- Peak rates at all other times

EV drivers can also combine the EV Energy Plan with the Smart Charging Program by investing in a smart charger supplied and installed by Origin. EV drivers can use the Origin App to select charging schedules for their smart charger. These schedules include:

- Solar optimisation – only charge with excess solar generation
- Customised charging schedules
- Charge according to EV Energy Plan



Additional Information

AI
Artificial Intelligence

ARENA
Australian Renewable Energy Agency

EV
Electric Vehicle

OCPP
Open Charge Point Protocol

VPP
Virtual Power Plant

Watt (W)
A measure of power when one ampere of current flows under one volt of pressure

Kilowatt (kW)
One kW = 1,000 watts

Kilowatt hour (kWh)
Standard unit of electrical energy representing consumption of one kilowatt over one hour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