How findings from the Electric Vehicle Charging Trial could shape our future

Prepared for Wellington Electricity
by Jake Roos and Concept Consulting
July 2018


“Technology is not a great soloist – it needs an orchestra to be truly appreciated by the public audience”
Greg Skelton – CEO Wellington Electricity

About this trial

In a changing world, the way we choose to consume electricity will drive how electric vehicles (EVs) will be adopted as a bigger part of our future.

Together with technology developers, we have the opportunity to better shape how this consumption can benefit our industry, our customers, the wider community and the planet.

To more deeply understand peak electricity demand, we* collaborated with retailers (see page 37), to monitor EV-owners' responses to price signals as part of the evolution to a cheaper night rate (EV-Nite lines charge), which is designed for more affordable EV night charging.

By modelling EV-charging over off-peak hours, we have the potential to enable more affordable EV-ownership and make electricity consumption less congested and more convenient.

This will:

1. Make EV ownership more accessible to consumers
2. Better utilise our existing infrastructure through greater flexibility, and
3. Be better for our environment, reducing greenhouse gas emissions.

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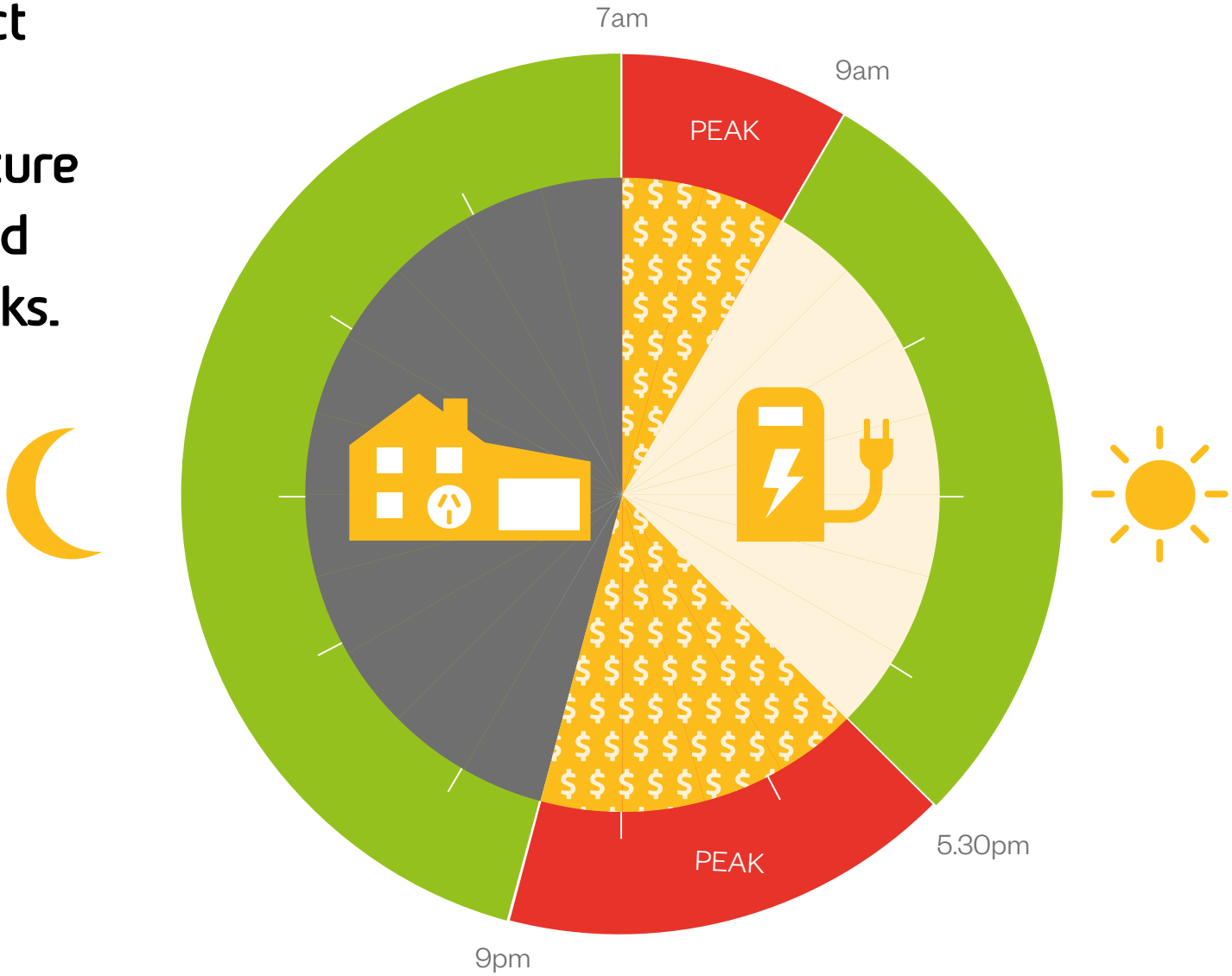
Executive Summary

By 2021, there will be over 64,000 EVs on New Zealand's roads. This brings in a new era of demand on the electricity network for (domestic) charging purposes, to the tune of 2,500kWh pa per driver – equivalent to leaving ten 100W lamps on for 3 months consecutively, or about 1/4 - 1/3 of current annual household usage.

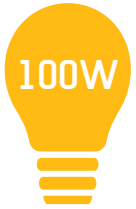
To help alleviate demand during peak times, we have the opportunity to better utilise our network during low-use periods – to both suit modern lifestyles and optimise use of our existing infrastructure.

The trial observes and tests existing and potential habits to inform how a designated night rate could shape the way we consume electricity to preserve our future.

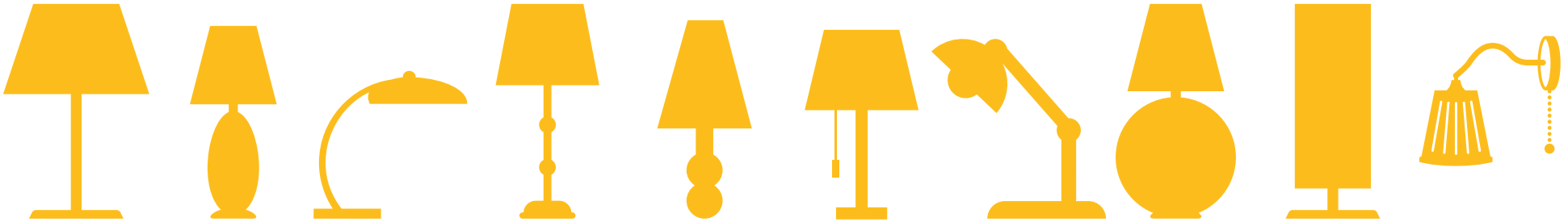
*Without price signals, a significant proportion of the demand impact will be adopted as a bigger part of our future will be in morning and evening network peaks.



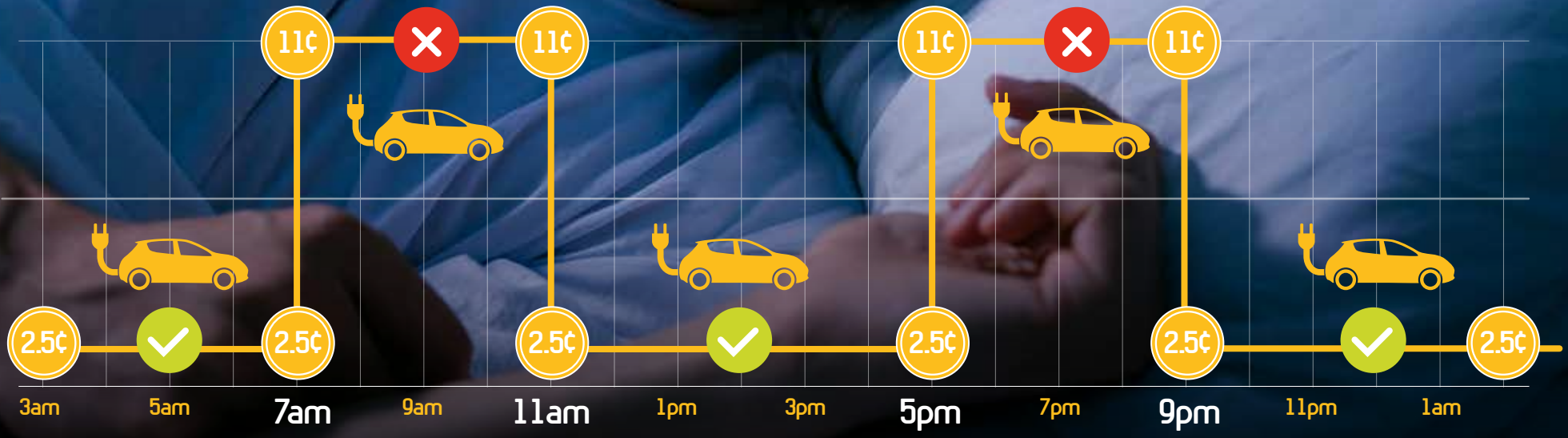
EV charging will increase average residential demand by approximately 2,500kWh, equal to 1/4 - 1/3 of your annual electricity consumption, or:

10 

for 3 months



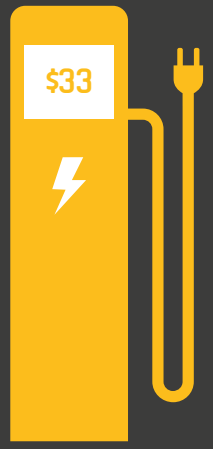
Sleep easy whilst your EV charges for less, during the less congested EVB-rate – doing your small bit to reduce greenhouse gas emissions.



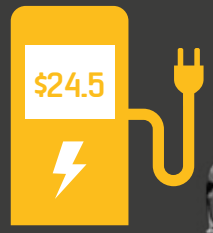
*Drivers were generally comfortable with suggested approaches to managing their demand.

(e.g. demand-based pricing, centralised service of EV charging, vehicle to grid technology) but the level of financial benefit to them was indicated as important.

Approximate comparison based on a 45L tank of fuel @ $100 refill in July 2018.

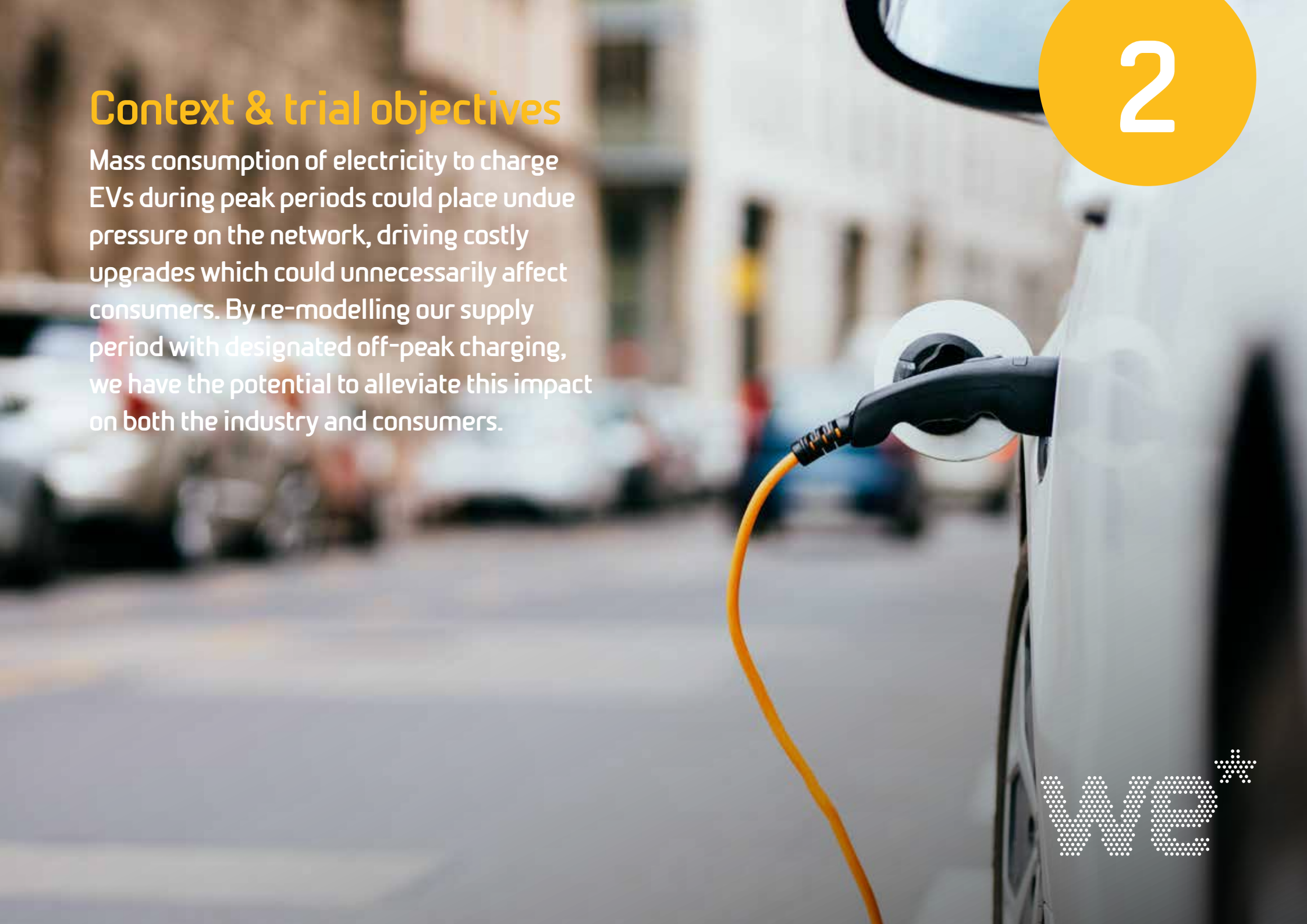


Off-Peak charging cost



Hyundai Tucson

Hyundai IONIQ



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Context & trial objectives

Mass consumption of electricity to charge EVs during peak periods could place undue pressure on the network, driving costly upgrades which could unnecessarily affect consumers. By re-modelling our supply period with designated off-peak charging, we have the potential to alleviate this impact on both the industry and consumers.

Industry

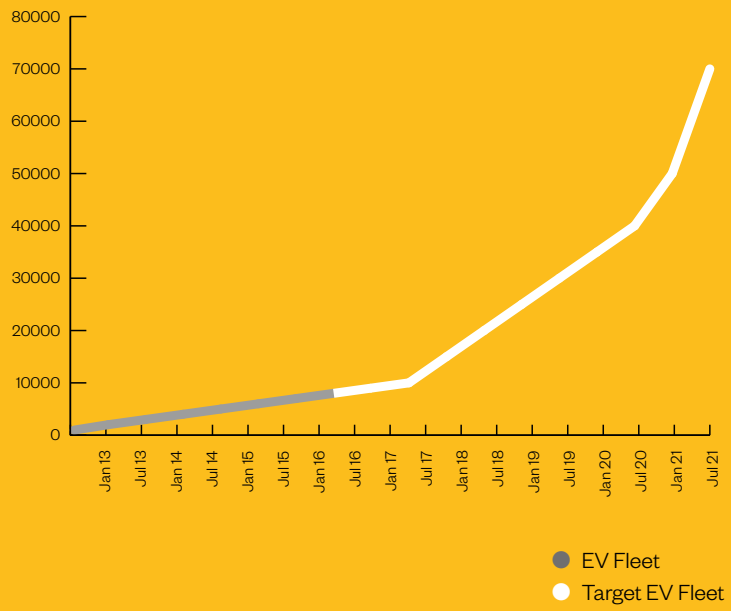
A number of challenges face the Electricity Networks in relation to Electric Vehicles (EVs) uptake:

Predicted rapid expansion in national EV fleet (64,000 by 2021).

The additional electricity consumption and demand (if not managed) could require costly network upgrades.

Move towards developing cost-reflective pricing.

Electric Vehicle Fleet and Government Target




*Predicted rapid expansion
in New Zealand's EV fleet
64,000 by 2021

Trial Brief

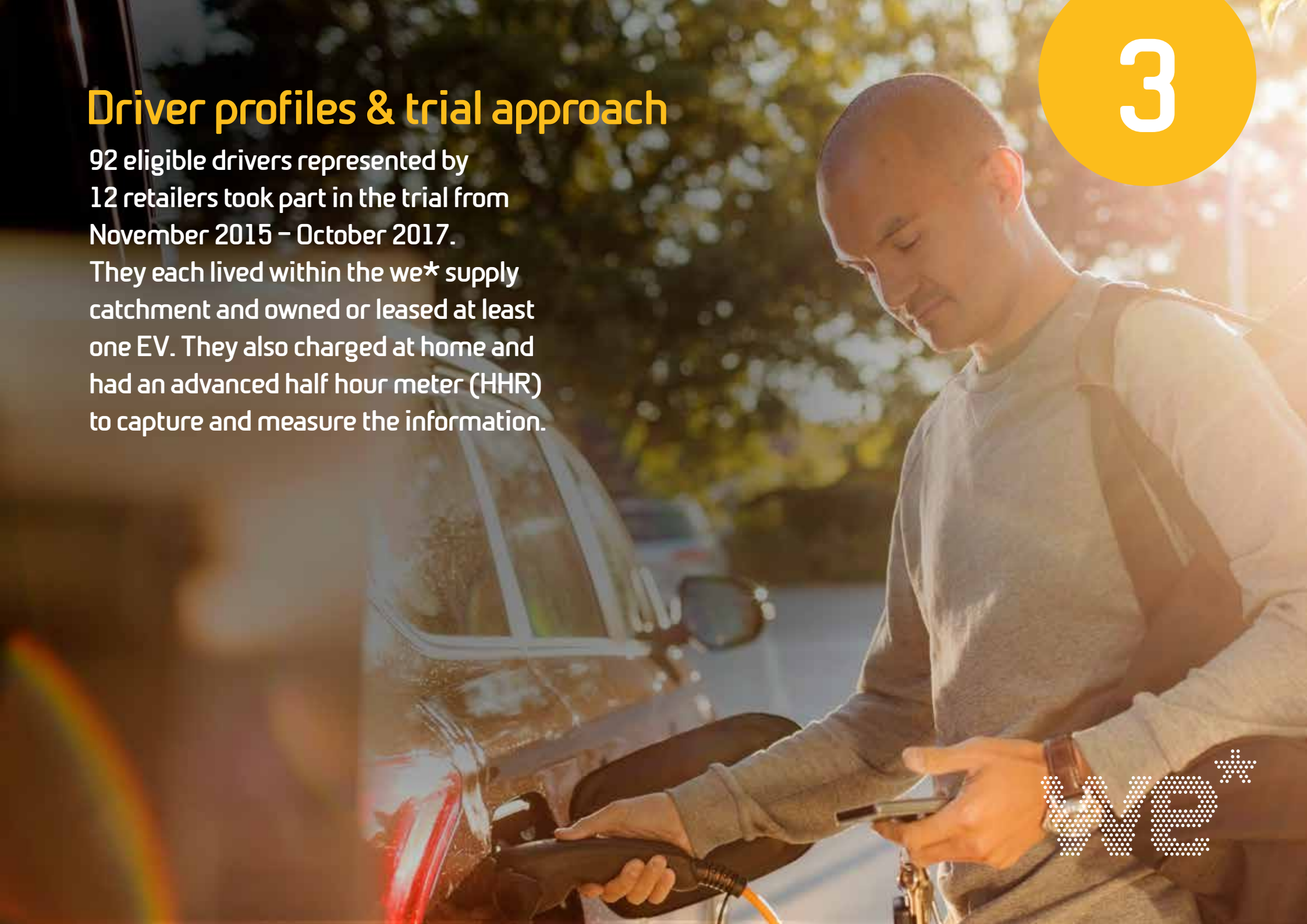
we* had implemented EV-specific pricing in 2016 (EV-Nite) and wanted to understand:

The peak electricity demand of households, of both EV owners and a control group of non-EV owners, to inform changes to Wellington Electricity's existing EV-Nite tariff, for the year starting 1 July 2018; and

What differences there were in peak electricity demand between EV owners that are receiving time-of-use (TOU) pricing and those that are not.

The desired outcomes were:

- To understand, compare and contrast electricity charging and usage behaviours for EV and non EV owners.
- Better understand the behavioural drivers behind that usage.
- Use the information to help inform pricing design for EVs and in turn provide an input into our thinking for future pricing and cost reflective price signals.



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Driver profiles & trial approach

92 eligible drivers represented by 12 retailers took part in the trial from November 2015 – October 2017. They each lived within the we* supply catchment and owned or leased at least one EV. They also charged at home and had an advanced half hour meter (HHR) to capture and measure the information.

Driver profiles & trial approach

92
Eligible participants.

12
Retailers
represented across the 92 eligible participants.

77
Half-hourly (HHR) Data Sets Received.

24
Months of HHR data sought
from Nov 2015 to Oct 2017.

860
Other we* ICPs Used as a control group.

Trial Methodology

Participants were:

Recruited through Facebook groups, advertisements, via retailers, the 'EV Talk' news website, radio advertisements, the 'Flip The Fleet' initiative and via two car dealerships.

Provided information about the importance of off-peak charging, practical advice on how to charge off-peak and the use of vehicle inbuilt timers.

Surveyed on their views of electricity pricing, other demand management approaches for EVs.

Information about participant EVs and charging habits was also collected

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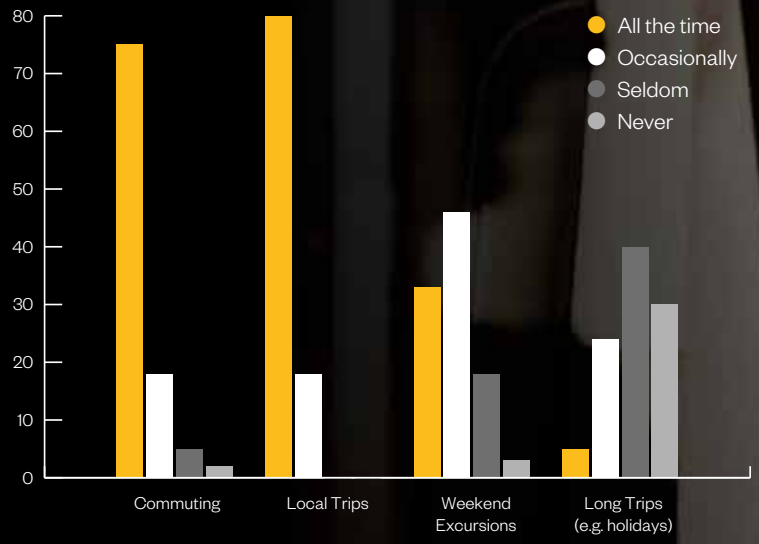
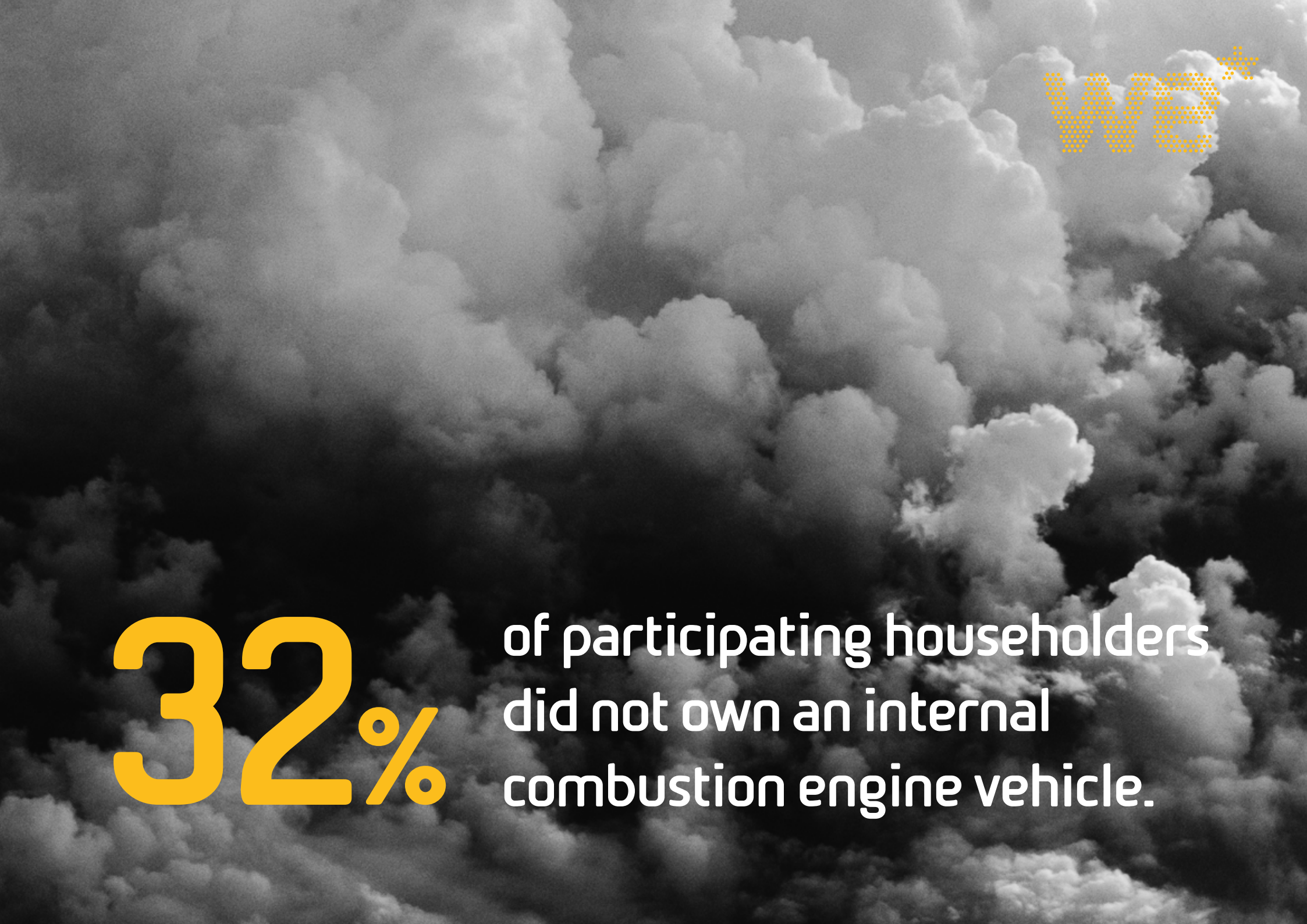
Understanding EV-owners driving habits

During the trial our Wellington drivers made several short trips, typically travelling 40kms or less a day. These were mostly for commuting or local trips, occasionally for weekend trips and seldom for longer journeys. Of our drivers 32% didn't own an internal combustion engine vehicle, with 50% of vehicles using a standard 8A household plug to charge from.

What is your first EV used for?



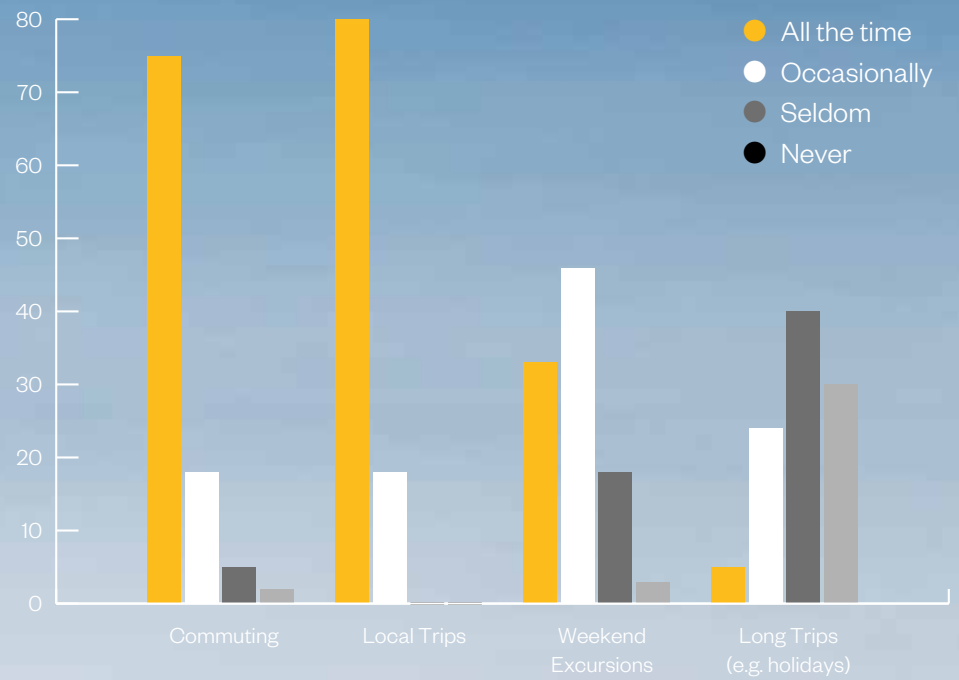

km/h
0040
km
or less driven per day
for typical driving


32%
of participating householders
did not own an internal
combustion engine vehicle.

50%

of participants' vehicles charged using a standard 8A household plug.

What is your first EV used for?



EV models in the trial

8%
Other

2%
Audi A3 E-Tron

3%
Hyundai IONIQ

4%
Nissan NV200 Van

11%
Mitsubishi Outlander (PHEV)

72%
Nissan Leaf

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Taking care of charging

It was clearly very important to our drivers to access the cheaper night rate (from 9pm) to charge their EV. Additionally, most drivers (66%) took control of this charging rate by using a timer to control when charging started. Notably, 70% of participants were conceptually comfortable passing this role over to an electricity supplier in the future.

26%

of participants were on a retail tariff that utilises we*'s EV-Nite. Of these 63% were on a home electricity supply option that is cheaper between 9pm & 7am.

31%

claimed to always charge their EV after 9pm, with a further 49% saying they *usually* did this.

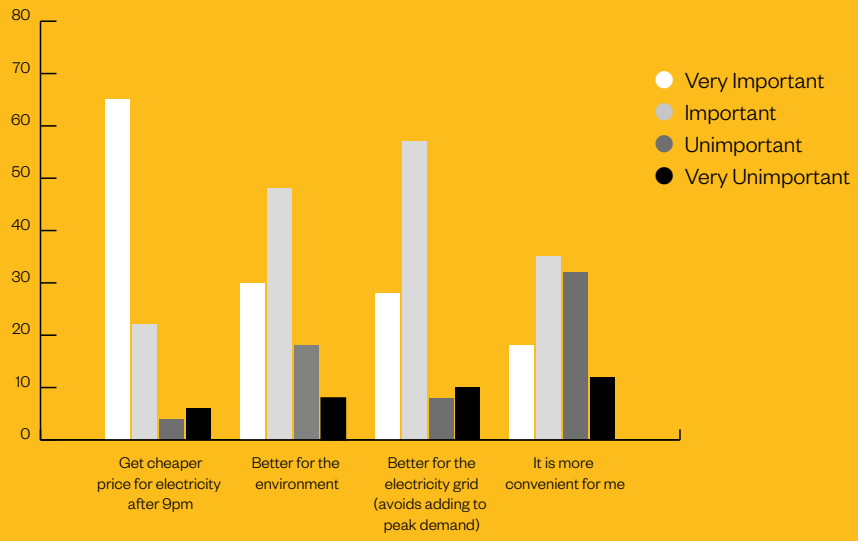
66%

said they always or usually used an automatic timer to control when home charging started.

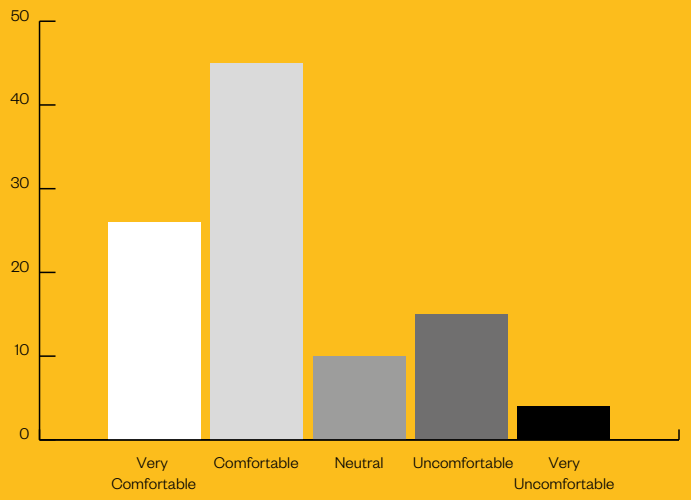
70%

comfortable with the concept of an electricity supplier or distribution company managing timing of EV charging and other flexible load.

If you usually charge your EV after 9pm, please rate the importance of your reasons why



Centralised service: How comfortable would you be with the described arrangement?



An overview of the trial findings

The purpose of this exercise was to determine how and when customers charge their EVs and how this might change in response to pricing choices. Overall, it's anticipated that EV-owners will drive a 33% or 2,500kWh increase per household/ pa. Encouraging disbursement of demand will enable EV-driver uptake and ease stress on the wider network, environment and delay costly upgrades.

Purpose

Determine how and when customers charge their EVs & how this might change in response to price signals.

Approach

Mathematical techniques, including linear regression to enable EV charging patterns to be discerned.

Comparisons to Control Group to help establish key differences in demand.

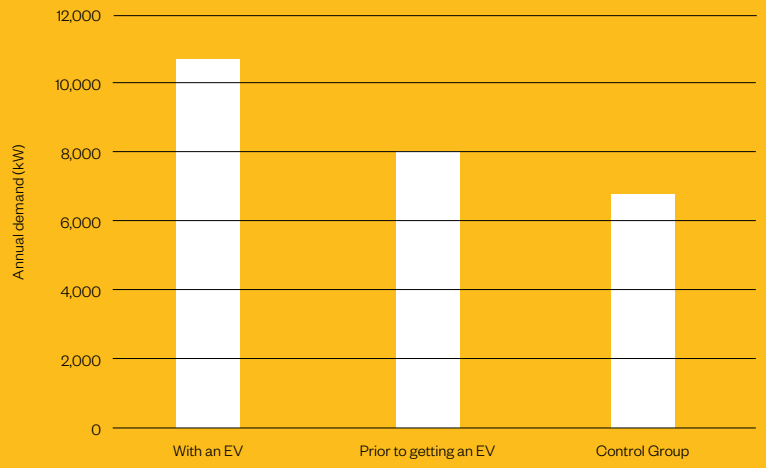
Inferences drawn from data differences to enable identification of EV charging. The majority of EV charging is done as part of the general household load rather than separately wired and metered.

Data validation undertaken to remove duplicates, resolve data file format issues and exceptions e.g. net negative results from (presumably) solar PV.

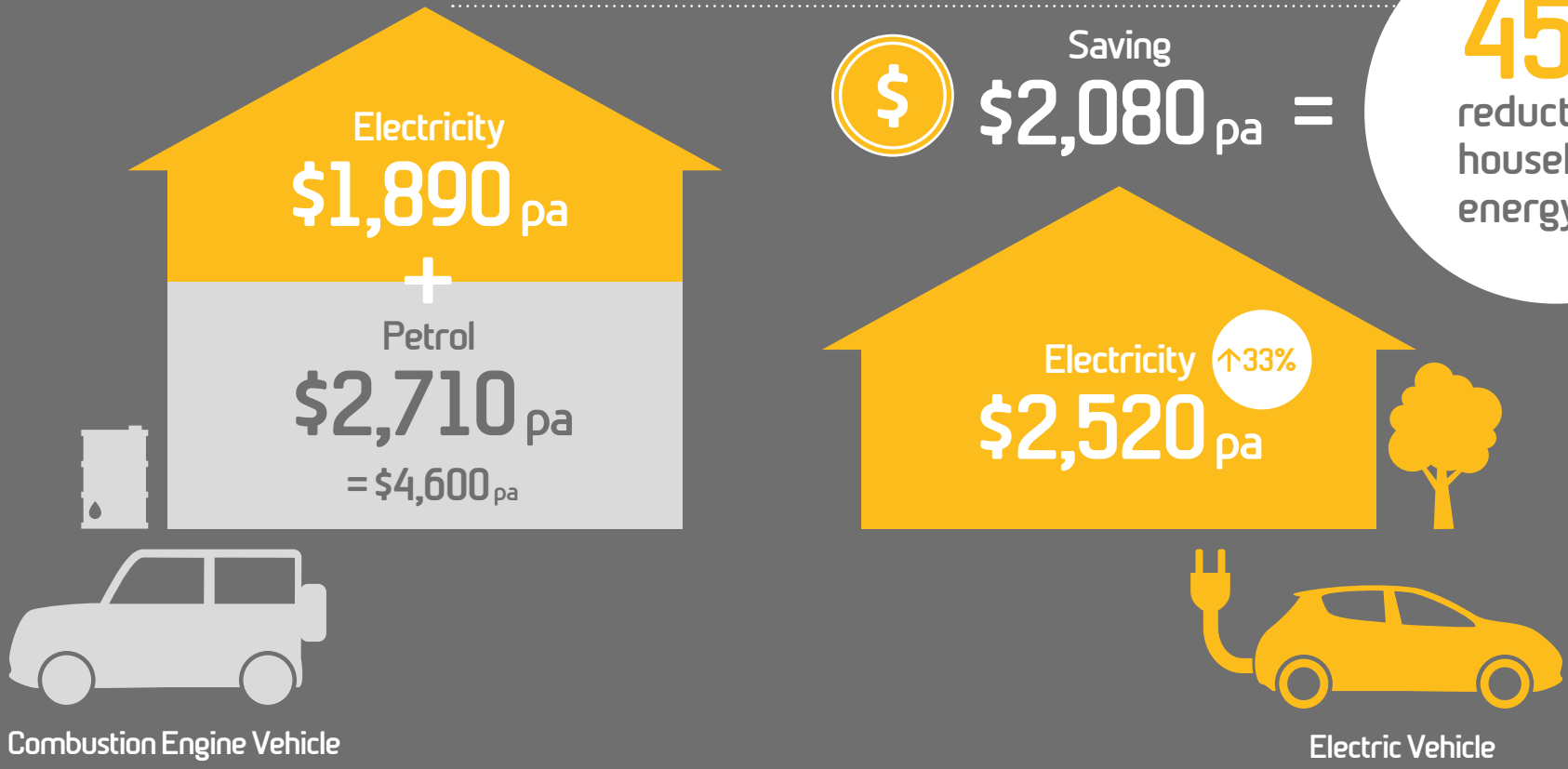
2,500kWh

increase in average annual residential demand from EV customers.

Annual demand with and without an EV



*33% increase in estimated average annual residential electricity consumption for EV owners is offset by zero petrol costs.



Findings on demand & timing from the trial

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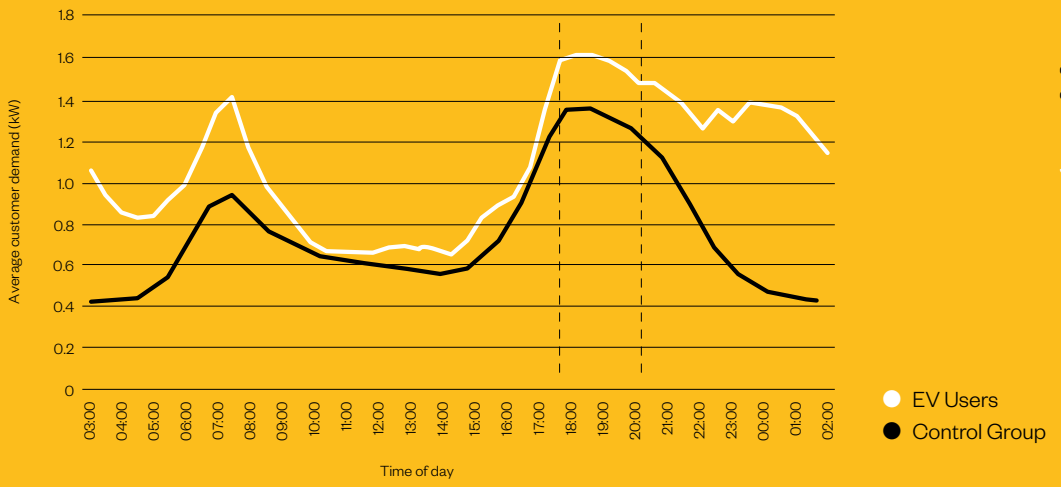
Easing the demand for electricity from peak-periods to off-peak is estimated to reduce the impact on the network by 87.5%. So, by changing behaviours of demand times with future EV-drivers by attracting them to a more advantageous night-rate (9pm – 7am), we have the potential to reduce wider impacts on EV charging, and potentially offset other household costs.

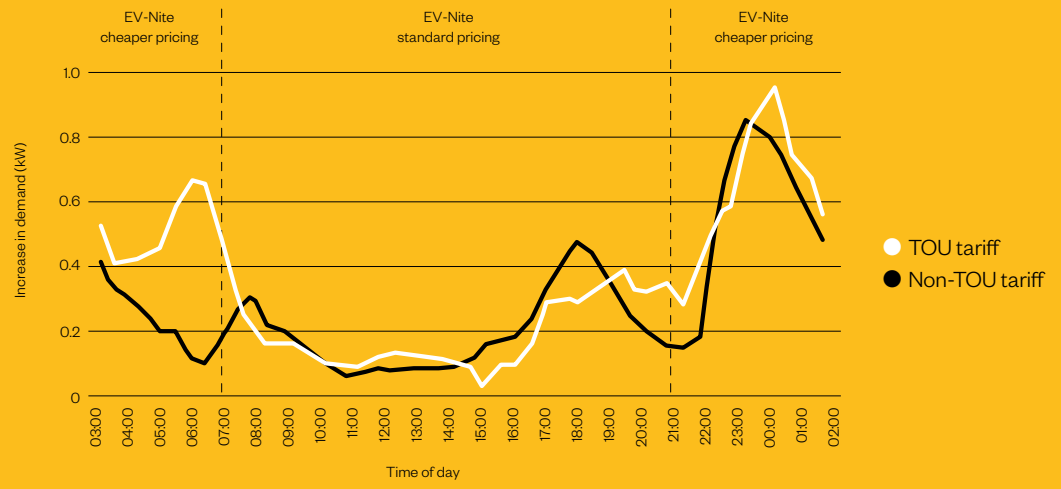
ADMD Definition

- After Diversity Maximum Demand (ADMD) determines the aggregated results of demand changes, taking into account timing differences.
- In other words, though the individual demand profile for EV customers is shown to increase, the variation in timing for when those customers charged their EVs reduced the demand impact.
- *It should be noted that the after diversity results may be reflective of a small sample size. More analysis is required here to determine the validity as the number of EVs on our network increases and the owner profiles towards more mainstream ownership (vs early adopter).*

Network Impacts & Price Signals for Cheaper EV Charging

- we*'s current peak demand periods occur between 5:30pm and 8pm during winter.
- On business days, the impact of EV users can be seen to increase consumption during the evening peak but also increase morning usage consumption as owners 'pre-condition' their vehicles in cold weather to help extend their driving range.
- Additional evening spikes can be seen as vehicles commence charging during the evening.
- Introducing the TOU tariff, EV owners are incentivised to shift their EV charging from congested evening and morning periods into the cheaper night periods where there is spare network capacity.
- TOU may create a higher night peak should EV's become ubiquitous, however further charging services are expect to smooth this impact.





Response to time of use rates (TOU*)

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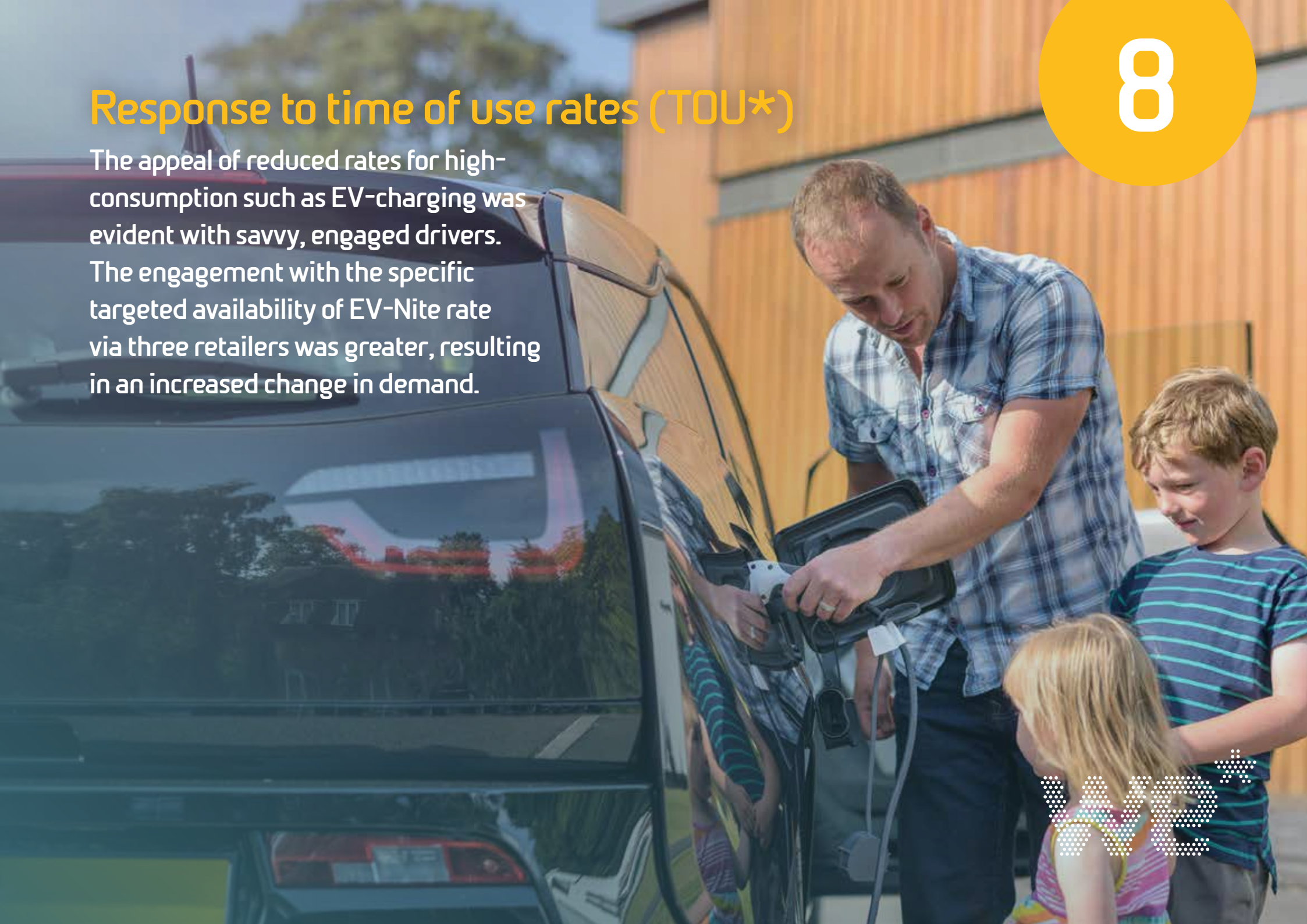
The appeal of reduced rates for high-consumption such as EV-charging was evident with savvy, engaged drivers. The engagement with the specific targeted availability of EV-Nite rate via three retailers was greater, resulting in an increased change in demand.

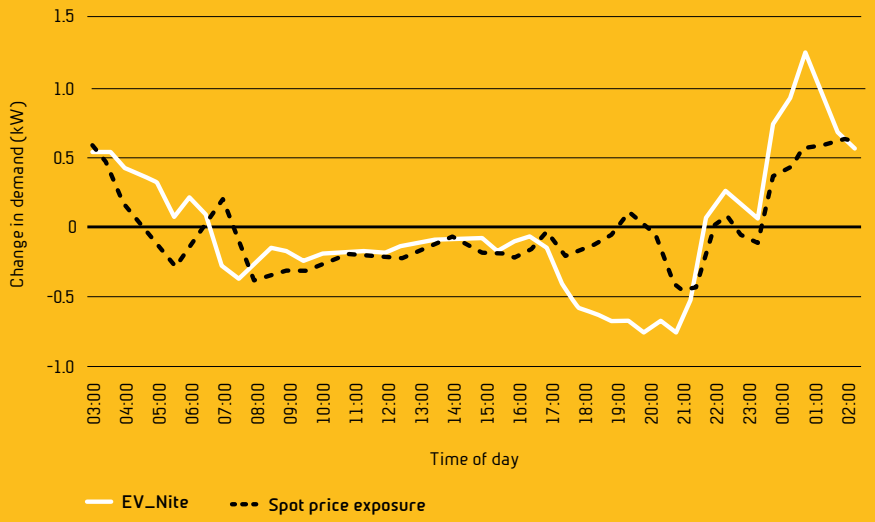


Spot Price Exposure

Some retailers provide their customers with the option to pay the wholesale price directly, i.e. they are exposed to the spot price.

The charging behaviour of customers exposed to the spot price was compared with those on more traditional pricing structures.

Customers exposed to the spot price charge more during off-peak periods as spot prices are often lower overnight than during the day.

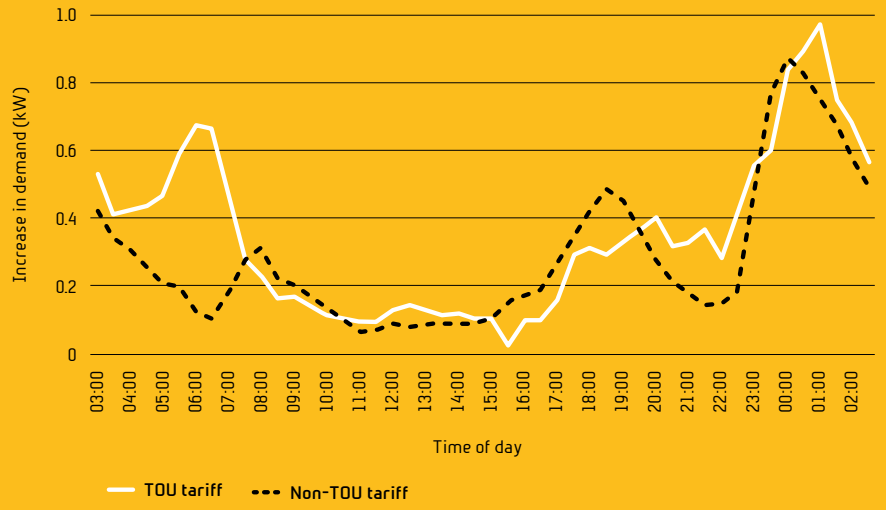


EV-Nite Distribution Charge

we* offered the EV-Nite tariff that was cheaper between 9pm and 7am. 3 retailers in the trial passed this on to customers. EV-Nite was replaced with a new TOU tariff, EVB from 1 July 2018.

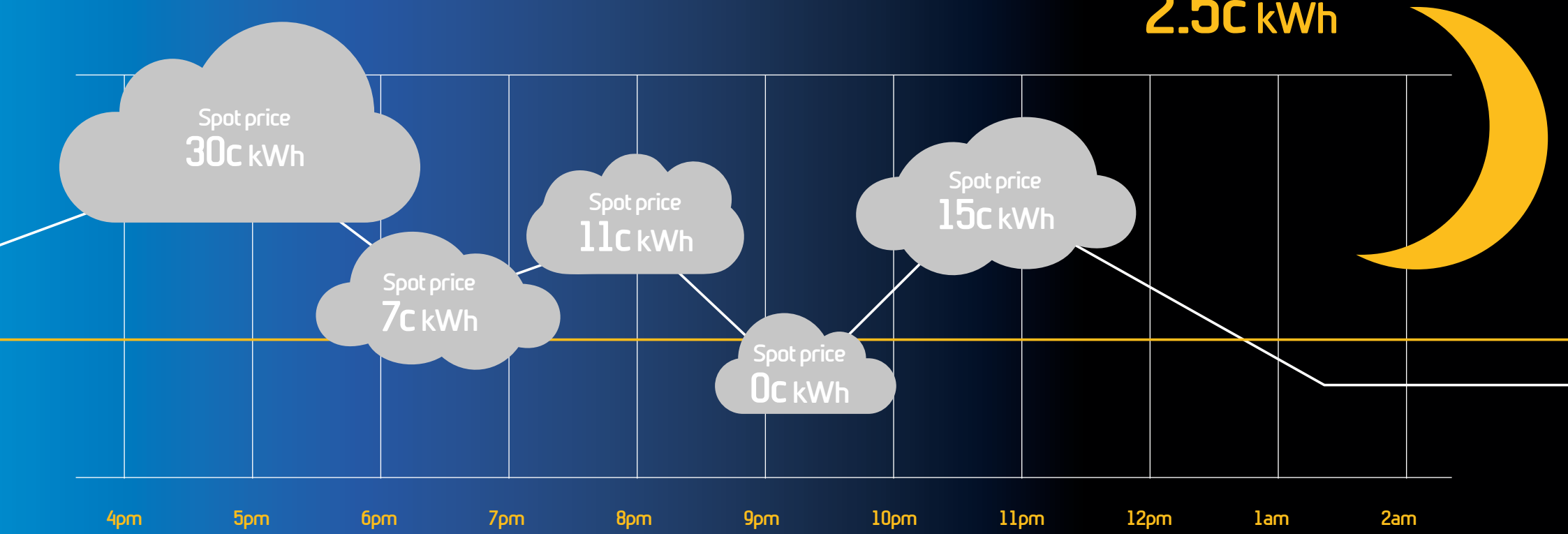
The change in demand resulting from this tariff is larger than the spot tariff demand reduction and more pronounced in the evening period.

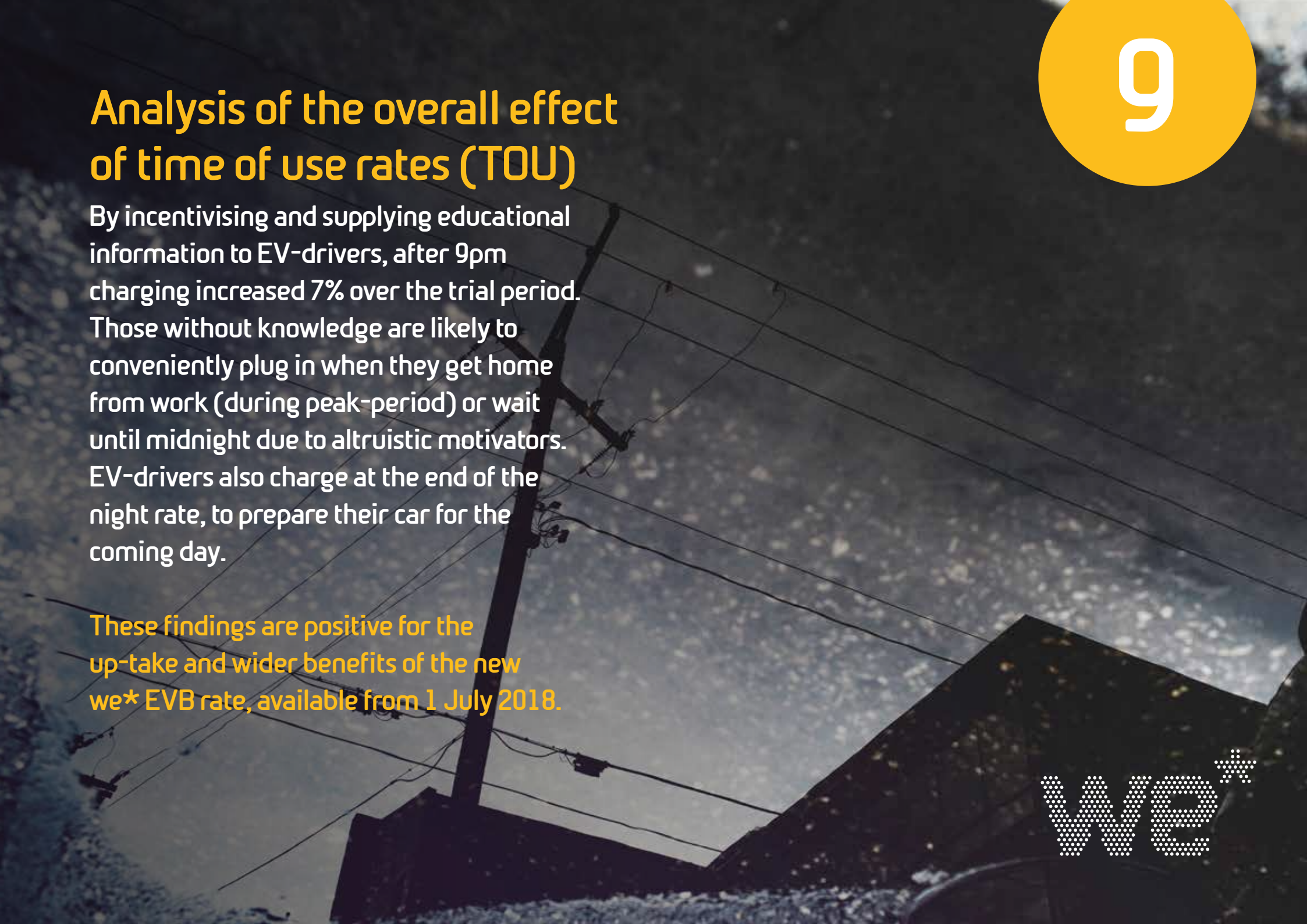
The resulting step-change at night is one of the potential concerns with a TOU price signal.



* Time of Use (TOU) pricing is defined as the provision of price (dis)/incentives to customers for time periods throughout a 24hr day. This is typically done to either reflect the costs of supply or to reduce strain (and potential cost impacts) on the electricity network.

EVB-rate is a
standard rate of
2.5c kWh





Analysis of the overall effect of time of use rates (TOU)

By incentivising and supplying educational information to EV-drivers, after 9pm charging increased 7% over the trial period. Those without knowledge are likely to conveniently plug in when they get home from work (during peak-period) or wait until midnight due to altruistic motivators. EV-drivers also charge at the end of the night rate, to prepare their car for the coming day.

These findings are positive for the up-take and wider benefits of the new we* EVB rate, available from 1 July 2018.

Analysis of the overall effect of time of use rates (TOU*)

Non-TOU EV customers have two peaks in the evening, dependent on their charging approach:

Convenience: Plugging in their EV when they get home.

Altruism:
Waiting until midnight to reduce the impact on the environment (night energy is typically generated from a higher proportion of renewable energy) or reducing peak demand impacts on the electricity network.

TOU EV customers also have increased demand during the traditional evening peak, though smaller than non TOU.

TOU EV customers also have an increase in demand in the mornings (just before the end of the cheaper pricing period, likely due to car preconditioning.

+7%

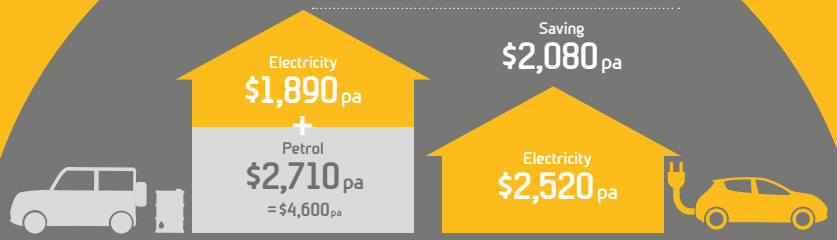
of participants charging after 9pm adopted this behaviour DURING the trial, presumably in response to education and information provided.

Conclusion

A higher proportion of customers would likely charge when they got home in the absence of a price signal or guidance on desirable charging behaviour.

* EV-Nite/EVB/spot price exposure = TOU
Customers with no TOU price signal = Non TOU

Conclusion



45%

potential reduction estimated in household energy costs through EV-Nite rate

↑33%

2,500kWh

or 33% increase in estimated average annual residential electricity consumption

64,000

cars forecast to be in use within the next 5 years (by 2021)

12

retailers represented across the drivers

80%

of drivers always or usually charging after 9pm

24

months of driver data

92

driver participants

70%

of drivers comfortable with the concept of an electricity supplier timing EV charging

9pm–7am

Off-peak evening period for optimal charging, and cheaper rates for your whole house

1 July

2018, we* EVB rate available for EV users' on the we* network

2.5 c/kWh

The EVB off-peak lines charge rate, saving at least 4.5c/kWh.

Many thanks to

Wellington Electricity wish to acknowledge EV trial participants, *Wellington EV Owners* Facebook group, the following people and organisations for their support of their EV Charging Trial:

Contact
meridian
Mercury
Trust power.
Flick Electric Co
ecotricity
ELECTRIC KIWI.CO.NZ
nova energy
greater WELLINGTON REGIONAL COUNCIL Te Pane Matua Taiao
POWERSHOP
Paua to the people
genesis
THE FLEET
ena
EVtalk
EVCENTRAL
Gazley
concept
JAKE ROOS CONSULTING LIMITED FOR A BETTER WORLD
charge.net.nz

Terminology

Cost Reflective Pricing

An electricity tariff which uses variable prices to signal the difference in cost between higher and lower consumption periods.

EV

Electric Vehicle.

EVB

A cost reflective TOU tariff from Wellington Electricity having cheaper night charge periods and more expensive peak demand period charges. EVB replaced EV-Nite from 1 July 2018.

EVSE

Electric Vehicle Supply Equipment – what is used as the device to charge the EV.

HHR

Half Hour resolution, a measurement from an electricity meter over a half hour period.

Kilowatt (kW)

Measurement of energy demand which when measured over an hour represents customer consumption of electricity units (kWh).

Lines Charge Tariff

Lines Companies recover their network costs through lines charges which are bundled by the customers Electricity Retailer into the customer electricity bill.

PHEV

A plug-in hybrid EV. PHEVs can connect to a power supply to recharge their battery but also use a conventional internal combustion engine to extend their range.

Off-Peak

The period of the day when there is the least demand for energy on the network. This will occur between the peak demand periods.

Peak

The period of the day when collectively there is the highest demand for energy on the network. At the residential level there is a morning and evening peak on the Wellington Electricity network.

Retailer

Electricity Retailer has the financial relationship with all customers for billing energy used, including packaging of the lines company tariff portion.

Spot Price

The actual wholesale market price of energy which changes on a half hour basis. Most customers take an average retail price for energy, however new retailers to the market are allowing customers to take a wholesale price which has the reward of cheaper energy and risk of expensive energy unlike the averaging of the retail price option.

Tariff

The charge or utility fee a lines company recovers for customers using the electricity infrastructure. The charge is packaged by electricity retailers who add this to the energy bill to customers.

Time of Use (TOU)

A Lines Charge Tariff which uses different charge rates in different time periods. Hence the time of use of electricity will attract different costs. Higher costs are assigned to higher usage periods to signal cheaper costs for shifting demand to less congested time periods.


“
The only stranding risk we will likely see will be in our own contemporary thinking – we need to progress collaboratively”
Greg Skelton – CEO Wellington Electricity

Ngā mihi nui
Thank you

For further information on the trial findings, please see the complete Electric Vehicle Charging Trial (Final version - July 2018) at www.welectricity.co.nz

Call us 0800 248 148
Email us we_CustomerService@welectricity.co.nz