The impact of COVID-19 on EV driving behaviour: findings from Vector's Auckland EV trial

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Outline

Why the need to smart charge EVs?

Vector's smart EV trial

General results

COVID related results

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Facilitating transport electrification

- ICCC report recommends the NZ government prioritises accelerating transport electrification to achieve deep greenhouse gas reductions[1]
- NZ domestic land transport used 216PJ in 2019[2]
- NZ electricity generation was 156PJ in 2019[2]
- Even with energy efficiency improvements of EVs, a complete shift of domestic transport energy use from fossil fuelled to electric will require careful planning

[1] ICCC, *Accelerated Electrification*, 2019
[2] https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/

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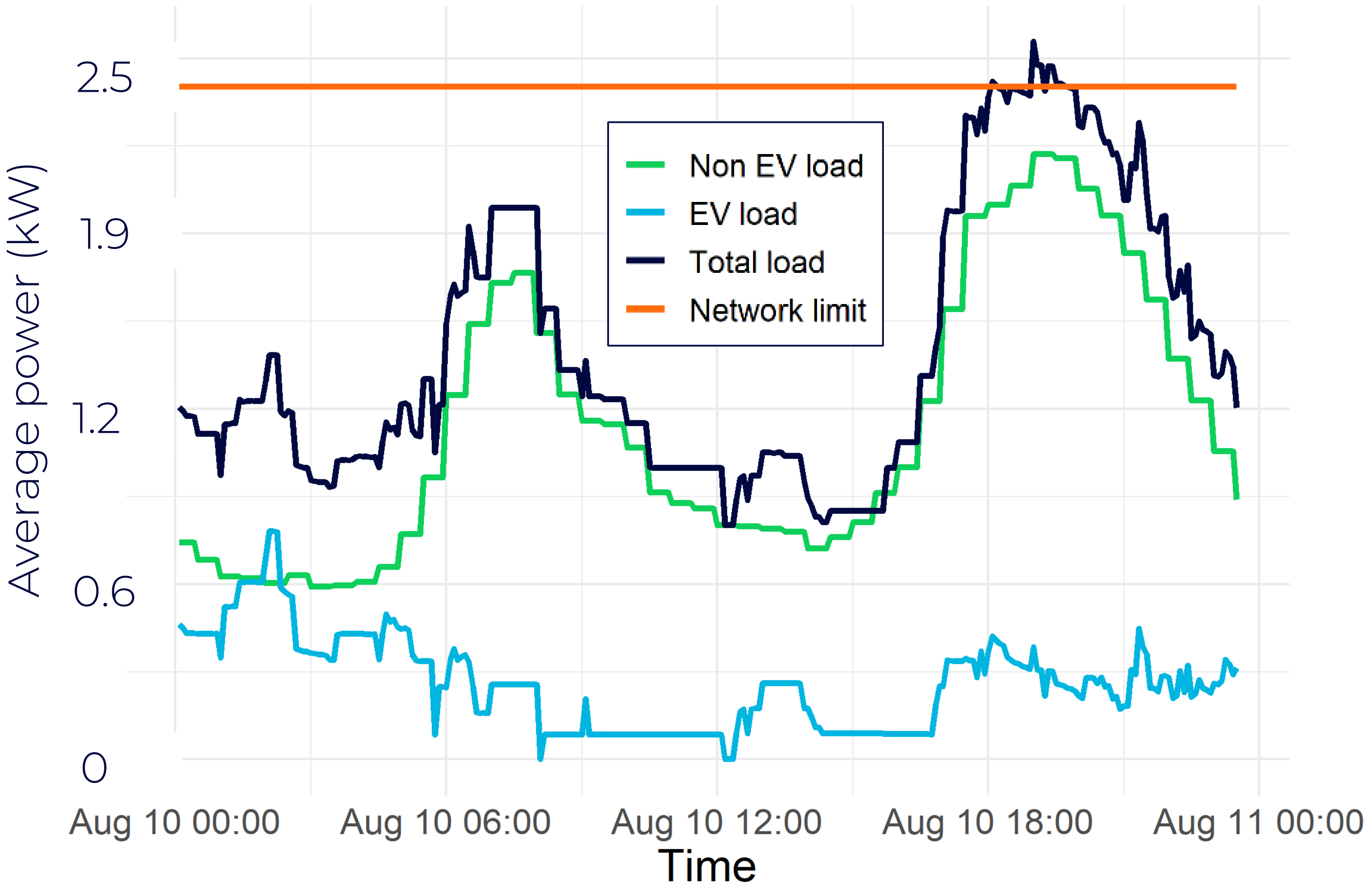
Why the need to smart charge EVs?

- LV network designed for ADMD of ~2.5kW per household
- EVs add between 1.8kW and 7kW to a household demand
- Under 'passive' charging, EV demand occurs during peak times
- With a high uptake, the electricity network could require expensive upgrades



Average winter electricity demand of trial participants over one evening

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Trial overview

Trial introduction

Vector EV Green Paper and Scenario Modelling have identified that EV charging behaviour and load control is a key uncertainty for future demand.

Local and international evidence has shown that the home will be the new ‘petrol station’, where nearly all charging occurs (>95%)[1],[2]

The EV smart behaviour trial is part of Vector’s New Energy Futures initiative, and was kickstarted by installing 120 EVSEs (7kW) in private homes

[1] Anderson et. al., *Will Flipping the Fleet F**k the Grid?*, 2020
[2] IEA, *Global EV Outlook*, 2020

Trial objectives

- Define reference charging behaviour
- Demonstrate that smart charging can also meet customer satisfaction and establish the level of flexibility that customers are willing to provide for network purposes
- Understand customers' perceptions (fears) of smart charging and motivators (financial and behavioural) to participate in smart charging

Trial design

Charger is installed at customer's home for > 1.5 years, including several periods of smart charging

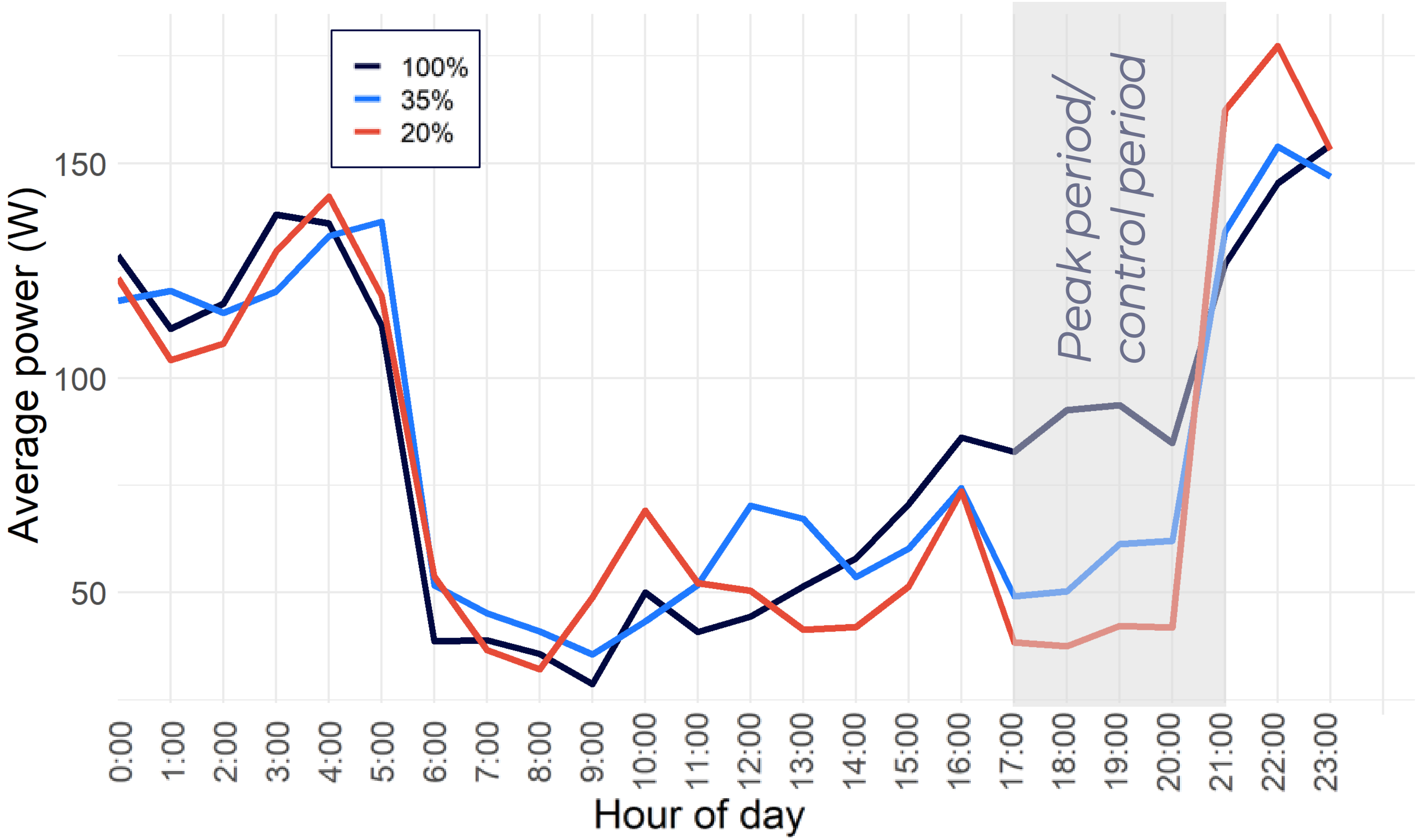
Phase 1 Oct – Dec 19	*Objective: Understand customer satisfaction*
Phase 2 Feb – Apr 20	*Objective: Understand customer satisfaction and ensure network integration during summer/autumn*
Phase 3 Aug – Oct 20	*Objective: Understand customer satisfaction and ensure network integration during winter*

Phase 1:

Collect and analyse data on existing charging behaviour

Understand customer acceptance of EV smart charging

- Some basic controls carried out (throttling during evening peak times)
- The sharp increase at 9pm indicates that many customers are already using a timer to charge
- This concurs with existing NZ EV research[1]
- This behaviour is prompted by good power sector understanding of engaged early-adopters in this trial that know that the peak period typically finishes at 9pm
- The customer satisfaction (captured through surveying) was high across customers independently of the level of controls



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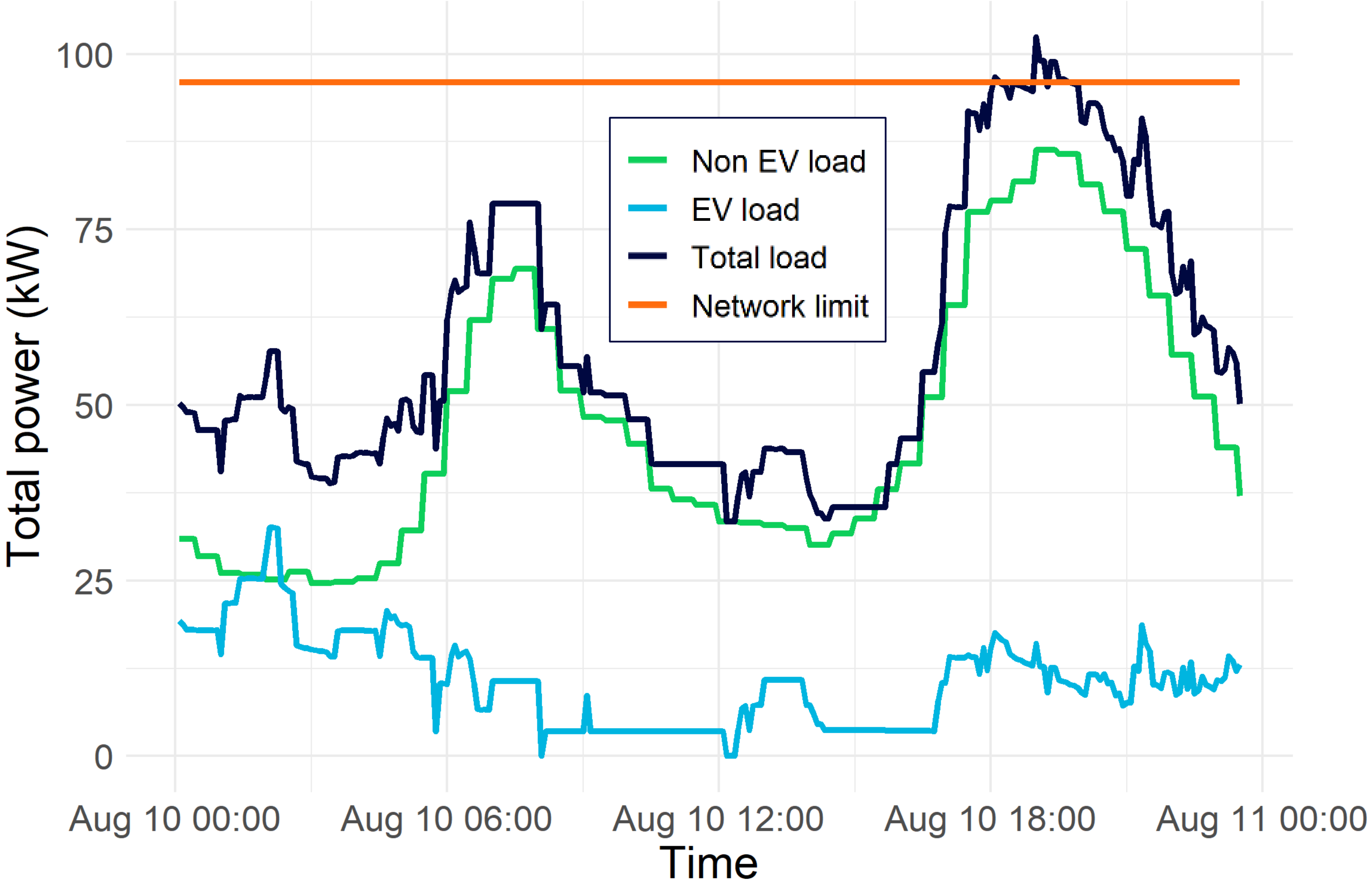
[1] Anderson et. al., *Will Flipping the Fleet F**k the Grid?*, 2020

Phases 2 and 3: **Objectives**

- Optimise EV charging so that the combined daily **EV** and **non-EV load** does not exceed network capacity expansion across each controlled group
- Develop different algorithms to achieve this
- Compare these algorithms with one another, both in terms of effectiveness at keeping after diversity electricity demand below the network limit, and customer satisfaction.



Winter electricity demand for a cluster of ~40 households with EVs

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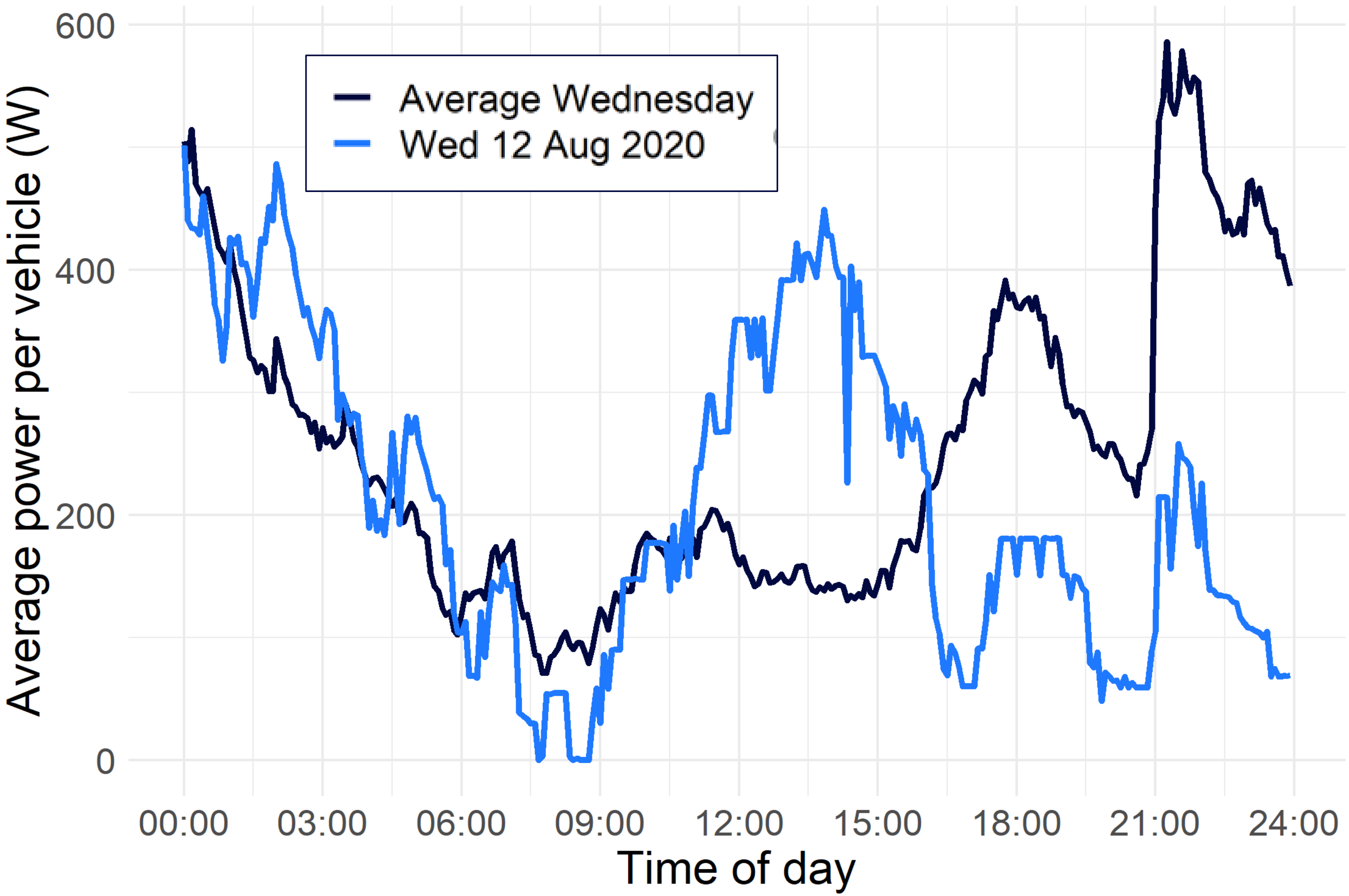
COVID impacts

Results: effect of Auckland lockdown

Lockdown begins midday

- Much more daytime charging
- Suggests morning driving occurred to carry out lockdown preparations
- Much less evening charging



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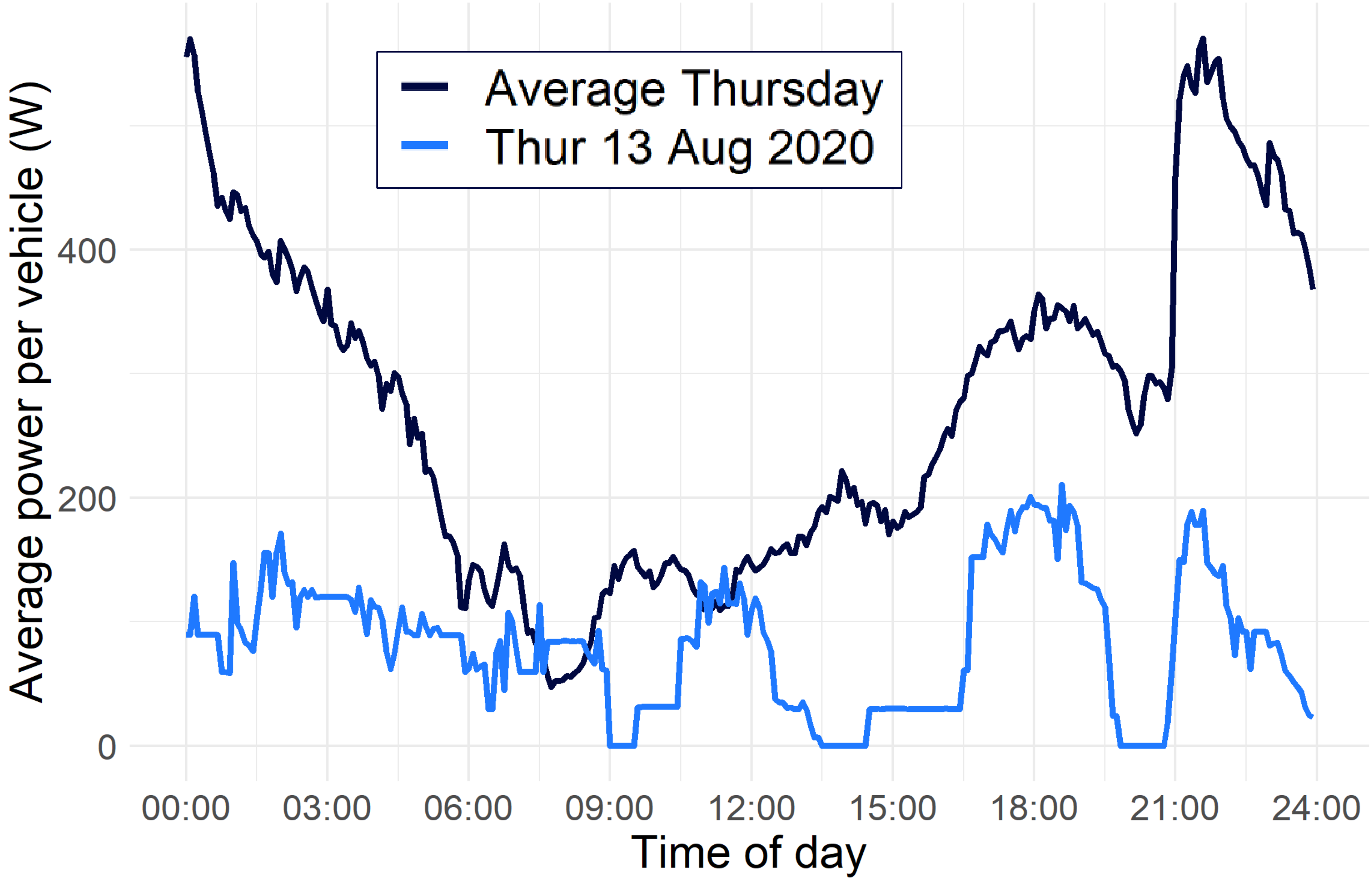
Results: effect of Auckland lockdown

13th August 2020:

First full day of level 3 lockdown

- Very little charging occurring
- Not enough to breach our network limit
- Trial put on hold



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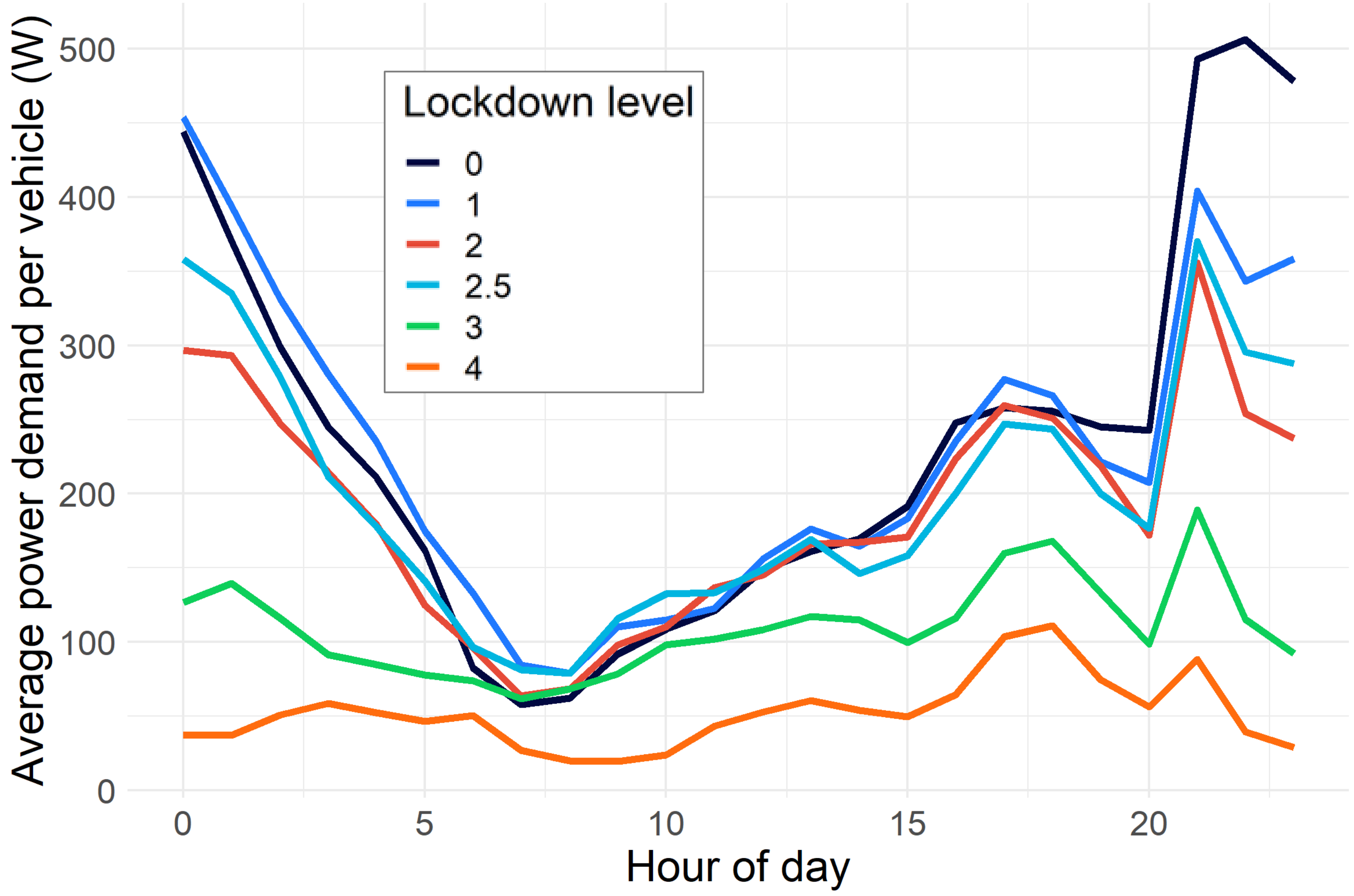
Energy demand during different lockdown levels



- Evening peak never returned to pre-COVID level
- Minimal differences in demand between levels 1,2 and 2.5
- Demand differences more drastic for levels 3 and 4
- Differences in peaks more pronounced than trough

Energy demand during different lockdown levels

Lockdown level	Average daily energy demand per vehicle (kWh)	Reduction from pre-COVID19 level (kWh)	Reduction from pre-COVID19 level (%)
0	5.37	0	0
1	4.87	0.5	9
2	4.18	1.19	21
2.5	4.22	1.15	20
3	2.43	2.94	51
4	1.18	4.19	73

- Total demand hasn't returned to pre-COVID level
- Minimal differences in demand between levels 1,2 and 2.5
- Level 3 demand half of pre-COVID
- Level 4 demand a quarter of pre-COVID

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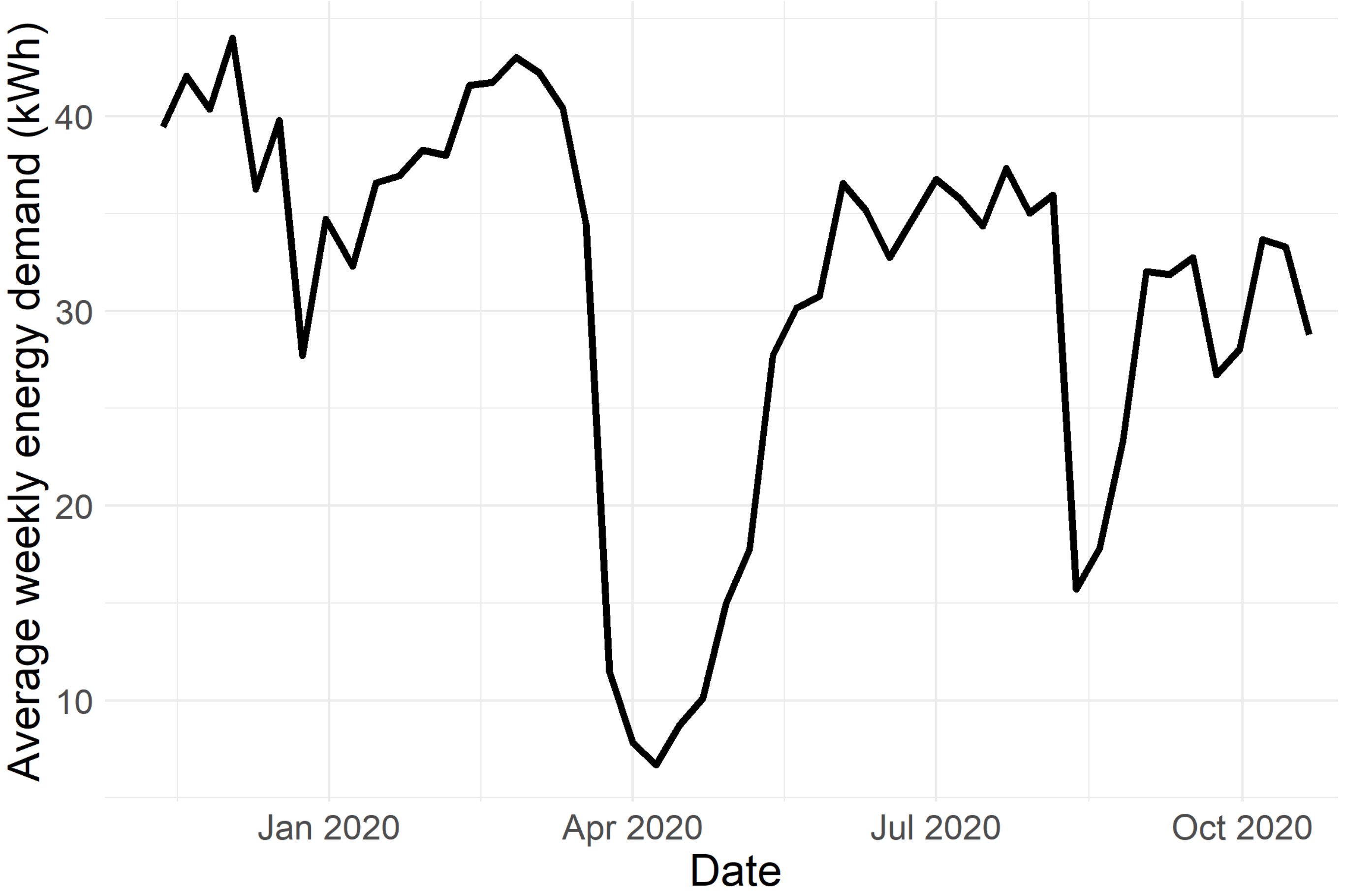
Impacts on driving: average energy demand



Average weekly energy demand for our trial participants

- Massive reduction in driving during first lockdown
- Less dramatic during second
- Did not return to pre-COVID demand between lockdowns
- Post second-lockdown 'normal' lower than between lockdowns.

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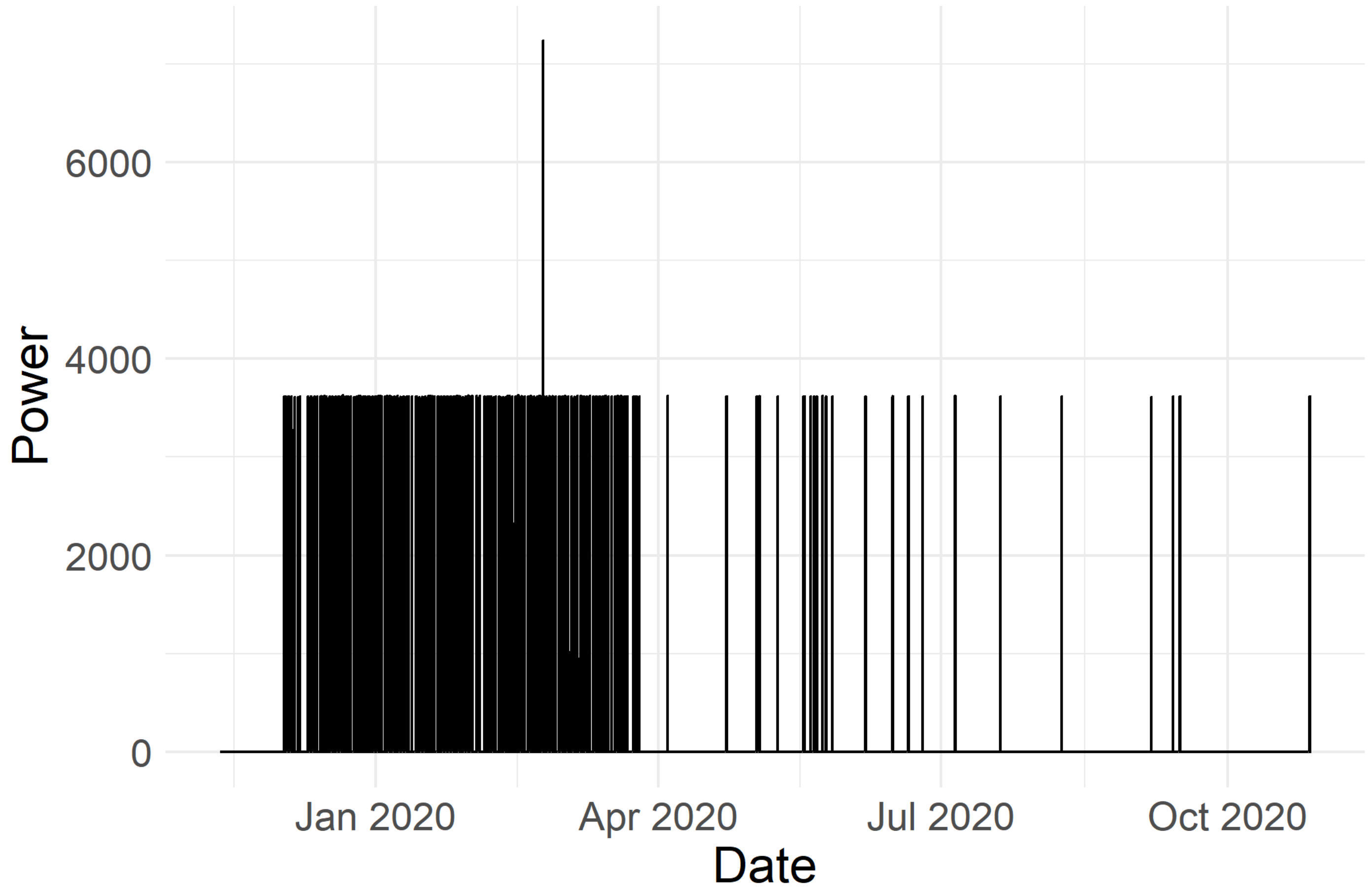
Impacts on driving: household level example

- Many participants show charging behavior that never returned to pre-COVID levels
- Some show minimal change
- Differences likely due to employment type (essential workers vs ability to work from home)



Extreme example of driving behaviour not returning to pre-COVID 'normal' for one trial participant

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Driving distance travelled and CO_2 emissions during different lockdown levels

	Daily averages per vehicle		
Lockdown level	Distance travelled (km)	CO_2 reduction[1] compared to pre-COVID (kg)	CO_2 reduction[2] assuming non-EV (kg)
0	32.2	0	0
1	29.2	0.05	0.75
2	25.1	0.12	1.78
2.5	25.3	0.11	1.73
3	14.6	0.29	4.40
4	7.1	0.41	6.28

- Average daily pre-COVID distance travelled was ~32km/day
- This reduced to 15km/day and 7km/day over Level 3 and 4 lockdowns
- CO_2 reduction minimal from reduced EV driving due to already low carbon intensity of NZ electricity
- More significant if we assume the same distance reduction is seen in ICE (assume 10km/L fuel economy and 2.5kgCO_2/L)

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[1] https://ecotricity.co.nz/news/carbon-knowledge/ - Attributed to *Energy Link NZ*
[2] Kawamoto et. al., *Estimation of CO2 Emissions of Internal Combustion Engine Vehicle and Battery Electric Vehicle Using LCA*, 2019

Where to next?

- Incorporation of another 40 participants into the trial
- Next smart charging phase scheduled for early next year (COVID permitting)
- We are seeking permission to use more recent smart meter data from the participants
- Continue to monitor and analyse charging patterns to better inform business decisions around facilitating transport electrification

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