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ELECTRIC POWER ENGINEERING CENTRE

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

DGHost to EVHost

Asset Management Forum

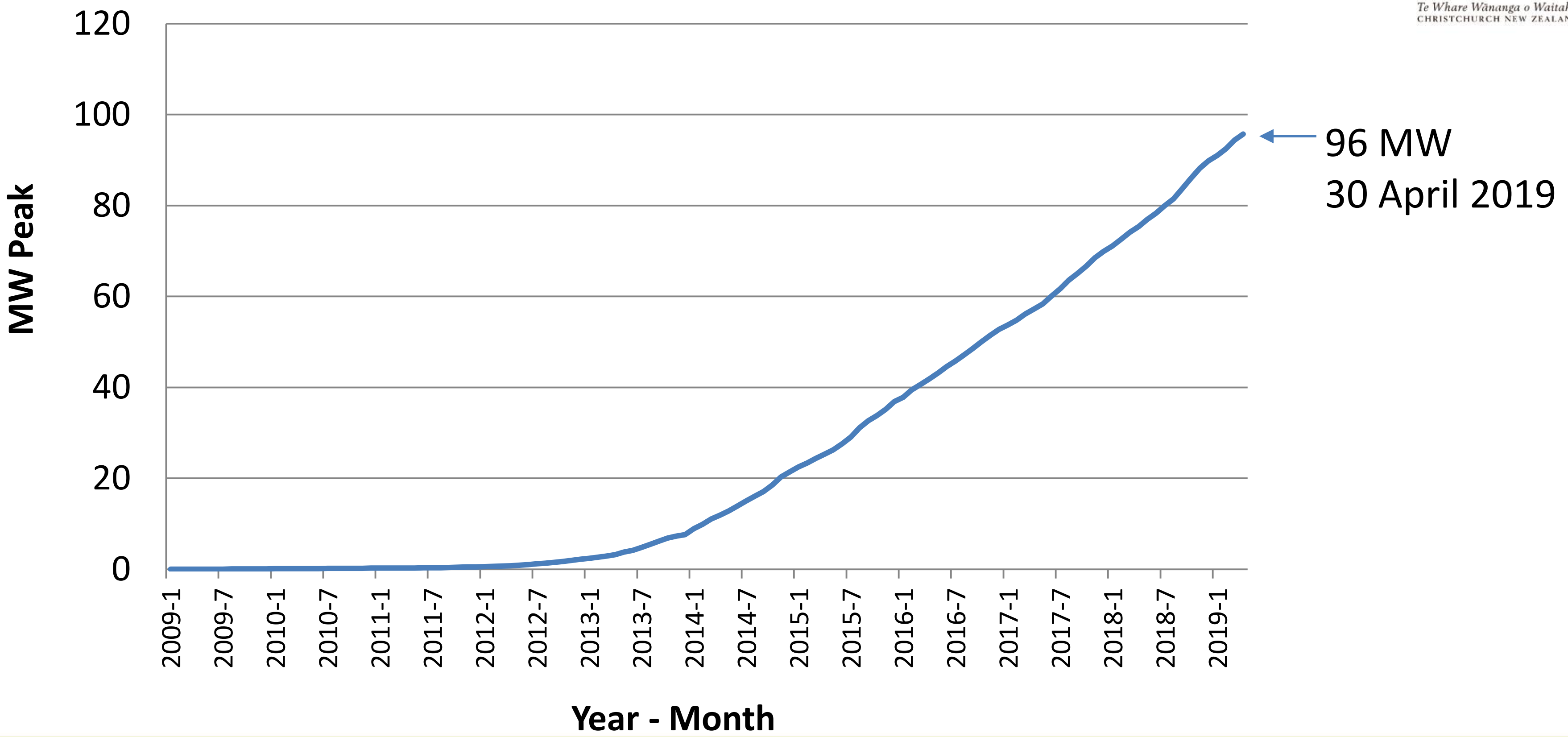
Presenter: Sharee McNab

24 June 2019

Outline

- Background
- DGHost^{TM}
- DGHost versus EVHost
- Hosting Capacity of EV's
  - Initial modelling results

Current PV Uptake in NZ



Solar PV Worldwide (2018)

Cumulative Capacity 2018

1		China	176,1 GW
2		USA	62,2 GW
3		Japan	56,0 GW
4		Germany	45,4 GW
5		India	32,9 GW
6		Italy	20,1 GW
7		UK	13,0 GW
8		Australia	11,3 GW
9		France	9,0 GW
10		Korea	7,9 GW
		EU*	115,0 GW

> 500GW PV worldwide

Watt/capita

Germany	548
Australia	459
Japan	442
*Honolulu	606
New Zealand	19

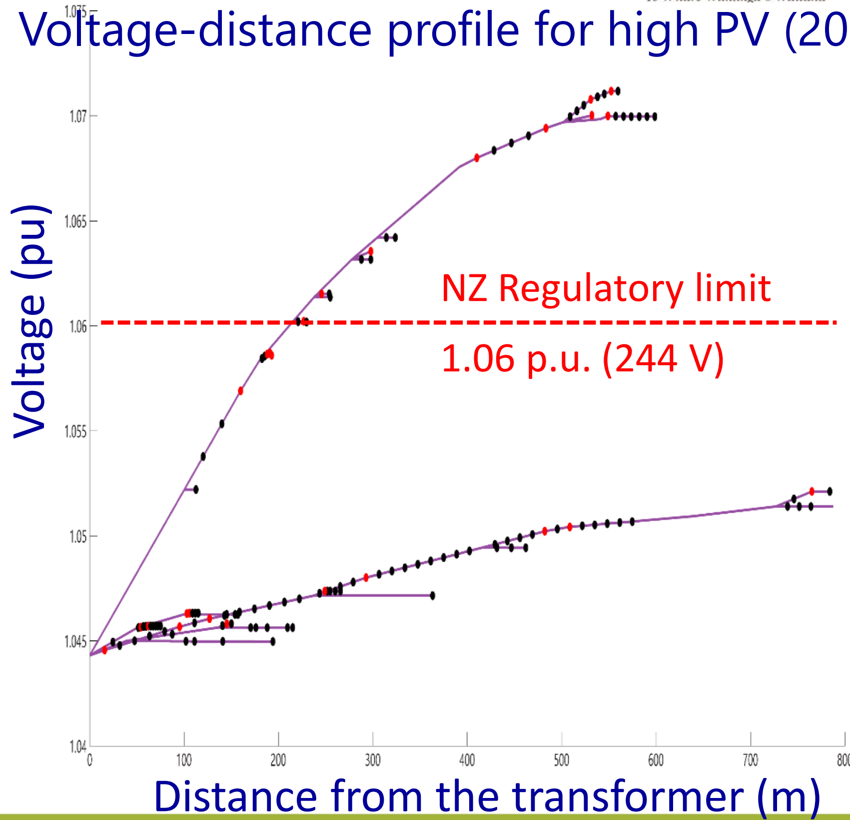
If NZ had 500 W/capita ~ 2.5 GW

NZ Total Generation 9.2GW (2017)

Impact of DG on Distribution Networks

- Congestion
  - Network voltage limits exceeded
  - Equipment current ratings are exceeded
    (transformers & cables)

Voltage-distance profile for high PV (20%)



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Evaluation Network Hosting Capacities Evolution of DGHost™

The ideal .....
Complete network data

The reality .....
Incomplete, paper based records

Full Power-flow Modelling LV Networks

Requires complete network data

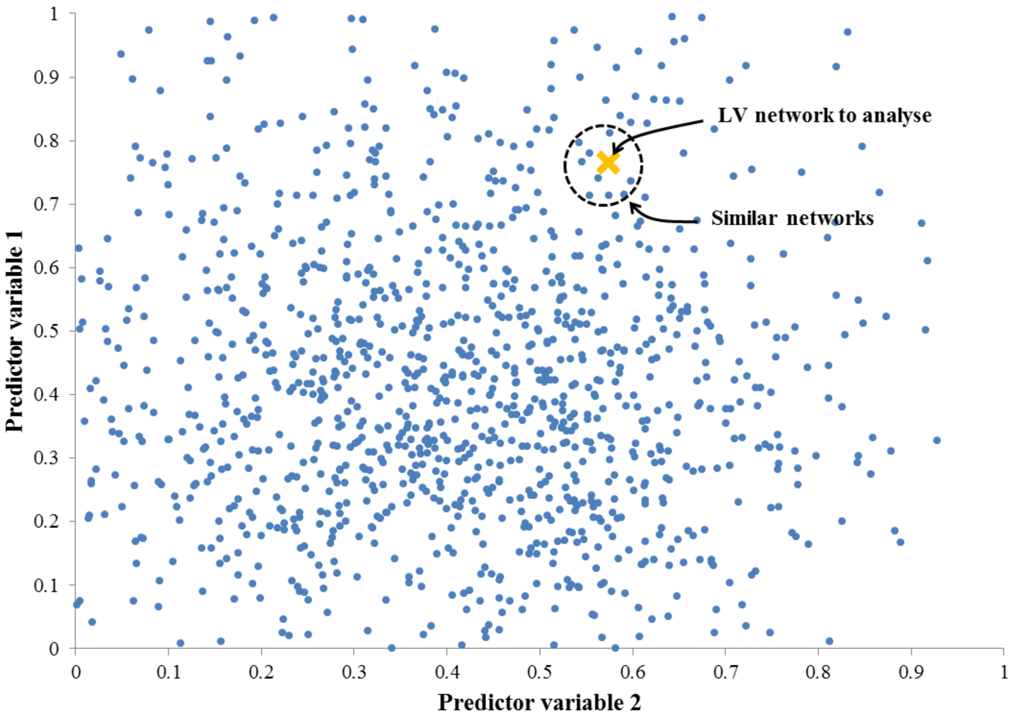
→

Approximate Method **(DGHost)**

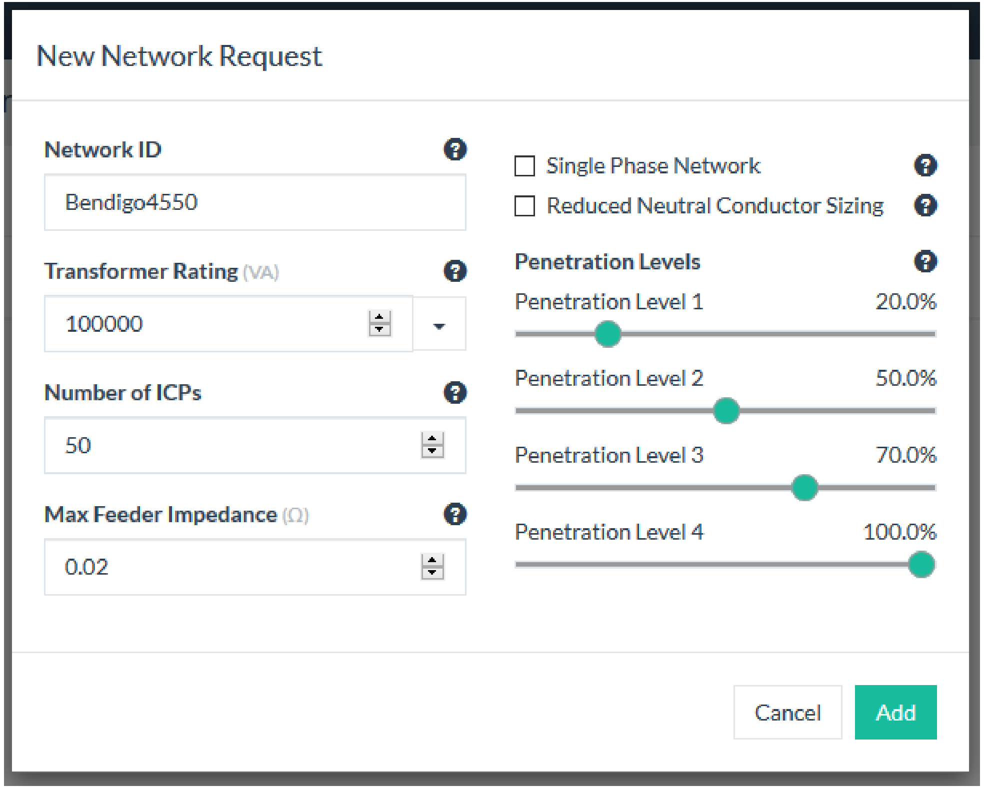
Simple inputs, large representative database of modelled LV networks

DGHost^{TM} An Approximation Method

- Hosting Capacity – maximum export power per DG
- Estimate hosting capacity (HC) of each LV network using the reference data set
  - 20 million HC results
- Optimization of predictor variables
  - As independent as possible
  - Easily determined by EDBs
- *k*-Nearest Neighbour Regression



DGHost™ Inputs

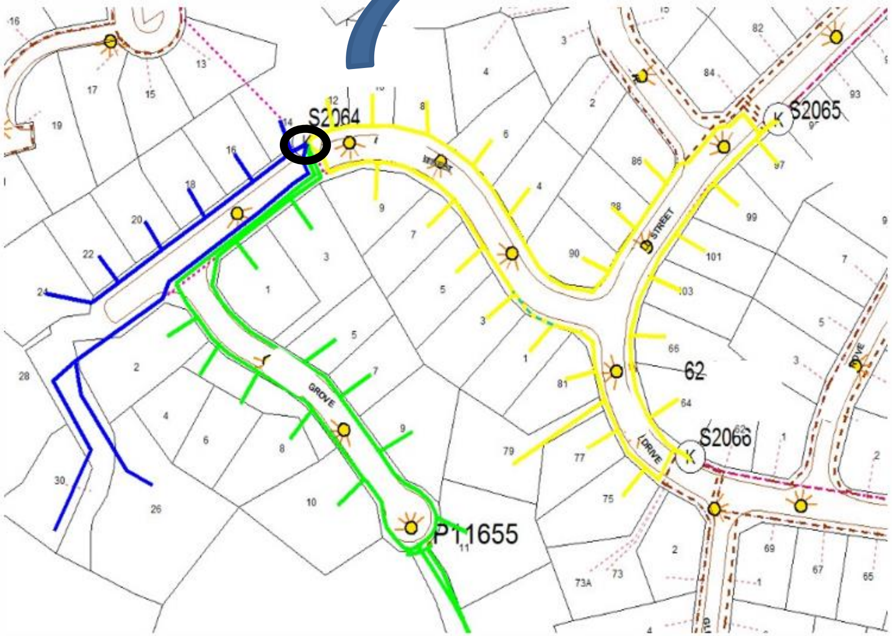


Per LV Network

- Transformer Rating
- Number of ICPs
- Max feeder impedance
- Penetration
  - 4 levels
- Network type
  - Single Phase
  - Reduced Neutral

Example Residential LV Network

GIS



DG Host Inputs:

Transformer Rating	300 kVA
Number of ICPs	31
Max Impedance |Z|	0.106 Ω
DG Penetration	??

3 radial underground feeders

- 70 mm^2 4 core Al underground cable

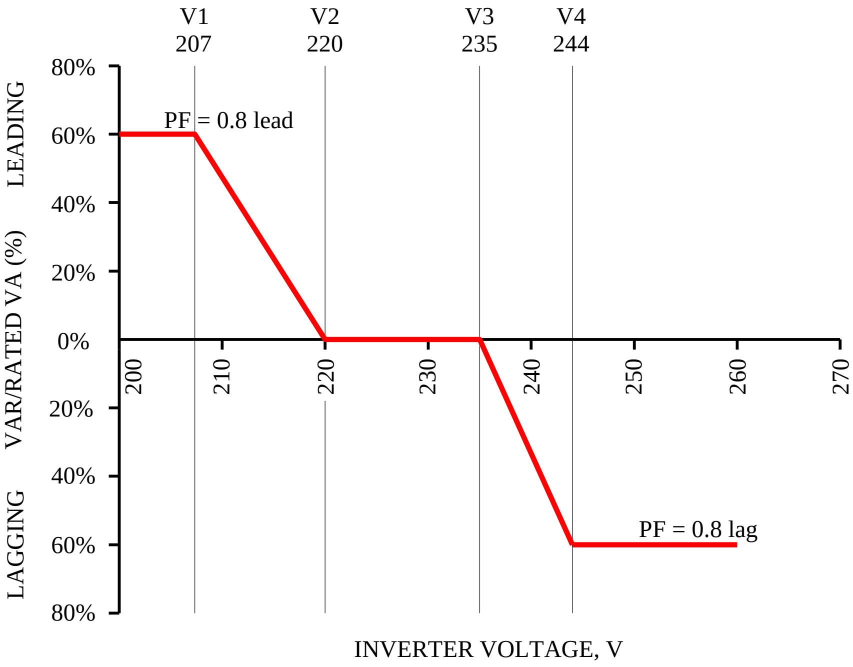
Hosting Capacity Results

Penetration Level 22.6%	
Conservative	**Median**
P25 (W)	**P50 (W)**
5400	5900

Penetration Level 48.4%	
Conservative	**Median**
P25 (W)	**P50 (W)**
3500	3700

Impact of Voltage Response Modes

- Inverters with grid supporting features
  - AS/NZS 4777.2:2015
- Voltage response modes
  - Volt-Var: voltages ↑ absorbs reactive power
  - Volt-Watt: voltages ↑ curtailing export



Example Volt-VAr Response (DG Connection Guide)

Hosting Capacity Results with Volt-Var

	Penetration Level 22.6%		Penetration Level 48.4%	
Volt-VAR	Conservative	Median	Conservative	Median
(%)	P25 (W)	P50 (W)	P25 (W)	P50 (W)
0	5400	5900	3500	3700
30	6900	7400	4900	5200
60	8900	9400	7600	8000

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DGHost
Online Tool

www.dghost.nz

Publications on our website

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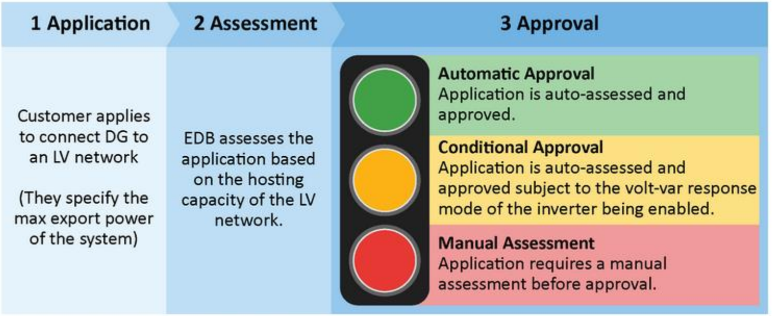
DGHost™

To learn more about the DGHost™ Service, have a look at our DGHost™ Brochure.

Distributed Generation connected on Low Voltage Networks

The connection of Distributed Generation (DG) units, such as solar PV systems, to an electricity distribution network can cause parts of the network to become congested. This congestion is typically the result of voltage rise along feeders or the overloading of equipment in the network. Consequently, when considering DG applications, Electricity Distribution Businesses (EDBs) must be able to determine the maximum amount of DG that can be installed at each ICP in a network, without adversely affecting its operation or breaching network requirements. This amount is defined as the hosting capacity of the network.

DG hosting capacity can be determined by full power-flow simulations of a network, or by approximation methods, such as those used in the DGHost™ Service. The EEA Guideline for the Connection of Small-Scale Inverter Based Distributed Generation *(draft)* specifies appropriate connection requirements for DG applications according to network-specific hosting capacity thresholds. This categorises DG applications into a three-tier traffic light system based on the hosting capacity, as shown in the picture below. Each category reflects the likely impact of the DG exporting into the LV network, and thus if it can be approved for connection.



Three tier traffic light system for assessing DG applications using hosting capacity.

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PV Modelling versus EV Modelling

	PV modelling	EV modelling
Location	Known, application process	Unknown, can infer from load analysis, incentivise registration
Energy profile	Sunshine hours well defined - Long historical records	Diverse EV Charging profiles - Multiple charging rates - Diverse charging frequencies
Correlation of generation/load	LV networks high degree of generation correlation	Some correlation eg. charge when home from work, however opportunities to introduce diversity

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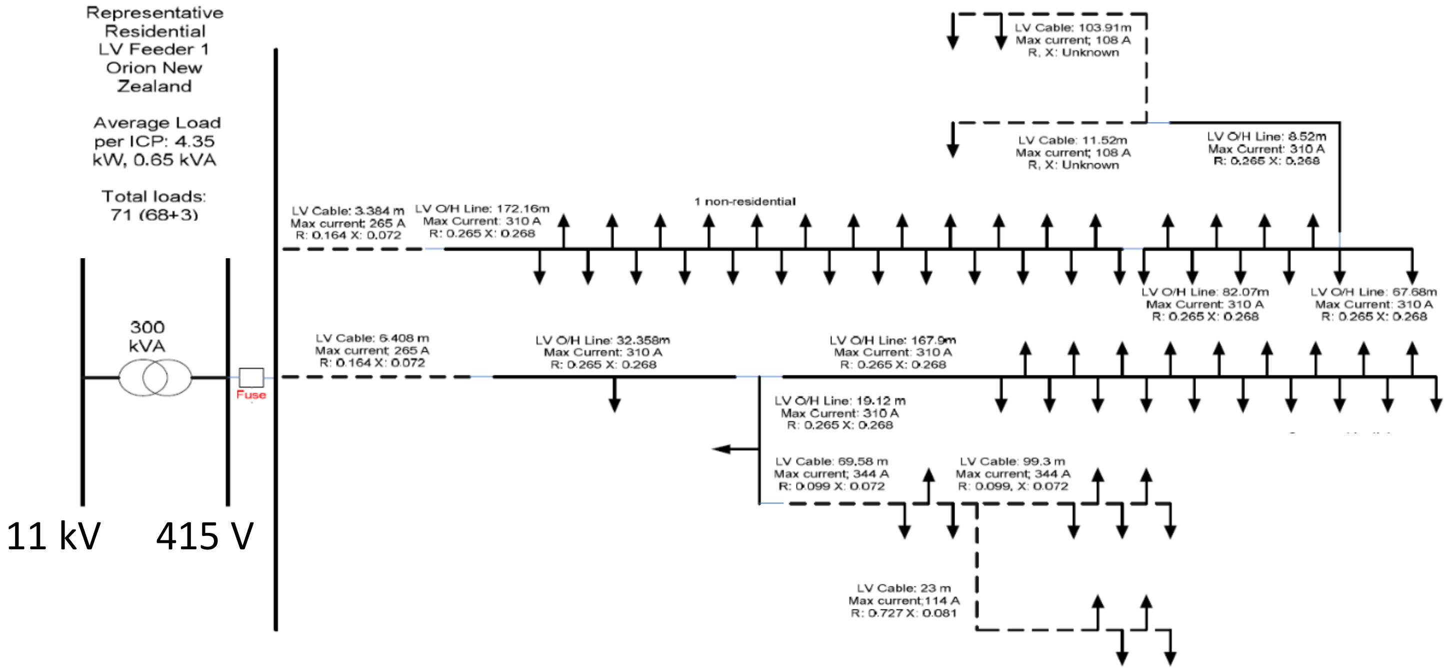
EV Modelling Results

- LV network chosen, cluster centre of an urban network, 71 households (Orion network)
- Different charging approaches explored
- Charging 2kW/4kW charger (Level 1/2 charging)
- Anxiety factor AF 0->1
  - 0 perfect knowledge of charge required for next day
  - 1, nervous, always charge no matter the SOC.

Typical Residential Network



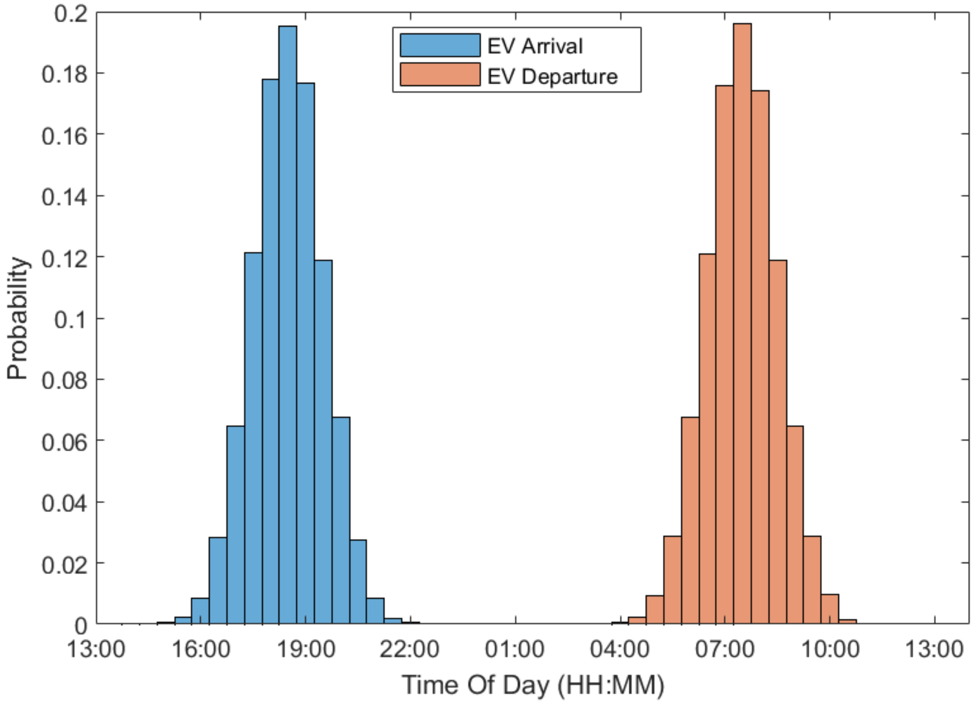
71 ICPs

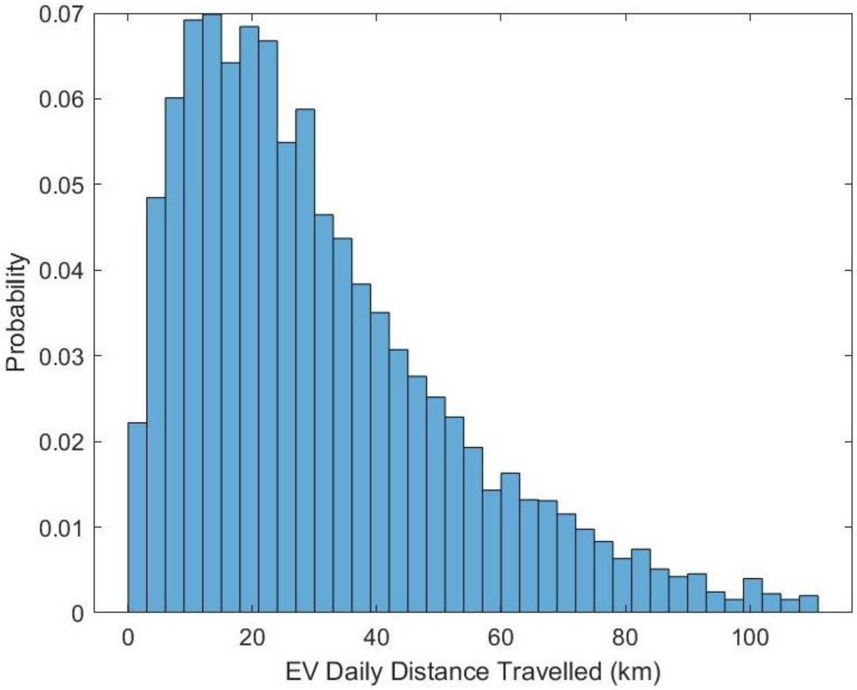
68 Residential

3 Non-residential

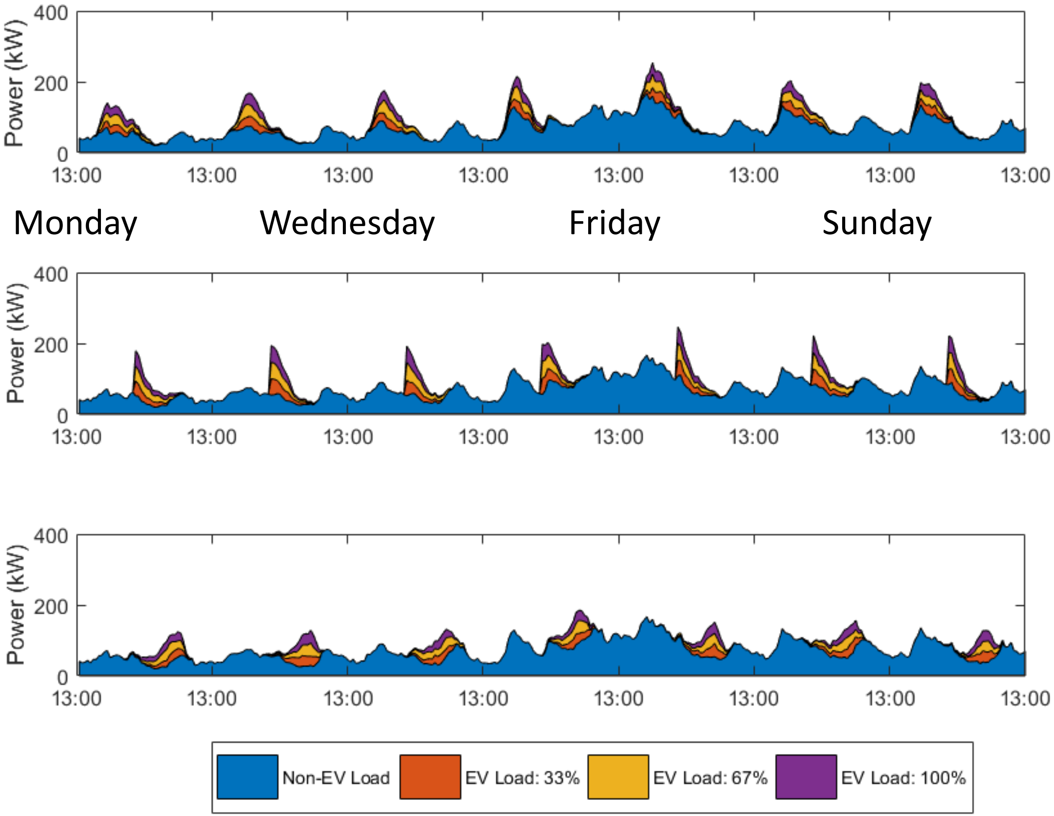
Alternating phase allocation

Journey Distributions





Transformer Load Charging Methodologies
2kW Charger



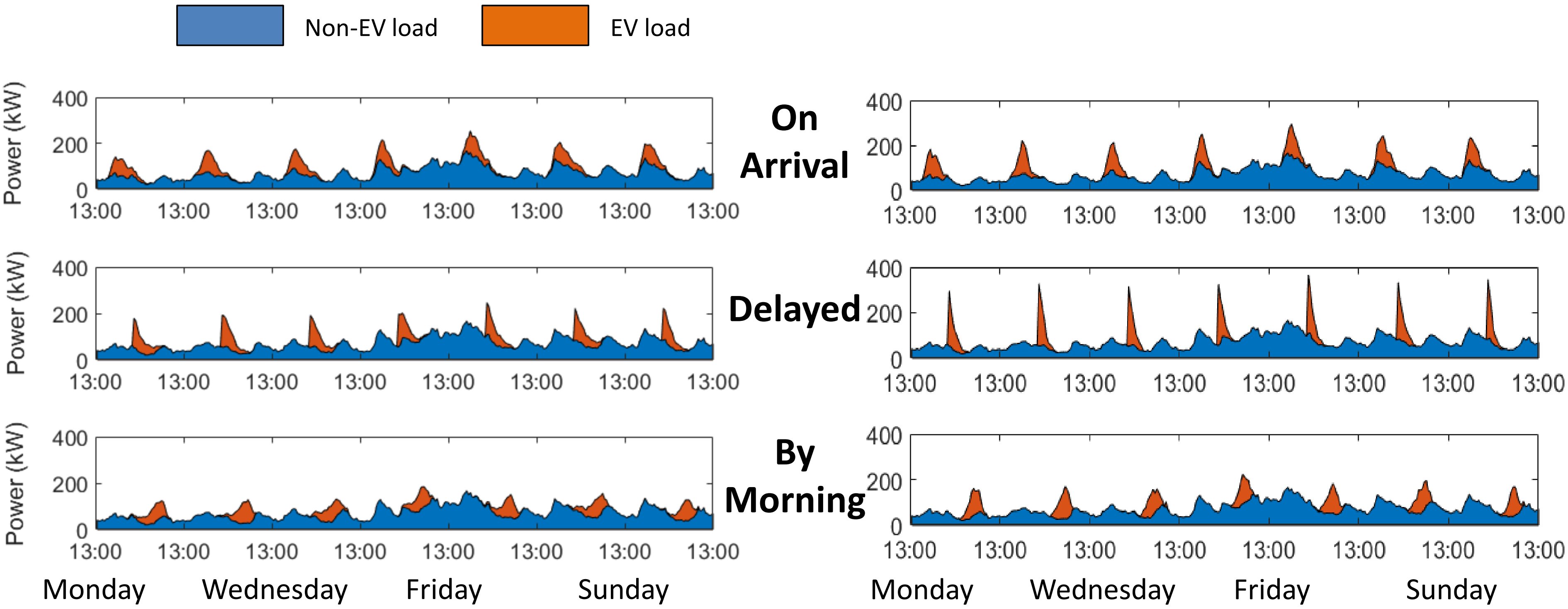
On Arrival Charging

Delayed Charging:
Reduced tariff @ 11 pm

By Morning: Battery fully charged by departure time

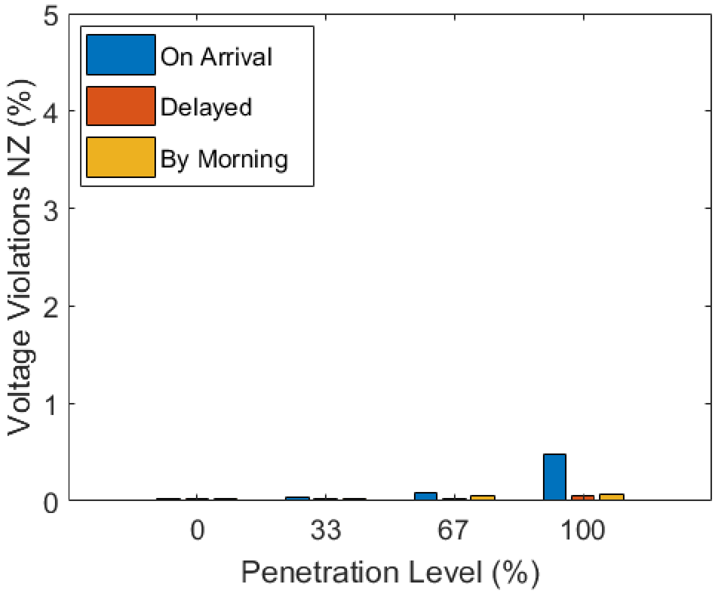
EV Charging, 100% Penetration

2kW versus 4kW

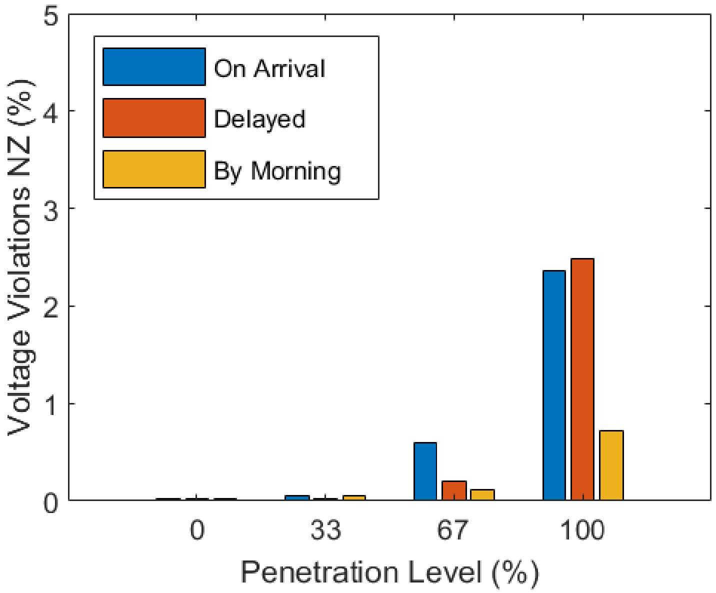


Voltage Violations in Test Network

2 kW Charger



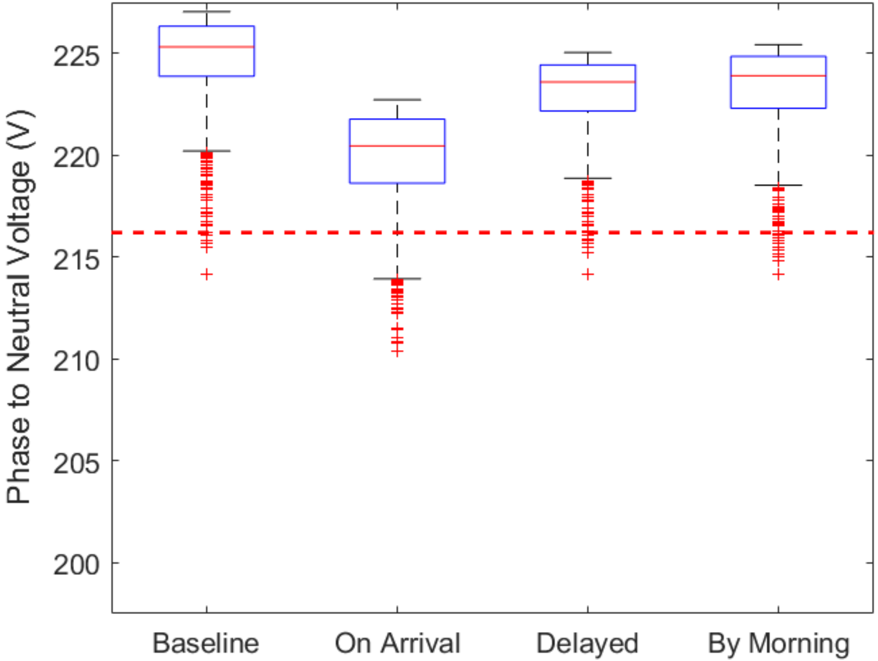
4 kW Charger



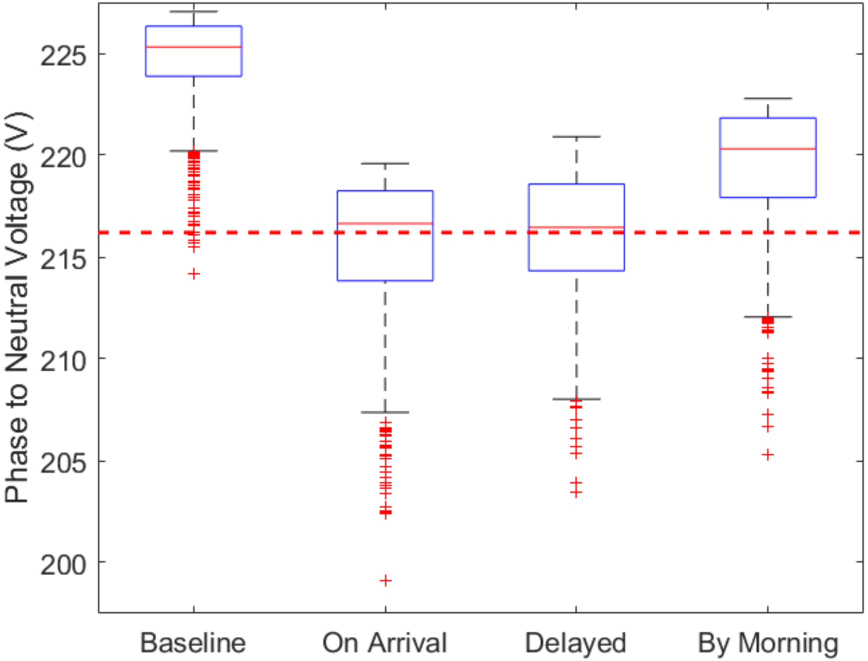
% of HH time periods in a year (2.5% equates to 438 HH’s/17520)

Voltage Violations Magnitudes

2 kW Charger - 100% EVs



4 kW Charger – 100% EVs



Distribution of 5% lowest Phase to Neutral Voltages

Summary

- Example analysis for a “typical” network, with typical loads
- Incentivising delayed charging for EV’s can reduce diversity, more problematic at higher charging rates.
- By morning the best charging strategy to give greater diversity on the network.
- While load diversity helps with transformer loading it doesn’t help with voltage issues as these intimately linked with how the loads are distributed.
- Future work extension to large LV data sets.

Premium Funder

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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