Assessing the Impacts of EVs on Australian Urban and Rural Grids

Electric Vehicle Integration Project

Prof Luis(Nando) Ochoa

Dr William Nacmanson

Webinar

6th October, 2021

Outline

1. The "EV[1] Integration" Project
2. Context: EVs and the Grid
3. HV-LV Feeder Modelling, Demand and PV
4. EV Modelling and Considerations
5. EV Impact Assessment on Urban and Rural Grids
6. Key Remarks

[1] EV = Electric Vehicle

1 The "EV Integration" Project

- UoM Project Website
- C4NET Project Website

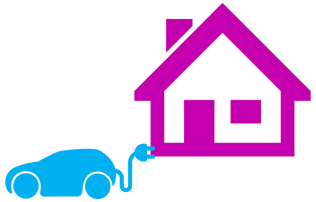
EV Integration Project
Scope

The project (Sep 2020 to Sep 2022) explores four key research areas:

1. Customer acceptance and expectations around EVs (Apr 2021)
2. **Distribution network impacts from unmanaged EVs** (Sep 2021)
3. Distribution network integration of EVs using active mngt strategies (Mar 2022)
4. Techno-economic network and system integration of EVs (Sep 2022)

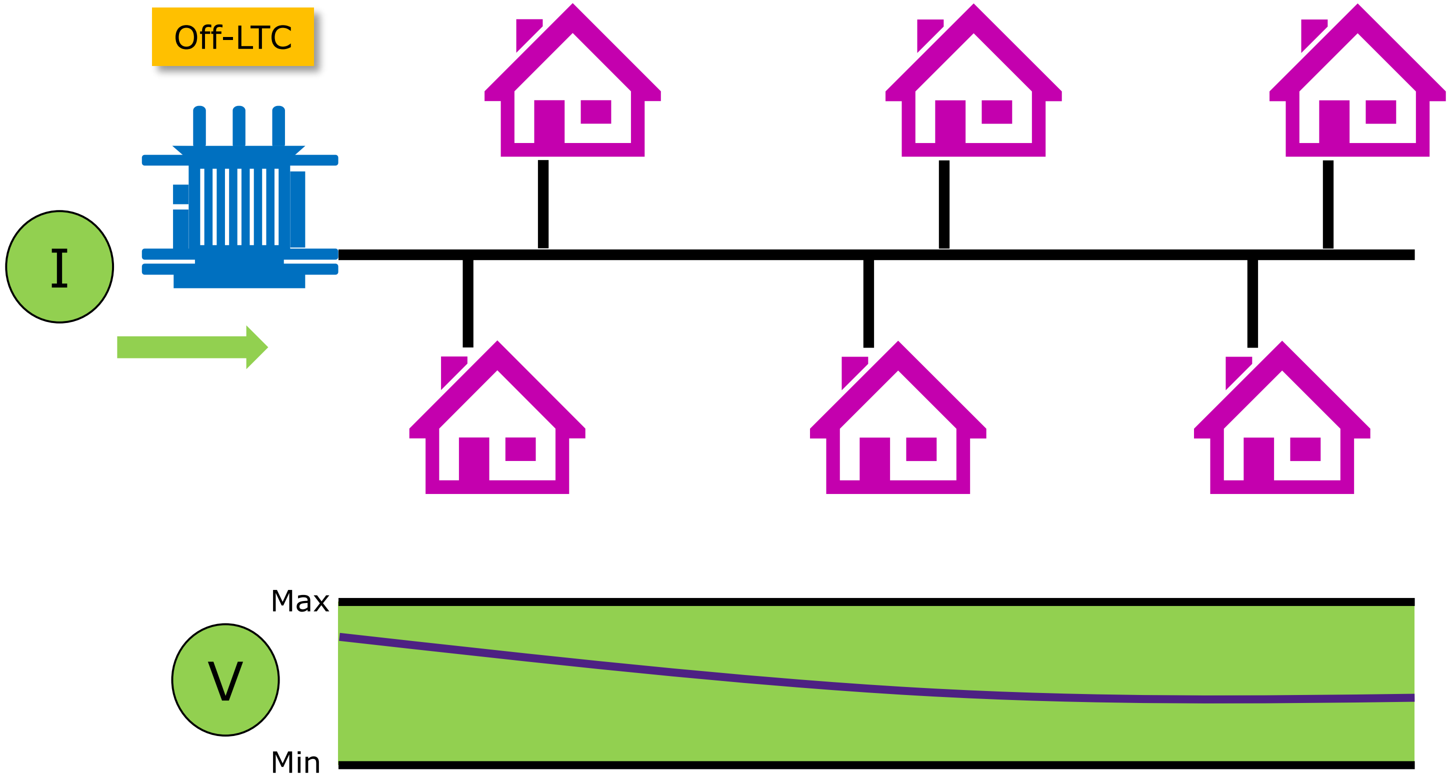
EV Integration Project
Team

- Prof Pierluigi Mancarella (Techno-Economics)
- Prof Luis(Nando) Ochoa (Distribution Networks)
- Dr Patricia Lavieri (Customers)
- Prof Majid Sarvi (Transport)
- Dr William Nacmanson, Dr Shariq Riaz
- Carmen Bas Domenech, Jing Zhu, Gabriel Oliveira
- Data and know-how from DNSPs



2 Context: EVs and the Grid

Low Voltage (LV) Networks – Design Principles



LV Feeder (3ϕ): 400V L-L
Homes (1ϕ): 230V L-N

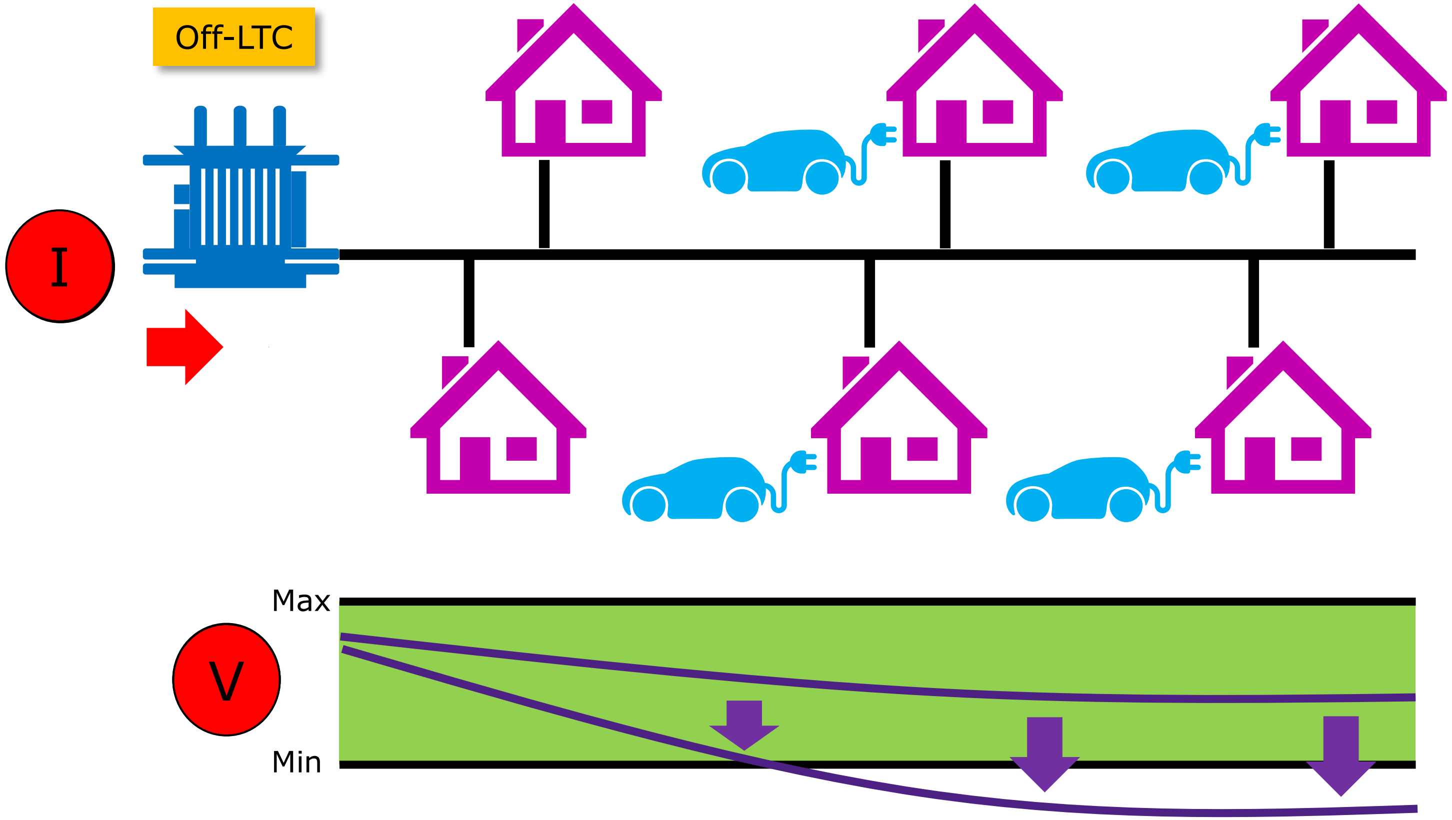
- ✓ Diversity
- ✓ Demographics
- ✓ Demand growth

Typical 1ϕ ADMD[2]	
NSW	6.5 kVA
VIC	3 to 5 kVA
TAS	4 to 6 kVA

Australian LV Networks are **designed** for an ADMD[1] of 3 to 7kW per house.
In practice, we use a bit less → There is room for EVs ☺. *But how much room?*

[2] ADMD = After Diversity Maximum Demand. Estimated average coincident peak demand.

Residential EV Charging and LV Networks

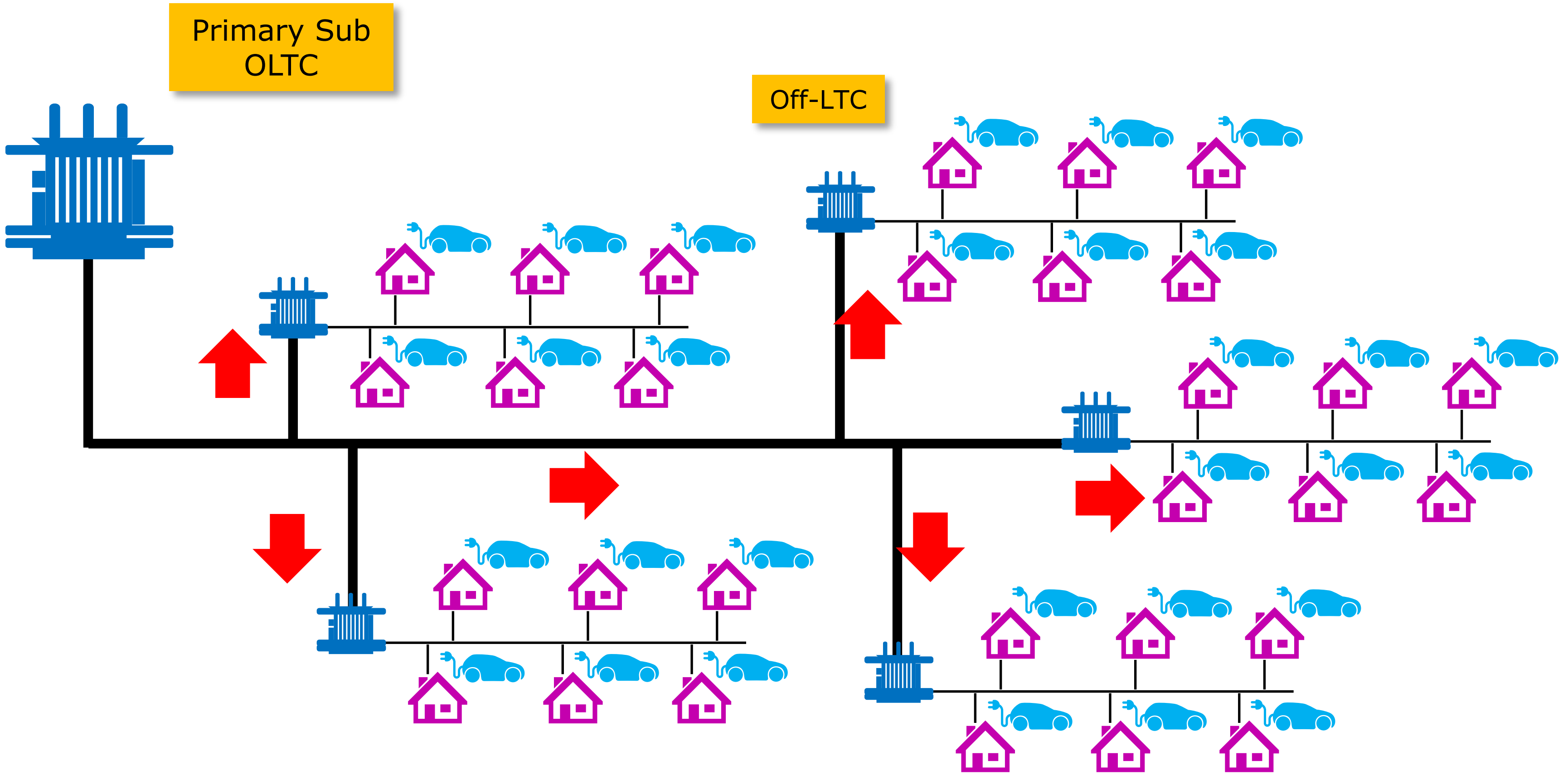


IEC 61851-1 1ϕ Modes	
Level 1	3.7 kW (16A, 230V)
Level 2	7.4 kW (32A, 230V)

EVs are charged when people return home → Larger peak demand

The trend is for *Level 2* charging → **New avg peak per house could be much larger**

EVs & High Voltage (HV) Networks



HV Feeder (3ϕ): 22kV L-L

Network Type	
Urban	⇩ Area ⇩ Z ⇧ Density ⇧ Tx kVA
Rural	⇧ Area ⇧ Z ⇩ Density ⇩ Tx kVA

I

V

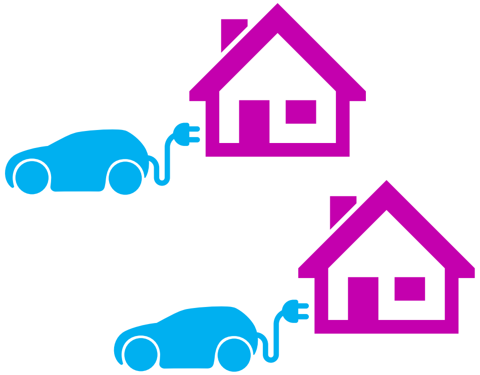
Widespread EV adoption → Widespread problems

How can we determine the EV hosting capacity of our networks?

→ Explore EV effects on different types of networks

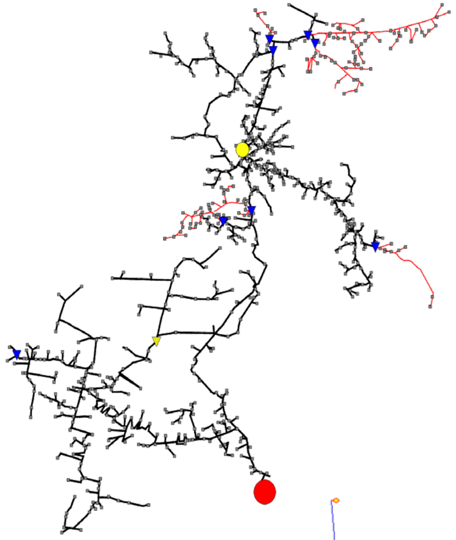
… Some Definitions

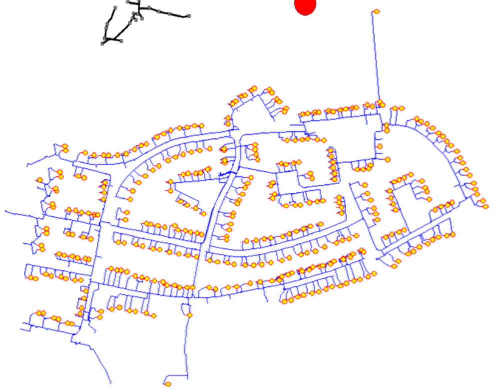
- EV Hosting Capacity
  - The maximum amount of EVs that a given distribution network (or part of it) can host *without negatively affecting its normal operation at any point in time*.
- Normal Operation
  - Voltages (statutory limits), asset utilisation (no congestion), protection, etc.
- Amount of EVs
  - Number (or %) of customers with EVs, kW of total charging infrastructure capacity, etc.



EV Hosting Capacity: Modelling Challenges

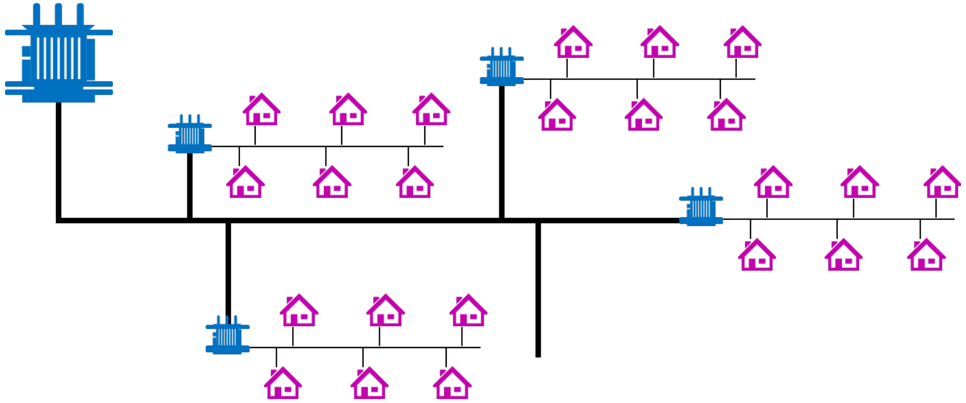
- Voltage is a locational effect → Network models (impedances)
- Residential EVs → LV network models (HV not enough)
- Unbalance (effects among phases) matter → Three-phase models
- Normal demand and EV demand → Realistic time-series profiles
- Other elements (e.g., OLTCs), solar PV, etc. → More complexity





Capturing the physics of HV & LV networks is key

But, in practice, distribution companies do not have complete data and models



3 HV-LV Feeder Modelling, Demand and PV

HV-LV Network Modelling

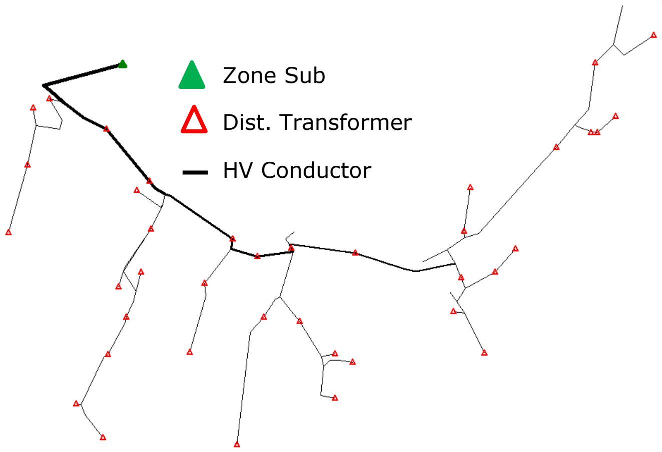
Feeder Overview

- Six HV feeders from VIC, TAS and NSW are modelled as integrated HV-LV feeders.

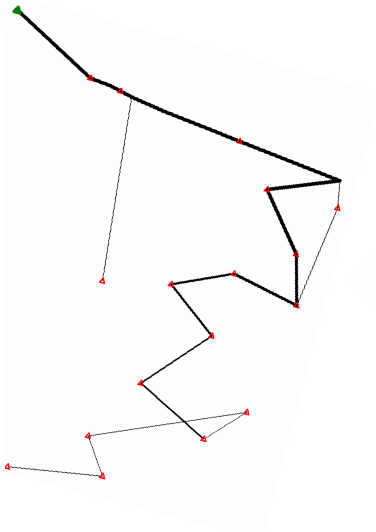
Feeder	Voltage Level (Total HV length)	No. Customers	No. LV Dist. Tx	Avg Residential Peak Size (kW)	Residential Data Used	ADMD (kW)	PV Penetration for Base Case (%)	Avg PV Size (kW)
Rural NSW (Hazelbrook)	11kV (20km)	1,401	39	2.0	VIC Smart Meter	6.5	24	3.8
Urban NSW (Preston)	11kV (6km)	616	17	2.0	VIC Smart Meter	6.5	30	5.8
Rural TAS (Norwood)	22kV (11km)	1,506	33	3.0	Avg Profile	5.0	0	-
Urban TAS (West Hobart)	11kV (6km)	620	12	3.5	Avg Profile	5.0	0	-
Rural VIC (SMR8)	22kV (486km)	3,669	765	2.0	VIC Smart Meter	4.0	0	-
Urban VIC (CRE21)	22kV (30km)	3,383	80	2.0	VIC Smart Meter	4.0	0	-

HV-LV Network Modelling

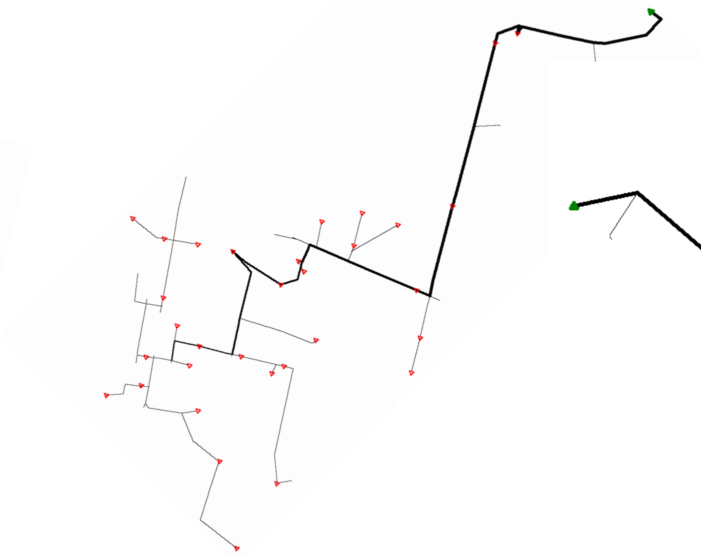
HV Feeder Topologies



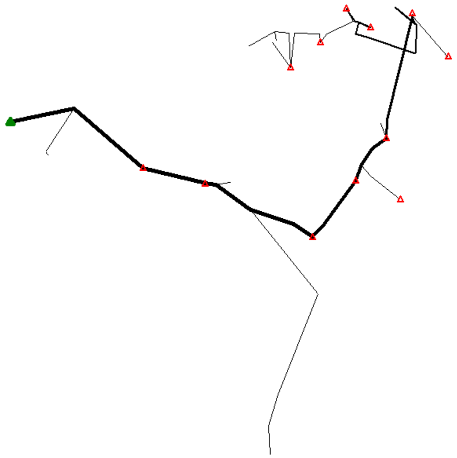
Rural NSW
Hazelbrook (11kV)



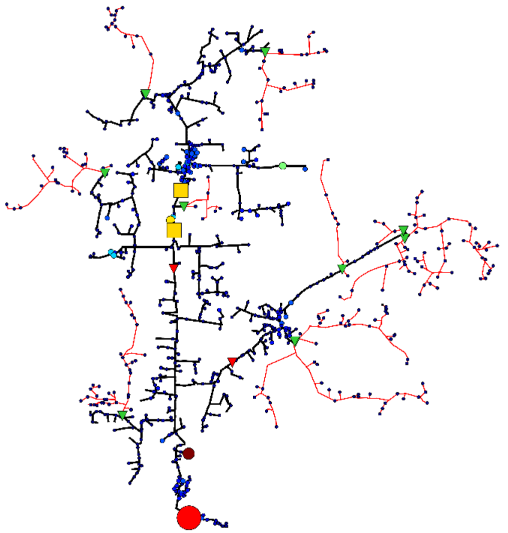
Urban NSW
Preston (11kV)



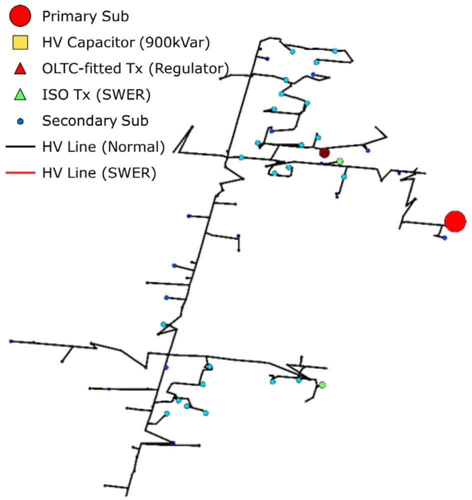
Rural TAS
Norwood (22kV)



Urban TAS
West Hobart (11kV)



Rural VIC
SMR8 (22kV)



Urban VIC
CRE21 (22kV)

- HV-LV network modelling process:
  - ✓ PSS Sincal and DIgSILENT PowerFactory → Python ⇔ OpenDSS
  - ✓ (Pseudo) LV Networks based on Australian design principles
    - ➢ Unbalanced 3ϕ modelling down to 1ϕ (230V) connection points

HV-LV Network Modelling

HV Feeder Validation (TAS and NSW)

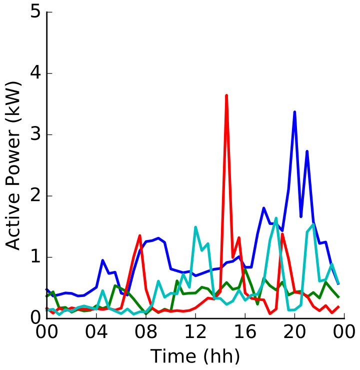
1. Select SCADA data (head of HV feeder $\boldsymbol{P_{HoF}}$ and $\boldsymbol{Q_{HoF}}$) for peak demand day (worst-case for EV impacts)
2. Assign available residential demand ($\boldsymbol{P_R}$) to customers
3. Assign available residential PV profiles ($\boldsymbol{P_{PV}}$, where applicable)
4. Tune C&I demand profiles ($\boldsymbol{P_{C\&I}}$) associated with each distribution transformer to align the active power at the head of the HV feeder from OpenDSS (simulation) with the SCADA data → $\boldsymbol{P_{HoF} \approx P_{OpenDSS}(P_R, P_{PV}, P_{C\&I}, network)}$
5. Tune reactive power of C&I customers and the network to align the reactive power from OpenDSS with the SCADA data → $\boldsymbol{Q_{HoF} \approx Q_{OpenDSS}(Q_R, Q_{C\&I}, network)}$. Lagging power factor is assumed for residential customers. Capacitors used when needed.

Adequate matching with SCADA data → Realistic network behaviour

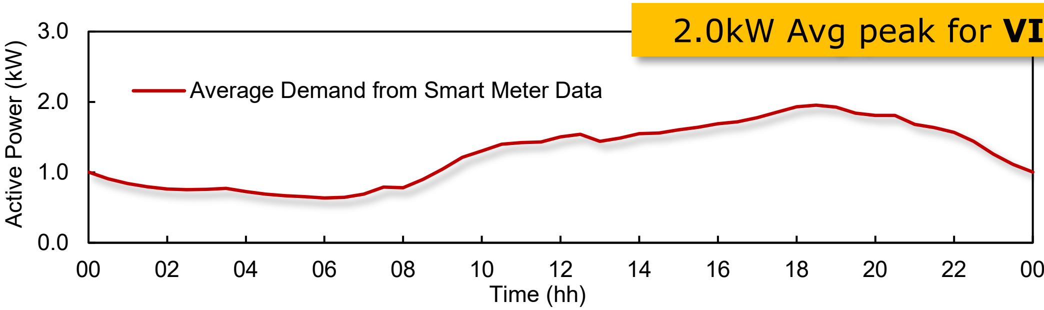
[3] C&I = Commercial and Industrial.

Demand Modelling

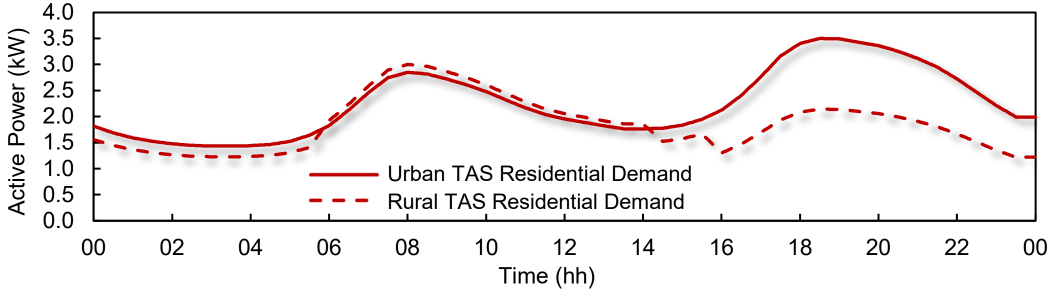
- For **VIC and NSW** feeders
  - ➢ Pool of 342 1-min resolution anonymized **VIC smart meter** profiles (peak demand day)
- For **TAS** feeders
  - ➢ **Diversified residential profiles** based on measurements



Example of smart meter profiles for **VIC and NSW**



2.0kW Avg peak for **VIC and NSW**



3.5kW Avg peak for Urban **TAS**

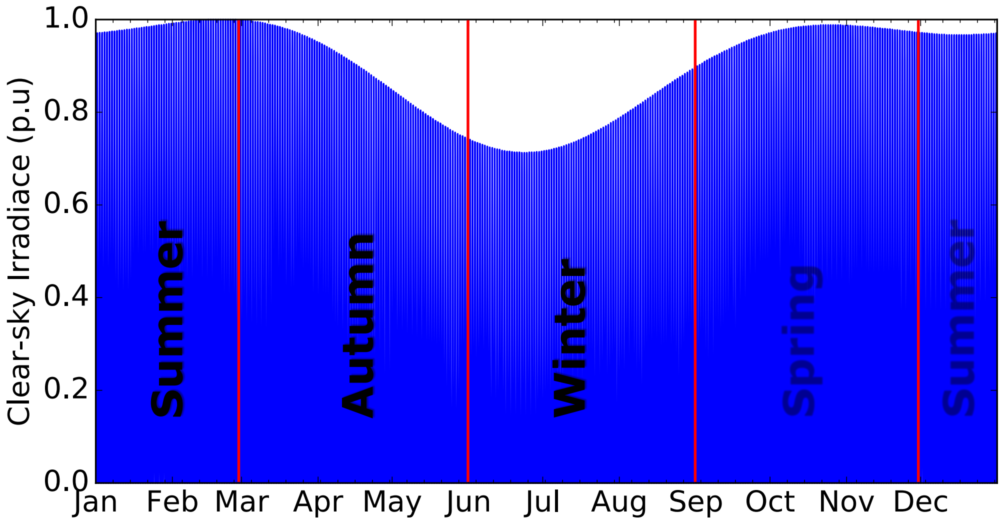
3.0kW Avg peak for Rural **TAS**

PV Modelling

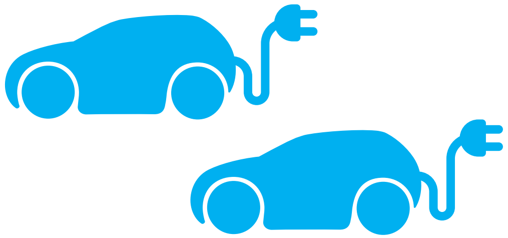
- **NSW** feeders used known installed capacities

Feeder Name	Residential PV Penetration for the Base Case (%)	Average Residential PV Size (kW)
Rural NSW (Hazelbrook)	24	3.8
Urban NSW (Preston)	30	5.9

- PV is modelled using a pool of 1-min resolution, year-long normalized PV generation profiles based on clear-sky irradiance profiles from Melbourne



Day corresponds to the SCADA peak demand day



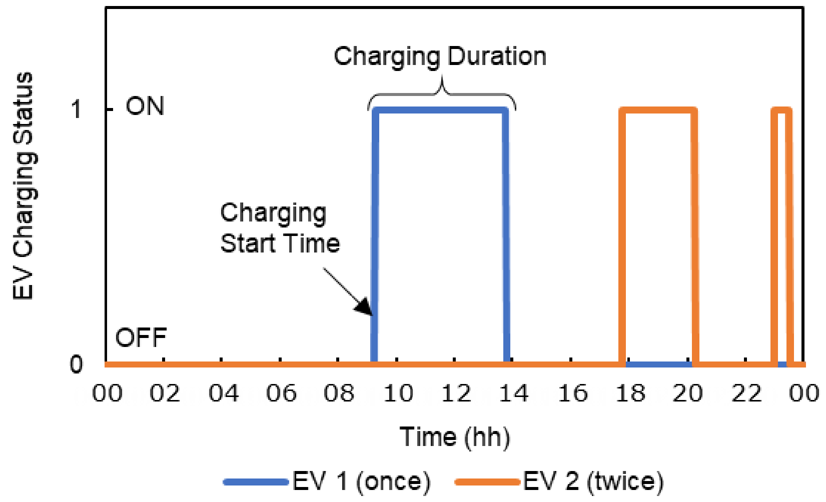
4 EV Modelling and Considerations

EV Modelling and Considerations
Overview

- Steps to create EV demand profiles using the UK Electric Nation[4] data[5]:

Step 0) Analyse and check EV data
Step 1) Define residential EV charger sizes
Step 2) Consider the implications of multiple EVs per house
Step 3) Divide data into subsets (if applicable)
Step 4) Extract probability distributions
Step 5) Produce EV binary profiles
Step 6) Translate into EV demand profiles
Step 7) Create EV demand profiles considering charging limits
Step 8) Extract the daily charging coincidence factor
Step 9) Consider a power factor
Step 10) Consider EV penetrations

From EV binary profile to EV demand profile



[4] Project "Electric Nation" with nearly 700 EV owners taking part from 2017-2018 (https://electricnation.org.uk/)
[5] https://www.westernpower.co.uk/electric-nation-data

EV Modelling and Considerations
Applicability of UK EV data

Step 0) Analyse and check EV data

a. Travel Mileage

- Similar travel milage: Average of 212km per week in Australia and ~300km in the UK trial

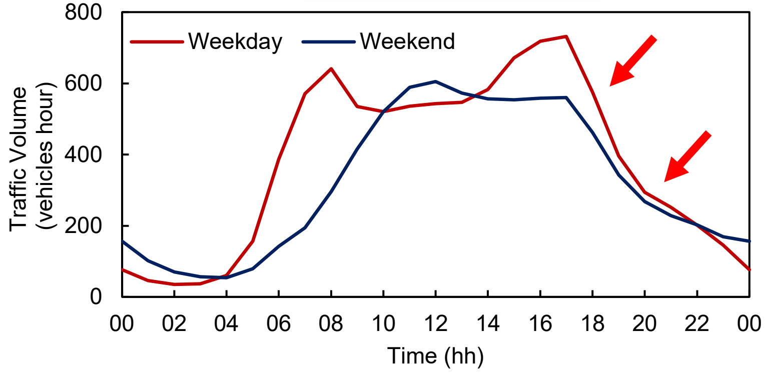
b. Plug-in Time

- Australian traffic decreases in the evening approximately as UK EVs are plugged in

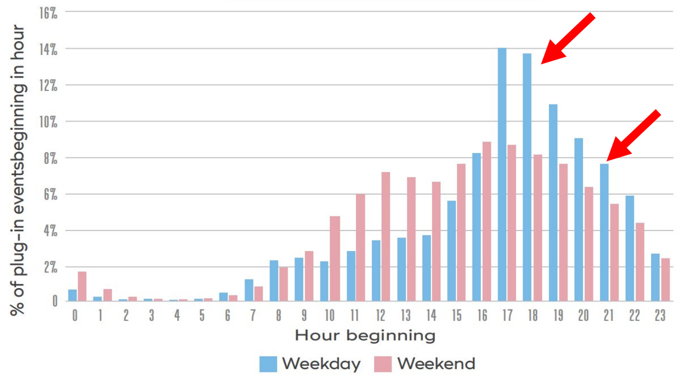
c. EV Model Diversity

- Fewer EVs available in Australia vs the UK trial
- But once the market catches up, it is expected to be similar

Australian Hourly Traffic Volume



UK Plug in Times



✓ UK EV data is applicable for EV planning studies in Australia

EV Modelling and Considerations
Charger Size and EVs per House

Step 1) EV Charger Size

- **80% of EVs** are assumed to be equipped with Level 2 chargers (7.4kW)
- **20% of EVs** are assumed to be equipped with Level 1 chargers (3.7kW)

Step 2) Multiple EVs per house

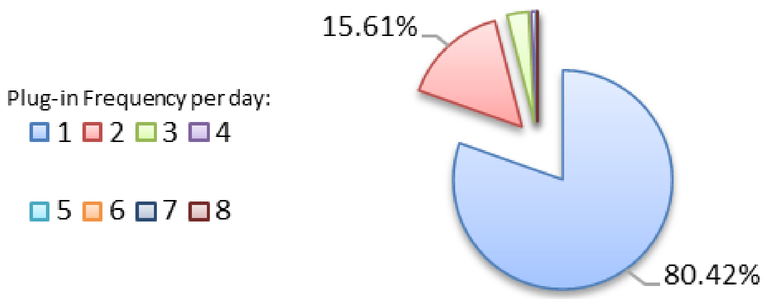
Case	1st EV	2nd EV	Chargers	Max Power
Case A	Level 1	Level 1	Separate chargers	3.68+3.68=7.36 kW
Case B	Level 1	Level 2	Separate chargers	3.68+7.36=11.04 kW
Case C	Level 2	Level 2	Dual-headed Level 2 charger	7.36 kW

- **Dual-headed level 2 chargers** (Case C) are assumed where two level 2 EVs are assigned to one house to avoid typical single-phase limits of 30-60A [7-14kW]

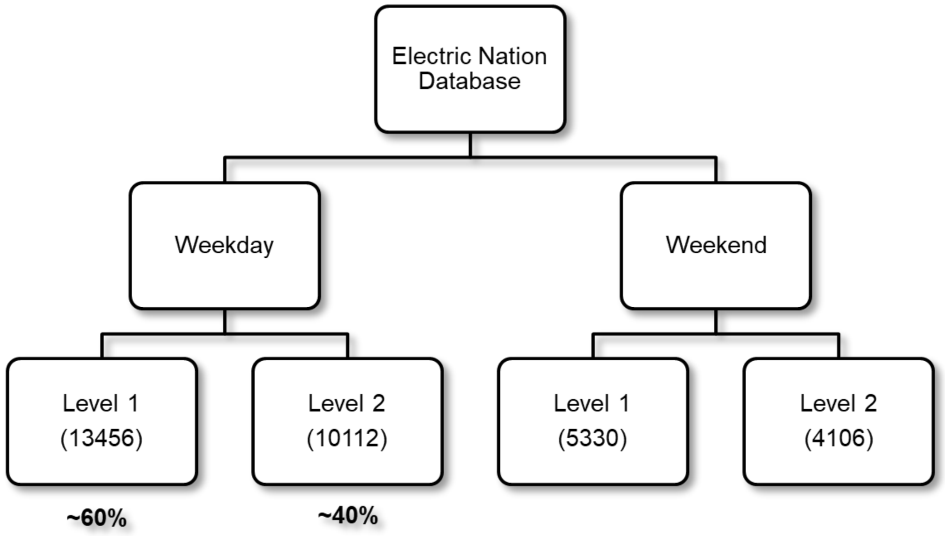
EV Modelling and Considerations
Create subsets if needed

Step 3) Divide data into subsets

- 96% of EVs plug-in up to twice a day
- Weekdays and weekends have different behaviours
- Charging levels have different behaviours

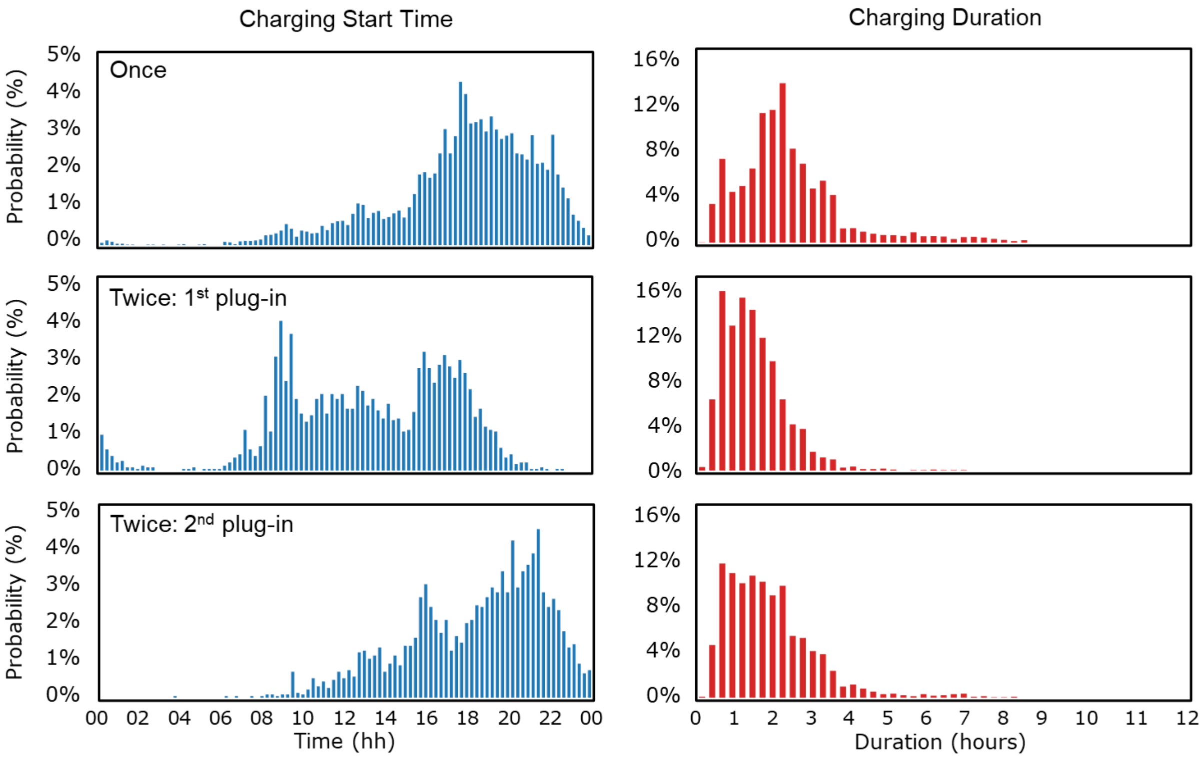


- Data is filtered to consider up to twice charging events per day
- Data is divided into Weekday/Weekend & Level1/Level2

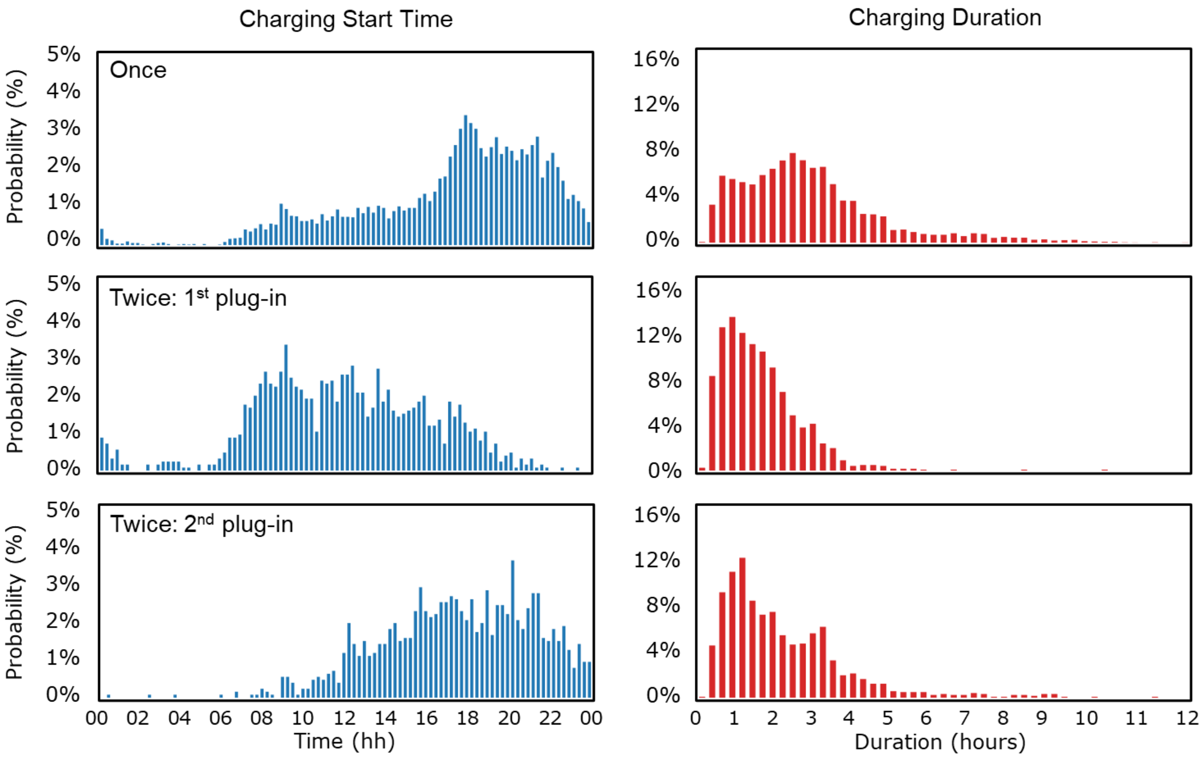


EV Modelling and Considerations
Extract Probability Distributions

Step 4) Extract probability distributions



Weekday Level 1 EV Charging



Weekday Level 2 EV Charging

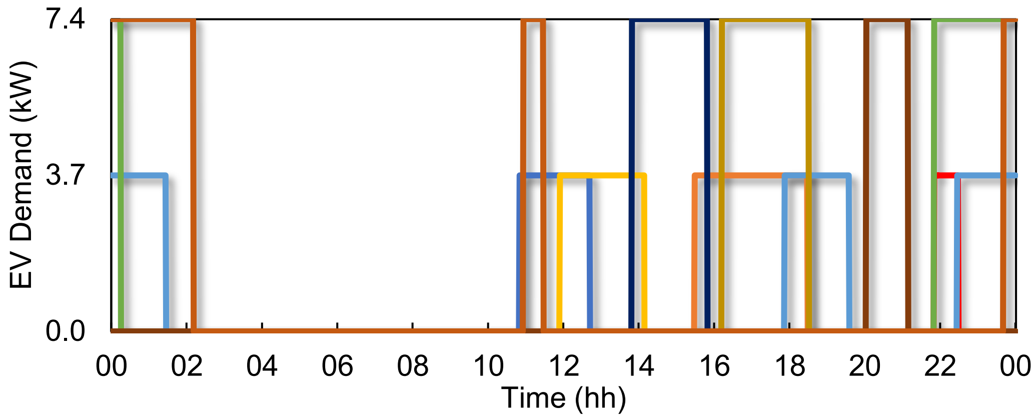
EV Modelling and Considerations
EV Demand Profiles

Step 5) Produce EV binary profiles

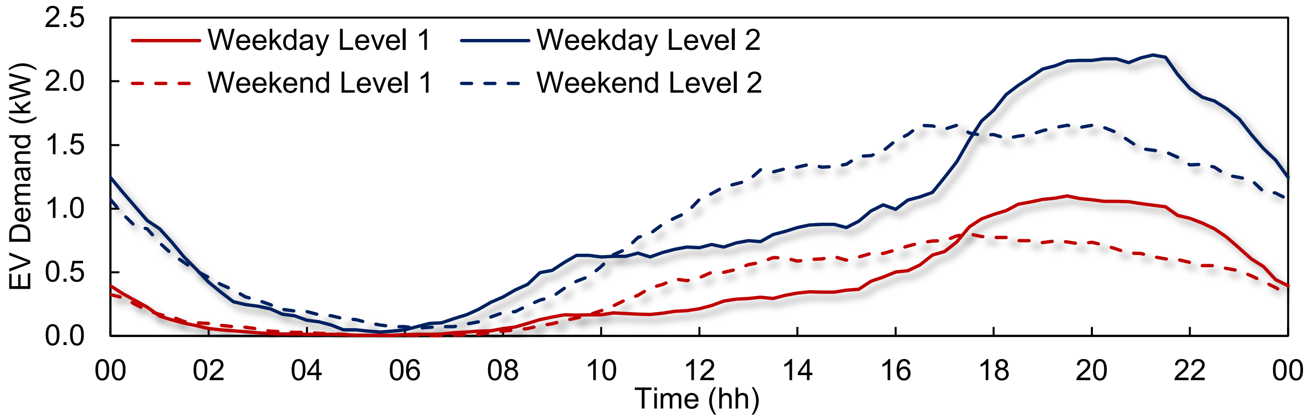
- Charging *start time* and *duration* are randomly selected and combined to produce 1,200 1-min resolution EV binary profiles for each subset

Step 6) Translate into EV demand profiles

- Apply the charging level (e.g., 7.4kW) to produce **1,200 1-min resolution EV demand profiles for each subset**



Individual EV Profiles

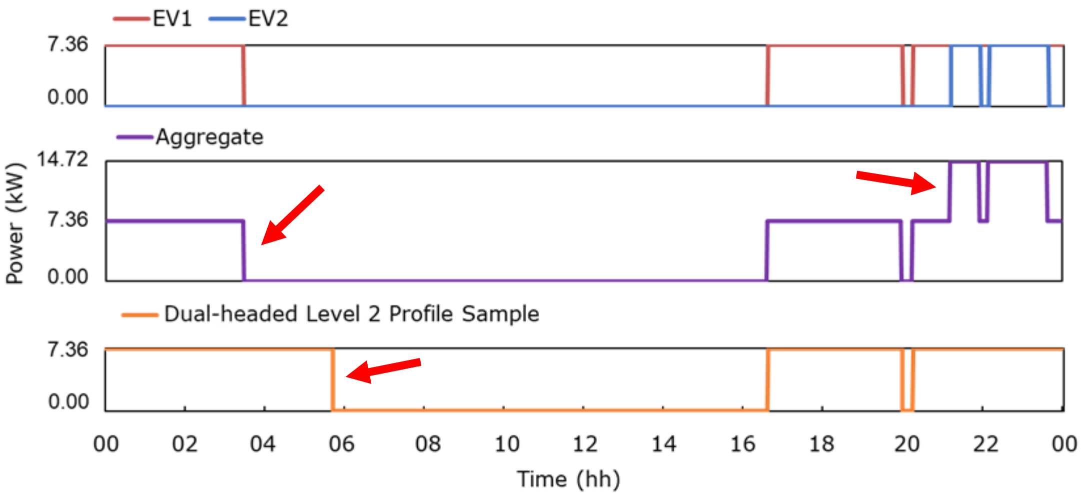


Diversified EV Profiles (avg of 1,200)

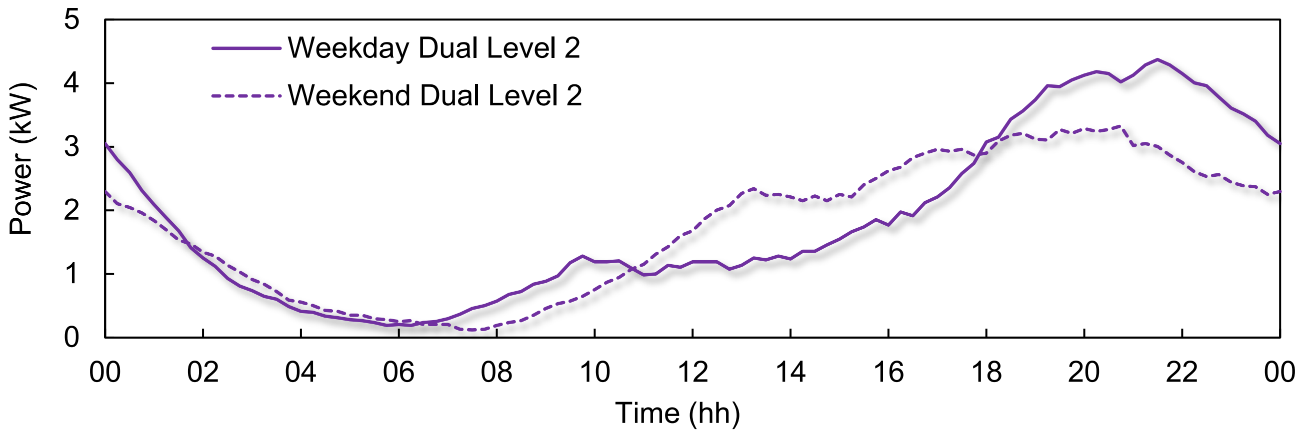
EV Modelling and Considerations
EV Profiles for Multiple EVs per House

Step 7) Create EV demand profiles considering limitations (of two Level 2 chargers)

- Special profiles for houses with dual-headed Level 2 charger (longer charging)
  - ➢ Half power (3.7kW) per EV with both charging, full Level 2 (7.4kW) with one



Two Level 2 profiles are overlapped and extended to capture the dual-headed charging behaviour



Diversified EV Profiles (dual-headed)

EV Modelling and Considerations
EVs Charging the Same Day

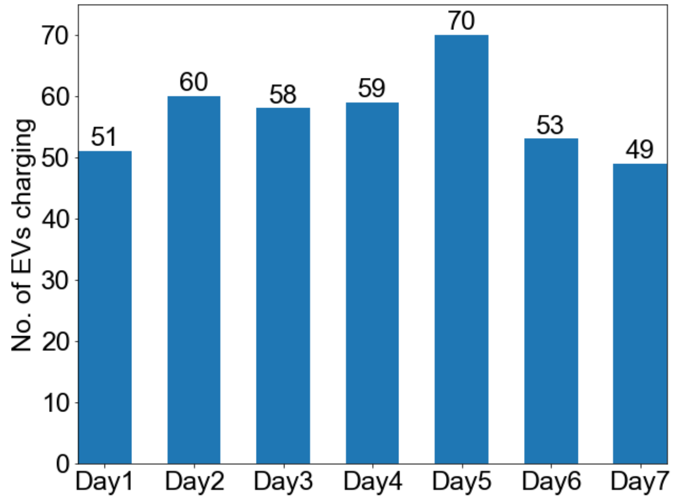
Step 8) Daily Charging Coincidence Factor

- As per the NSW Electric Vehicle Owners Survey[6], EVs are charged only 3-4 days of the week

- Assuming 4 days out of the 7 days, for a 99% probability, 70% or less of EVs will have a charging event on the same day (99.9% is 73%)

➢ **70% daily charging coincidence factor used**

Example week considering charging 4 days per week for 100 houses



[6] Ausgrid, "New South Wales Electric Vehicle Owners Survey - Summary Report", 2020

EV Modelling and Considerations
Power factor and EV Penetrations

Step 9) Consider a power factor

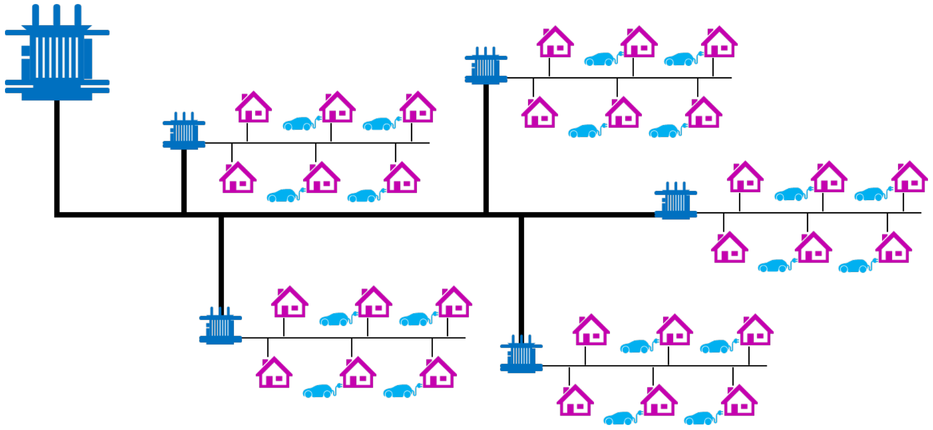
- Power factor of 0.99[7] (lagging/inductive) is used

Step 10) Consider EV penetrations

- EV penetration is defined in this project as the % of houses with a single EV
  - 100% EV penetration means all houses will have one EV
  - This is before second EVs are considered (i.e., beyond 100% EV penetration)
- Since eventually ~60% of houses will have two EVs (like regular cars[8]), the maximum EV penetration to be considered in this project is 160%
  - 160% EV penetration means every house has one EV and 60% have a second EV

[7] Idaho National Laboratory, "Advanced Vehicle Testing Activity" (https://avt.inl.gov)

[8] CSIRO, "Projections for small-scale embedded technologies" (https://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2020/CSIRO-DER-Forecast-Report)



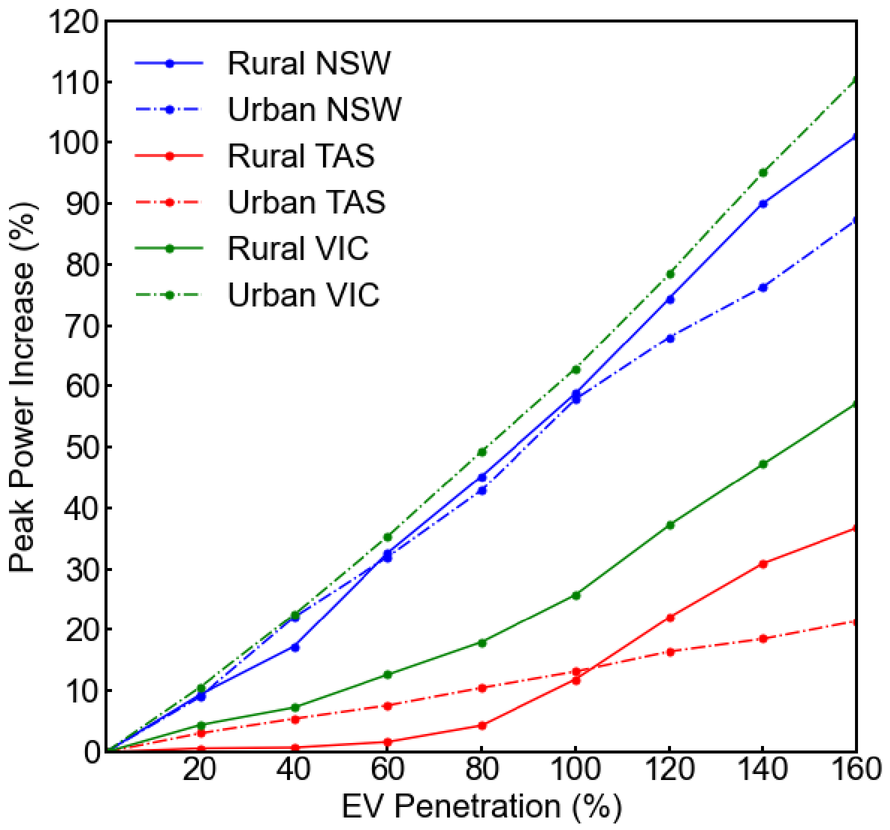
5 EV Impact Assessment on Urban and Rural Grids

EV Impact Assessment
Methodology (in a nutshell)

1. Set EV penetration rate from 0-160% (up to 100% only 1 EV per house)
2. Allocate (randomly) EVs to residential customers
3. Assign (randomly) peak-day demand profiles for residential customers
4. Assign (randomly) charger sizes
   - 80% Level 2 (7.36kW) and 20% Level 1 (3.68kW)
   - Only 70% of EVs will plug-in on the day
5. Assign (randomly) EV profiles
   - If a house is assigned two Level 2 chargers → Dual-headed EV profile instead
6. Run time-series power flows (24 hours, 1-min resolution)
7. Assess the network impacts (voltage issues, asset congestion)

EV Effects on Total Peak Demand

- Increase in peak apparent power from base case (no EVs)
  - Depends on # of residential customers and original time of the peak demand
  - Only residential charging
- For maximum EV penetration
  - NSW peak increases by 80-100%
  - TAS peak increases by 15-40%
  - VIC peak increases by 50-110%



EV uptake will affect also the zone substation and **upstream assets**/networks

EV Hosting Capacity Summary

⚖ = Minor breach of performance metric

Network	EV Hosting Capacity							
	20%	40%	60%	80%	100%	120%	140%	160%
Rural NSW	⚖	✗	✗	✗	✗	✗	✗	✗
Urban NSW	✓	✓	✓	✓	✗	✗	✗	✗
Rural TAS	✓	⚖	✗	✗	✗	✗	✗	✗
Urban TAS	⚖	✗	✗	✗	✗	✗	✗	✗
Rural VIC*	✗	✗	✗	✗	✗	✗	✗	✗
Urban VIC*	✗	✗	✗	✗	✗	✗	✗	✗

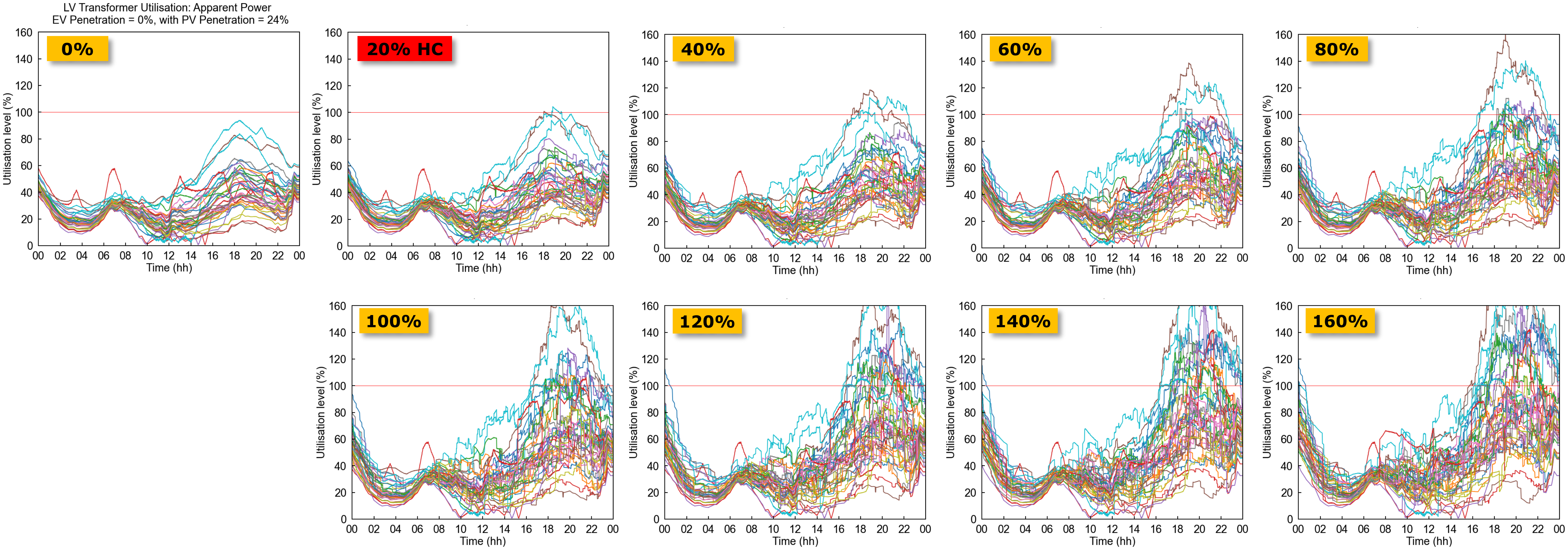
- Rural grids struggle to host even 20% of houses with one EV
- Urban grids have different capabilities depending on the State (different design ADMD)

* VIC voltage limits of +13% and -10%

EV Impact Assessment - Rural NSW (1/5)

LV Distribution Transformers

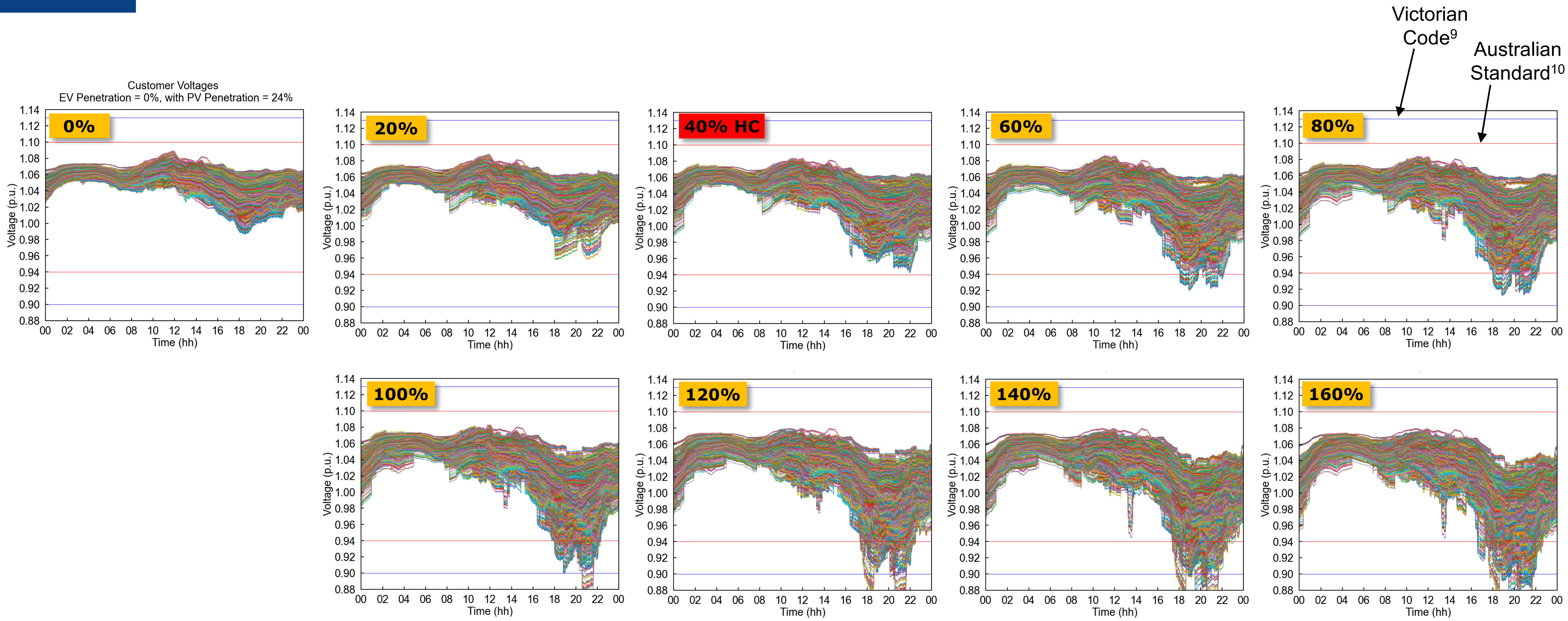
Avg Res Peak	2.0 kW
LV ADMD	6.5 kW
Res Data	VIC Smart Meter
PV Pen/Size	24%/3.8kW



Significant transformer problems at 40% → Hosting Capacity: **20%**

EV Impact Assessment - Rural NSW (2/5)

Residential Customer Voltages

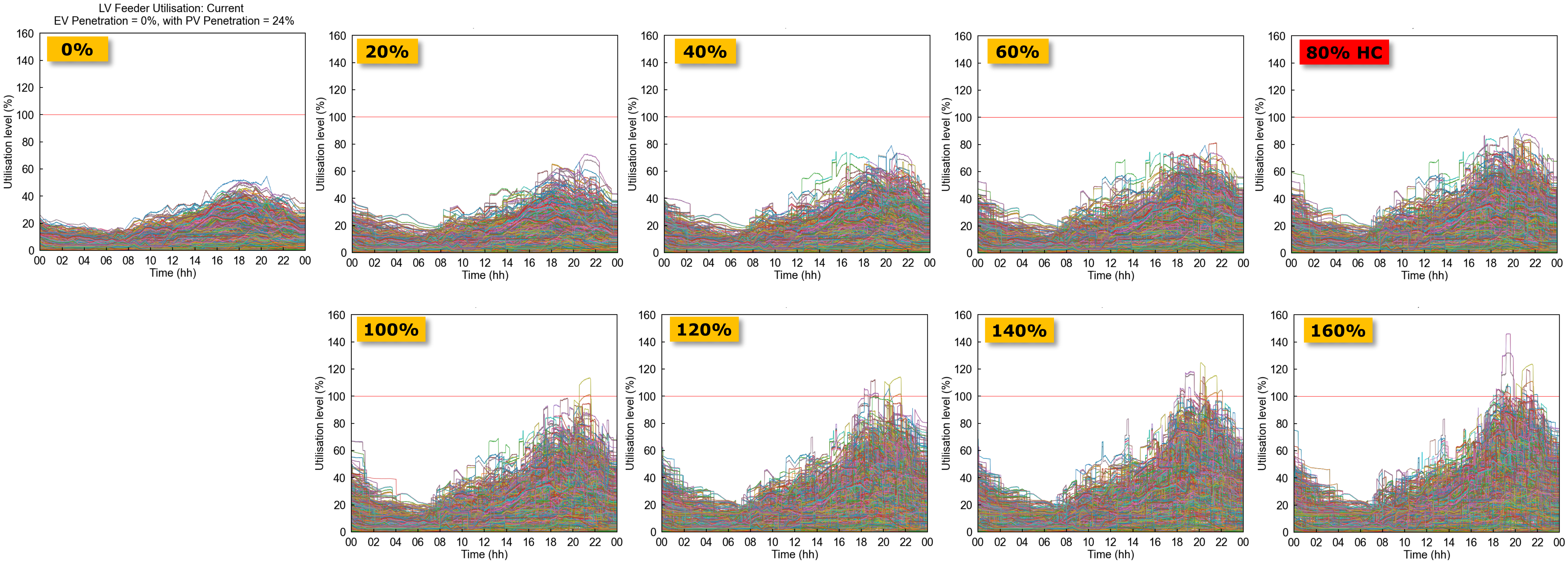


Voltages issues at 60%, so transformers are bottleneck → Hosting capacity: **20%**

[9] VIC ESC, "Electricity Distribution Code" v13 2021 ; [10] AS 61000.3.100

EV Impact Assessment - Rural NSW (3/5)

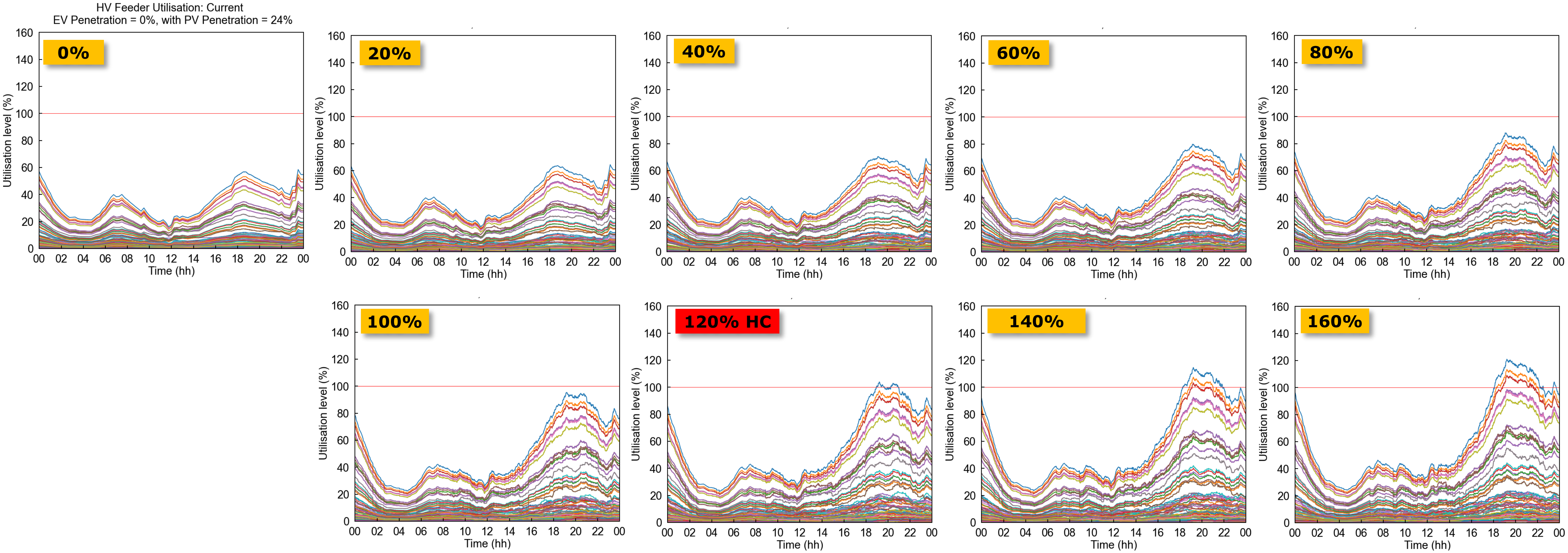
LV Conductors



LV conductor issues at 100%, so transformers are bottleneck → Hosting capacity: **20%**

EV Impact Assessment - Rural NSW (4/5)

HV Conductors

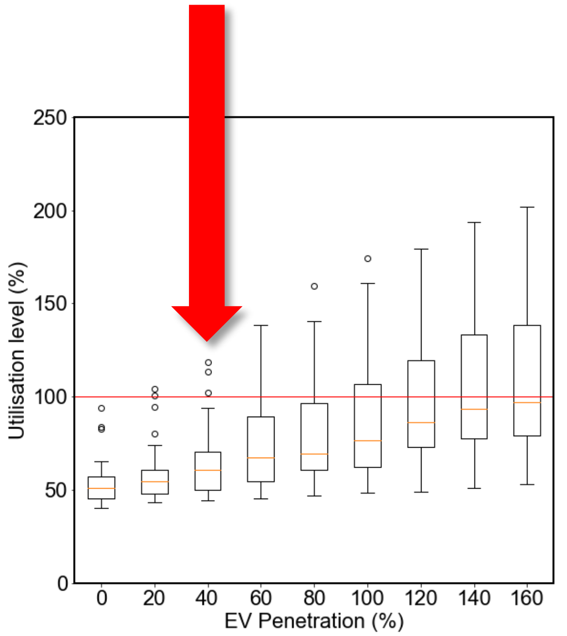


HV conductor issues at 140%, so transformers are bottleneck → Hosting capacity: 20%

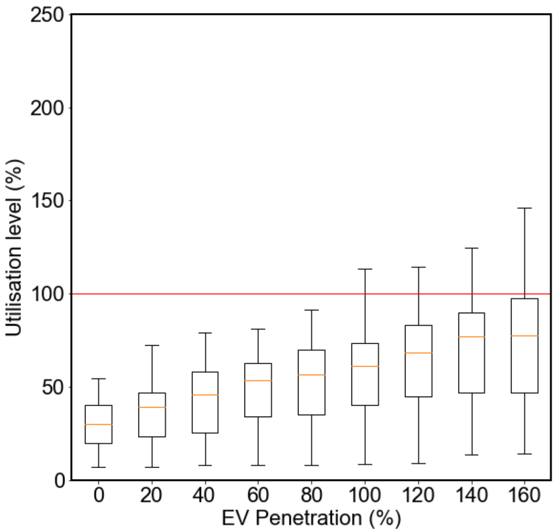
EV Impact Assessment - Rural NSW (5/5)

Summary

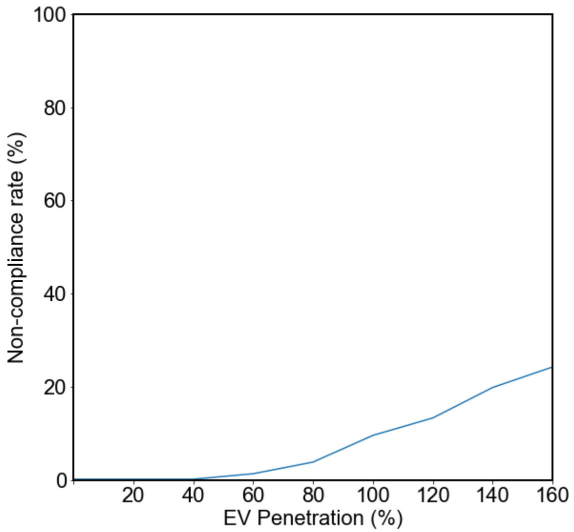
Avg Res Peak	2.0 kW
LV ADMD	6.5 kW
Res Data	VIC Smart Meter
PV Pen/Size	24%/3.8kW



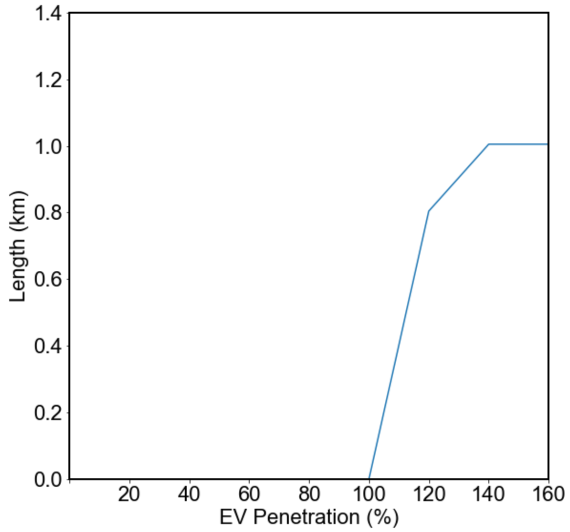
LV Distribution Transformer
Max. Utilisation



LV Conductors
Max. Utilisation



Customer
Non-compliance Rate



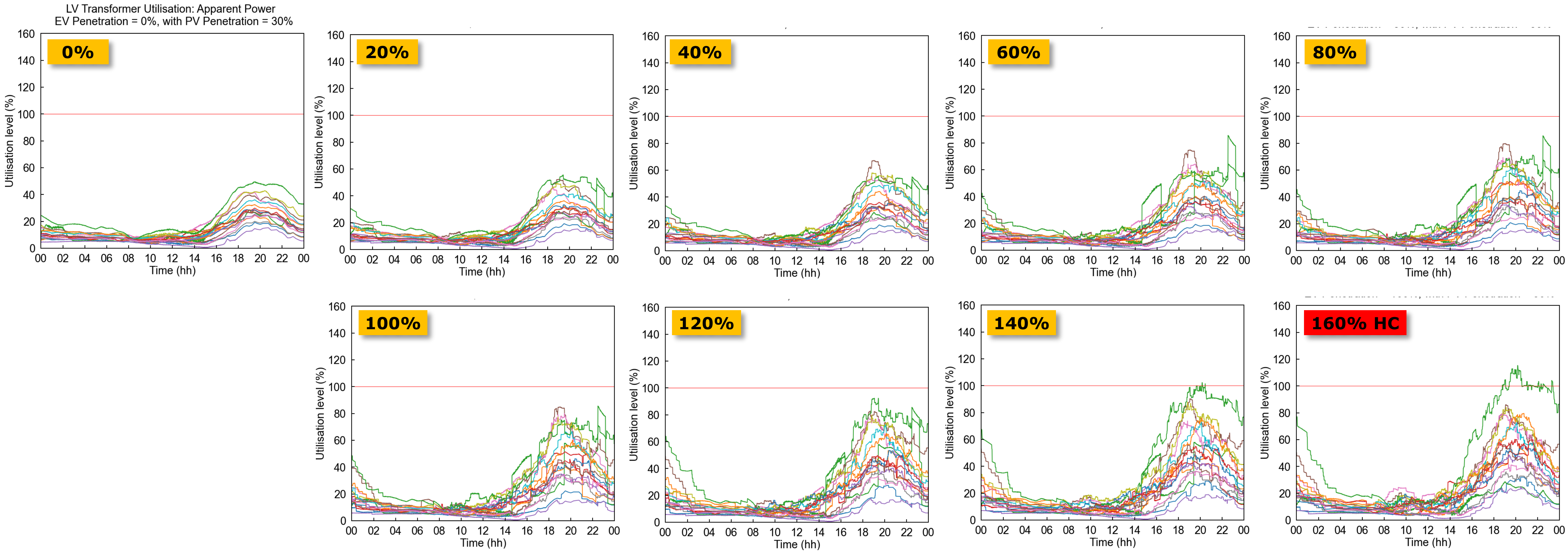
HV Feeder
Length of Congestion

LV distribution transformers are the bottleneck → **Final** Hosting capacity: **20% EV penetration**

EV Impact Assessment - Urban NSW (1/5)

LV Distribution Transformers

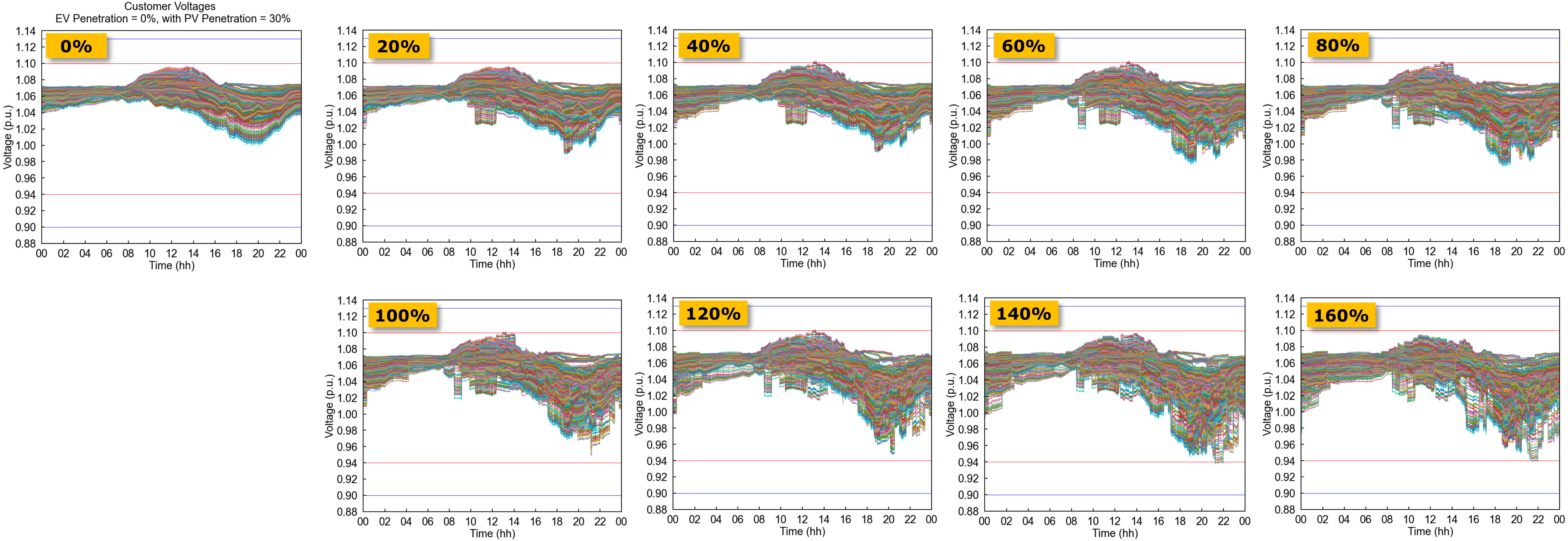
Avg Res Peak	2.0 kW
LV ADMD	6.5 kW
Res Data	VIC Smart Meter
PV Pen/Size	24%/3.8kW



Only 1 transformer with problems at 160% → Hosting Capacity: **160%**

EV Impact Assessment - Urban NSW (2/5)

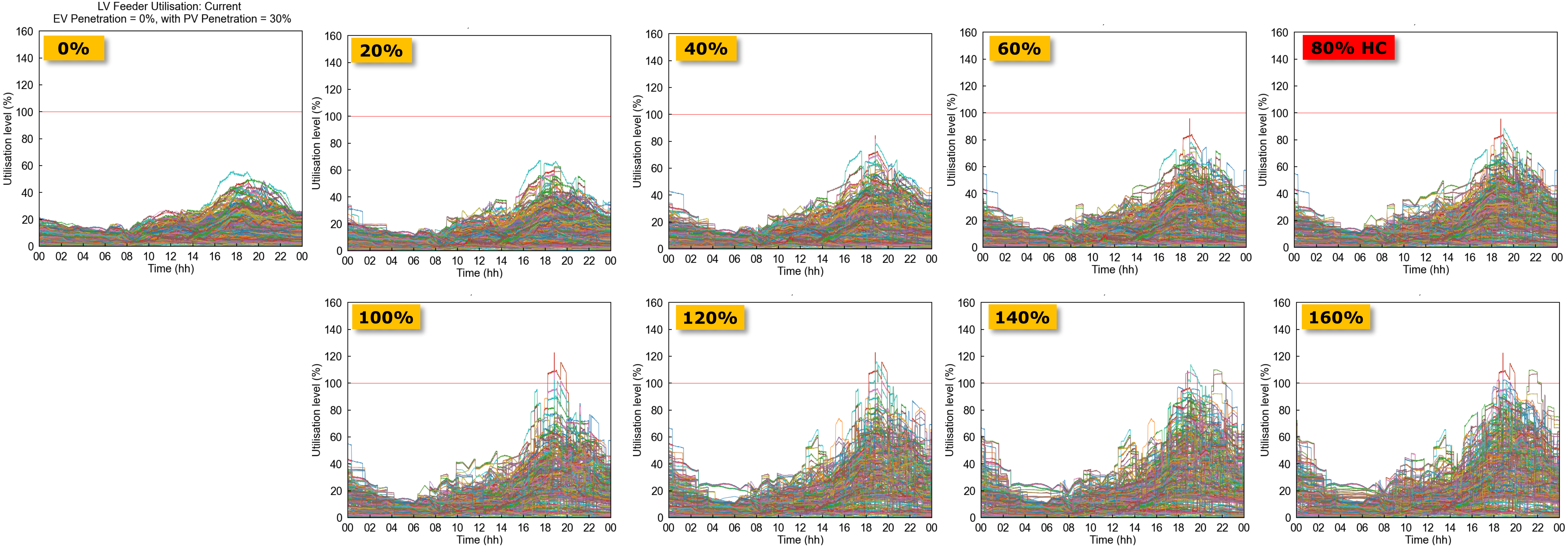
Residential Customer Voltages



No voltages issues at 160% and no other bottleneck → Hosting capacity: **160%**

EV Impact Assessment - Urban NSW (3/5)

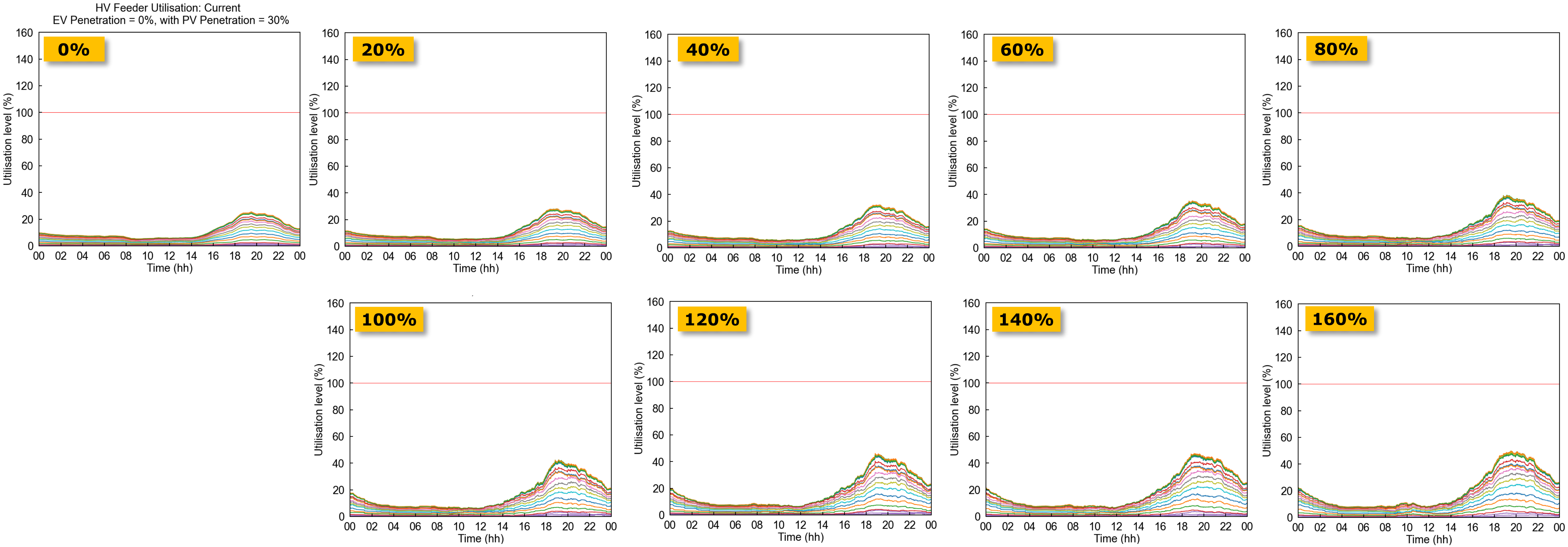
LV Conductors



LV conductor issues at 100% → Hosting capacity: **80%**

EV Impact Assessment - Urban NSW (4/5)

HV Conductors

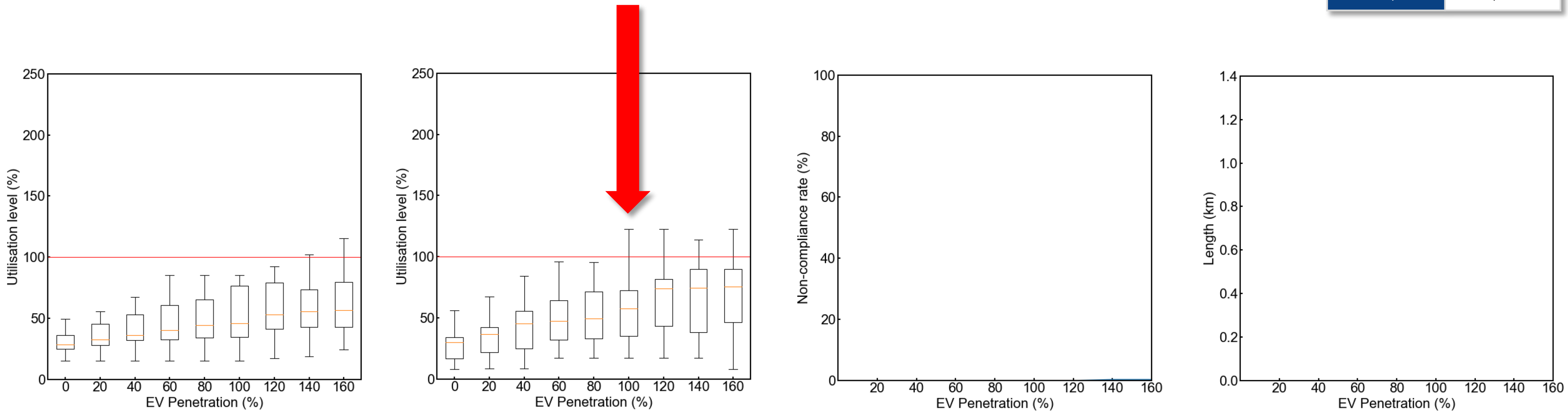


No HV conductor issues, so LV conductors are bottleneck → Hosting capacity: **80%**

EV Impact Assessment - Urban NSW (5/5)

Summary

Avg Res Peak	2.0 kW
LV ADMD	6.5 kW
Res Data	VIC Smart Meter
PV Pen/Size	30%/5.9kW



LV Distribution Transformer Max. Utilisation

LV Conductors Max. Utilisation

Customer Non-compliance Rate

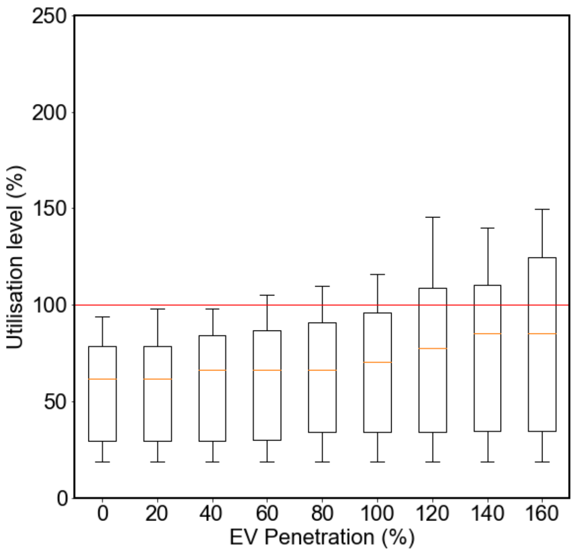
HV Feeder Length of Congestion

LV conductors are <u>the</u> bottleneck → **Final** Hosting capacity: **80% EV penetration**

EV Impact Assessment – Rural TAS

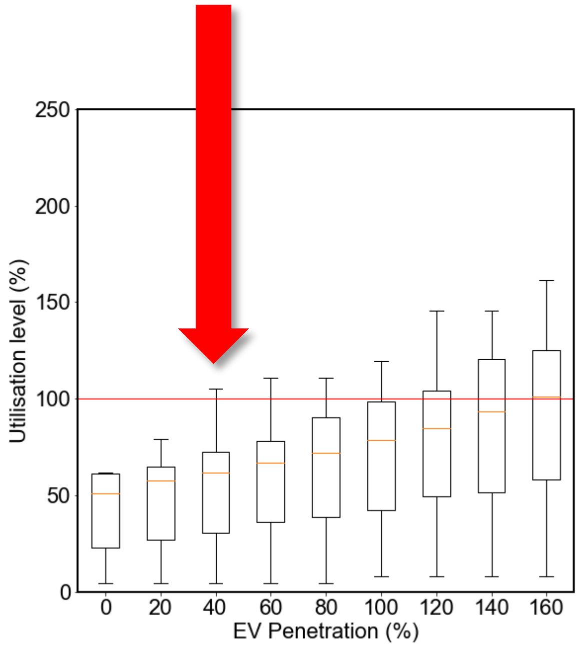
Summary

Avg Res Peak	3.0 kW
LV ADMD	5.0 kW
Res Data	TAS Avg Residential
PV Pen	0%



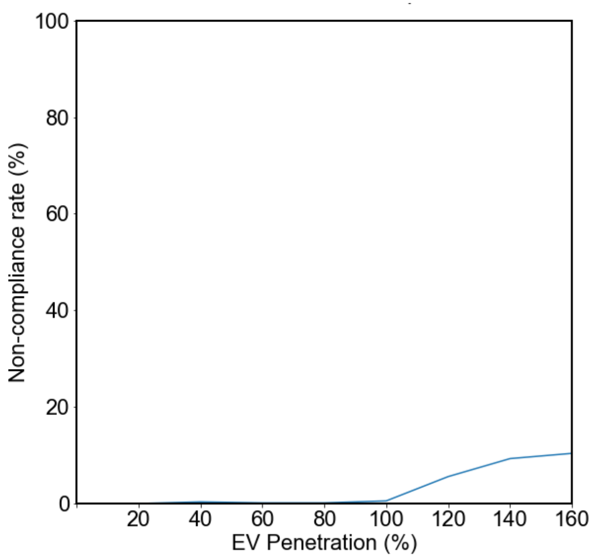
LV Distribution Transformer

Max. Utilisation



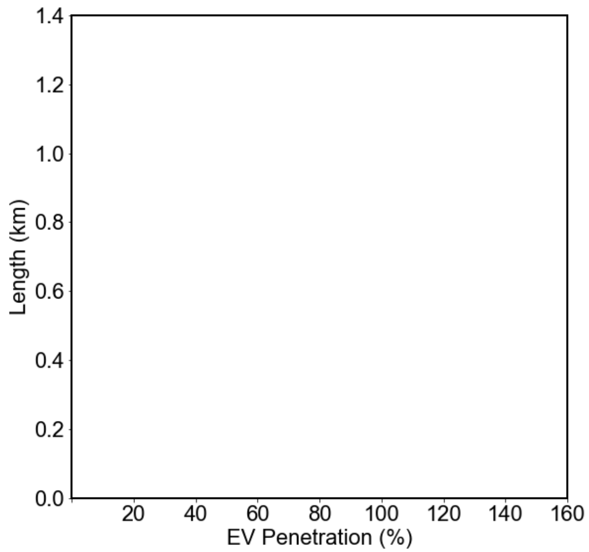
LV Conductors

Max. Utilisation



Customer

Non-compliance Rate



HV Feeder

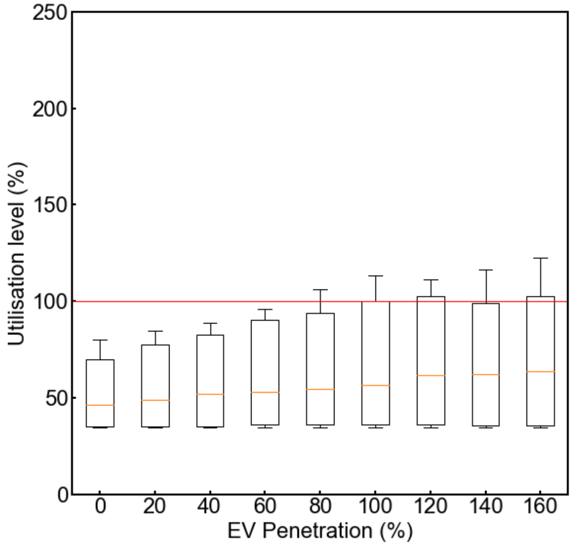
Length of Congestion

LV conductors are the bottleneck → **Final** Hosting capacity: **20% EV penetration**

EV Impact Assessment – Urban TAS

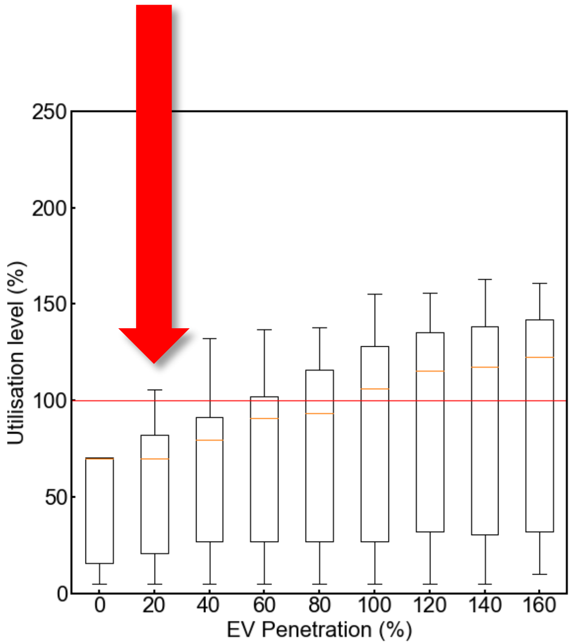
Summary

Avg Res Peak	3.5 kW
LV ADMD	5.0 kW
Res Data	TAS Avg Residential
PV Pen	0%



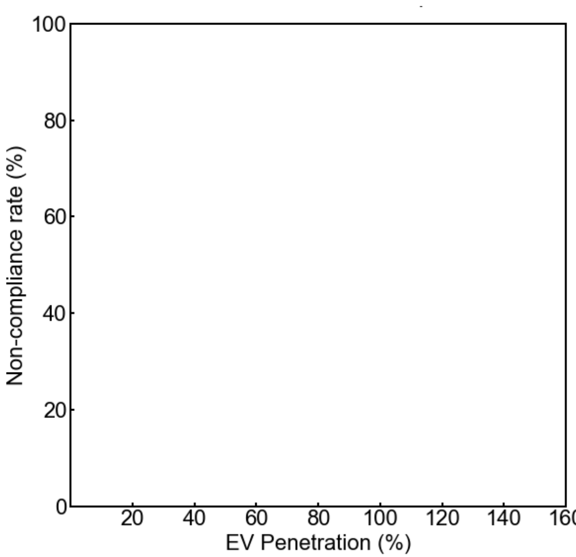
LV Distribution Transformer

Max. Utilisation



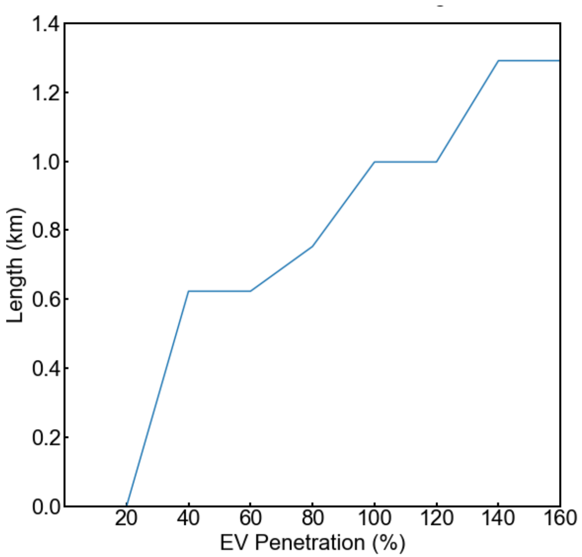
LV Conductors

Max. Utilisation



Customer

Non-compliance Rate



HV Feeder

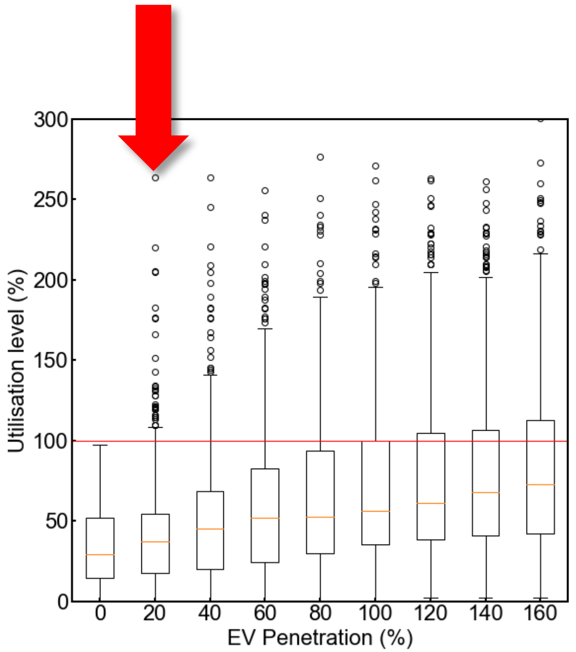
Length of Congestion

LV conductors are <u>the</u> bottleneck → **Final** Hosting capacity: <**20% EV penetration**

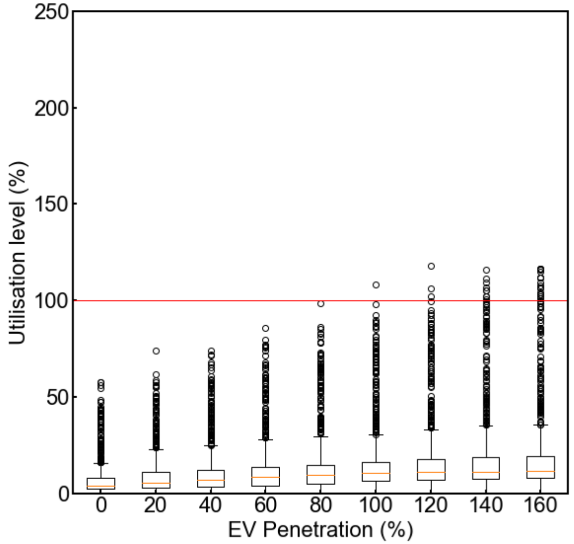
EV Impact Assessment – Rural VIC

Summary

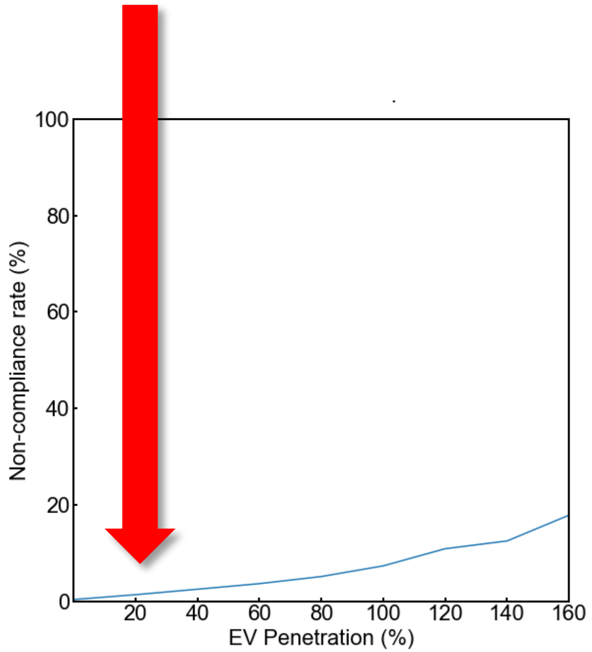
Avg Res Peak	2.0 kW
LV ADMD	4.0 kW
Res Data	VIC Smart Meter
PV Pen	0%



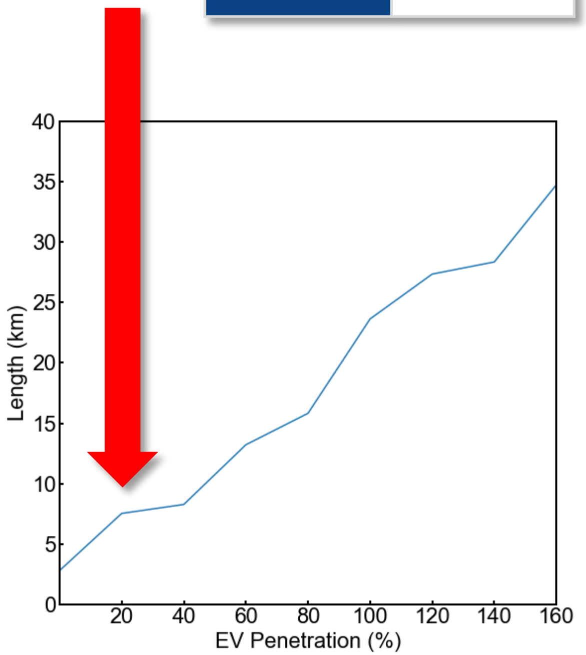
LV Distribution Transformer
Max. Utilisation



LV Conductors
Max. Utilisation



Customer
Non-compliance Rate



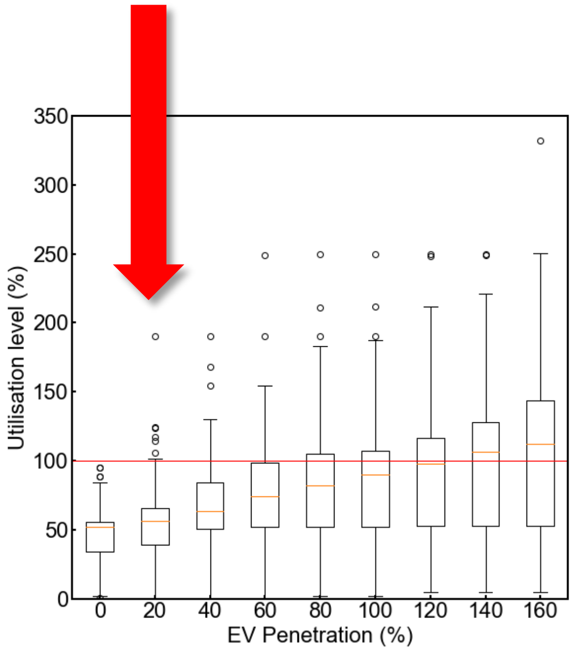
HV Feeder
Length of Congestion

Multiple bottlenecks → **Final** Hosting capacity: <**20% EV penetration**

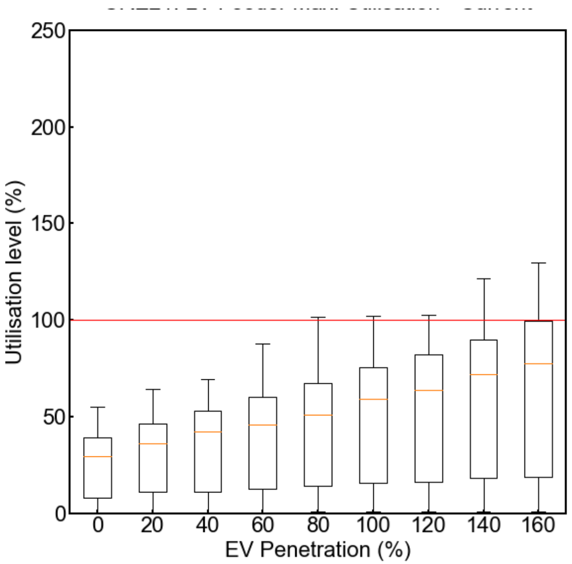
EV Impact Assessment – Urban VIC

Summary

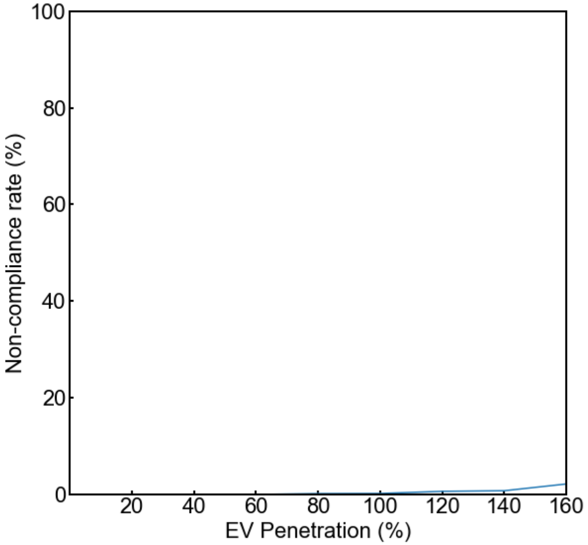
Avg Res Peak	2.0 kW
LV ADMD	4.0 kW
Res Data	VIC Smart Meter
PV Pen	0%



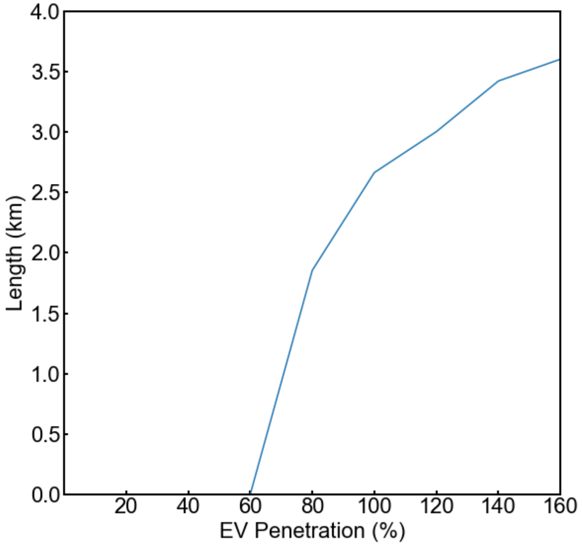
LV Distribution Transformer
Max. Utilisation



LV Conductors
Max. Utilisation



Customer
Non-compliance Rate



HV Feeder
Length of Congestion

LV transformers are <u>the</u> bottleneck → **Final** Hosting capacity: <**20% EV penetration**

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EV Hosting Capacity Summary

All within limit
Marginally exceeding limit
Significantly exceeding limit

Network	EV Hosting Capacity							
	20%	40%	60%	80%	100%	120%	140%	160%
Rural NSW	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond
Urban NSW	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond
Rural TAS	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond
Urban TAS	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond
Rural VIC*	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond
Urban VIC*	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond	V Cust LV TX LV Cond HV Cond

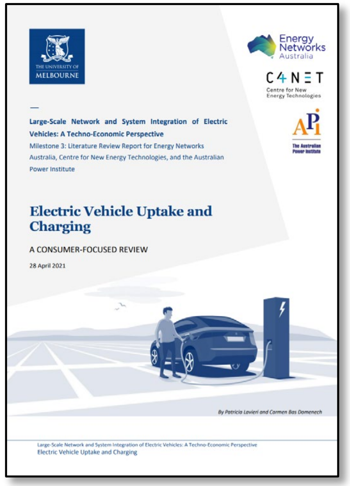
* VIC voltage limits of +13% and -10%

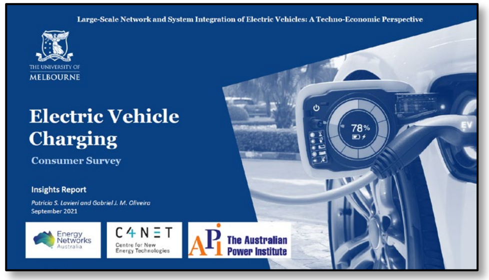
6 Key Remarks

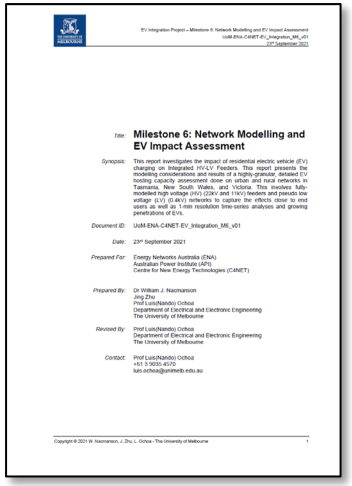
Key Remarks

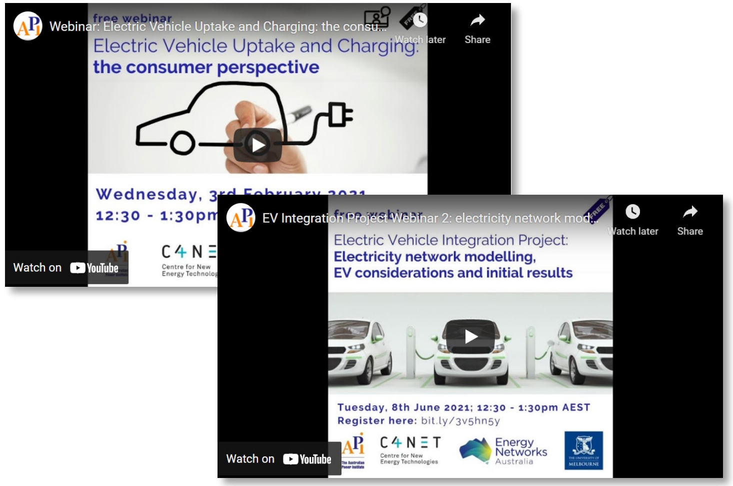
- **EV impacts** will vary depending on the **type of network** and **typical demand**
  - Areas with larger ADMD values (NSW, TAS) can handle higher EV penetrations
- **Rural grids** were found to have an **EV hosting capacity from 0 to 40%**
  - LV transformer issues can appear with as little as 20% EV penetration for Rural VIC and become wider at 40% for Rural NSW and TAS, including significant customer voltage drops and LV conductor issues
- **Urban grids** were found to have an **EV hosting capacity from 0 to 80%**
  - First limiting factors involve LV conductors, HV conductors, and LV transformers
- **Asset congestion is the predominant limiting factor**. But larger voltage drops can also become an issue
  - Mitigation of voltage rise issues due to solar PV can exacerbate voltage drop issues due to EVs

Project Reports and Webinars









- [UoM Project Website]
- [C4NET Project Website]

✓ Milestone 3: Electric Vehicle Uptake and Charging: A Consumer-Focused Review

✓ Milestone 3: Electric Vehicle Charging: Consumer Survey

✓ Milestone 6: Network Modelling and EV Impact Assessment

Further Reading 1/2

How Electric Vehicles and the Grid Work Together

Lessons Learned from One of the Largest Electric Vehicle Trials in the World

By Jairo Quirós-Tortós, Luis (Nando) Ochoa, and Timothy Butler

IN THE COMING YEARS, HUNDREDS OF THOUSANDS of new electric vehicles (EVs), from plug-in hybrids to fully electric, will hit the roads around the world, adding to the current EV fleet of more than 2 million, according to the Global EV Outlook 2017. The electrification of transportation can bring environmental, health, and economic benefits when coupled with a low-carbon electricity generation portfolio; however, ensuring that this transition goes smoothly requires addressing several grid-integration challenges.

To understand the challenges and opportunities that come with the widespread adoption of EVs, particularly passenger light-duty vehicles, many distribution network operators (DNOs) and stakeholders in various countries have carried out EV trials. One of the largest EV trials in the world was My Electric Avenue (MEA) (www.myelectricavenue.info) in the United Kingdom. Led by EA Technology, the trial ran from January 2013 to December 2015 and was subsidized by the Low Carbon Networks Fund along with partners from industry, DNOs, and academia. The MEA project deployed more than 200 Nissan LEAFs to customers in the United Kingdom to study the driving and charging habits of a geographically and socioeconomically diverse population. This industrial project also investigated the technical effects of EVs on European-style low-voltage networks and trialed the direct control of EV charging points to increase hosting capacity.

In this article, we provide details about the MEA trials, including the main infrastructure adopted. Based on the data analysis and network studies carried out, we present key findings in terms of 1) the charging habits of EV users, 2) the impact of EVs on low-voltage networks, and 3) the effectiveness of the proposed strategy to increase hosting capacity. Using what was learned from this large-scale project, we then show the additional results that aid in understanding the extent to which EVs could provide services to the electric grid. Finally, we summarize the key lessons learned from MEA.

The My Electric Avenue Project

The MEA project deployed more than 200 Nissan LEAFs with a battery size of 24 kWh across the United Kingdom (Figure 1), making it one of the largest (if not the largest) EV trials in the world to date that examines the challenges and benefits arising from the use of this technology at

to mitigate the impacts that EVs may pose on European-style low-voltage networks (i.e., multiple low-voltage feeders connected to the same distribution transformer supplying dozens or hundreds of customers). To achieve this, the project performed EV data analysis, modeling, impacts, and management studies. MEA was the first project to focus on how to best manage the local electricity network when a large number of EVs charge on the same street at the same time.

Digital Object Identifier 10.1109/MPE.2018.2863060
Date of publication: 18 October 2018

IEEE PES Magazine Nov/Dec 2018

Further Reading 2/2

- My Electric Avenue Project
  - Research Gate Website
  - EA Technology Summary Report and Data
- Electric Nation Project
  - Project Website and Data
- Relevant Publications

Multi-Year Planning of LV Networks with EVs Accounting for Customers, Emissions and Techno-Economics Aspects: A Practical and Scalable Approach, IET GTD, 2021 (DOI, ResearchGate)

Regional-Scale Allocation of Fast Charging Stations: Travel Times and Distribution System Reinforcements, IET GTD, 2020 (DOI, ResearchGate)

Advanced Control of OLTC-Enabled LV Networks with PV Systems and Electric Vehicles, IET GTD, 2019 (DOI, ResearchGate)

Control of EV Charging Points for Thermal and Voltage Management of LV Networks, IEEE Trans. on Power Systems, 2016 (DOI, ResearchGate)

Thanks!

Questions?

luis.ochoa@unimelb.edu.au
william.nacmanson@unimelb.edu.au

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