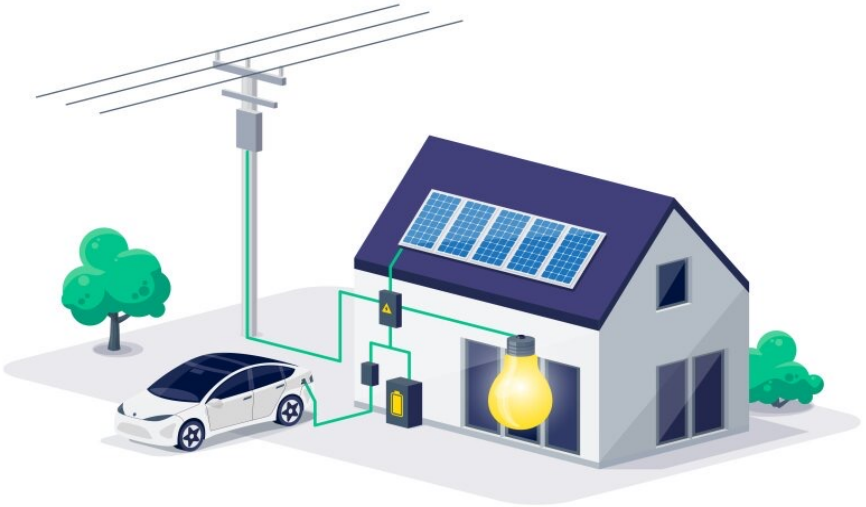
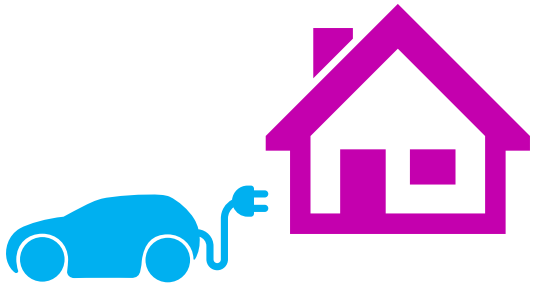
Making EVs and the grid work together: new challenges and opportunities

Presenter: **Jing Zhu**, *The University of Melbourne*

Outline

1. Context: EVs and the Grid
2. Challenges on Distribution Networks
3. EV Management & Customer Impacts
4. V2G Opportunities
5. Key Remarks

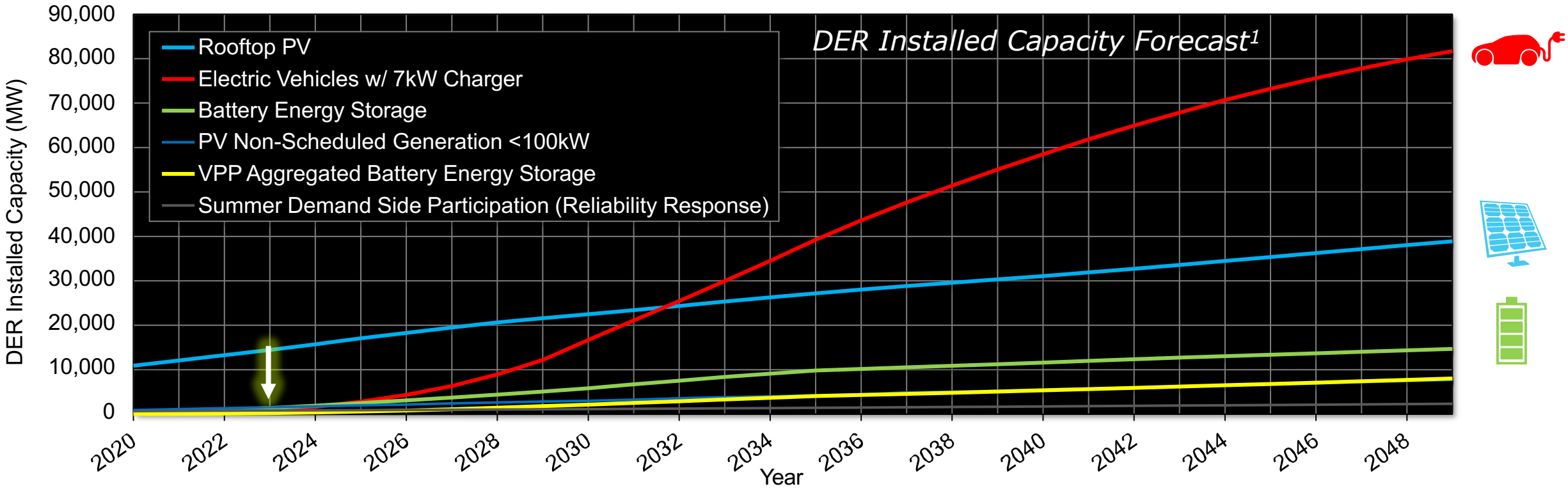




1 Context: EVs and the Grid

1 Context: EVs and the Grid

What is the future for EVs ?



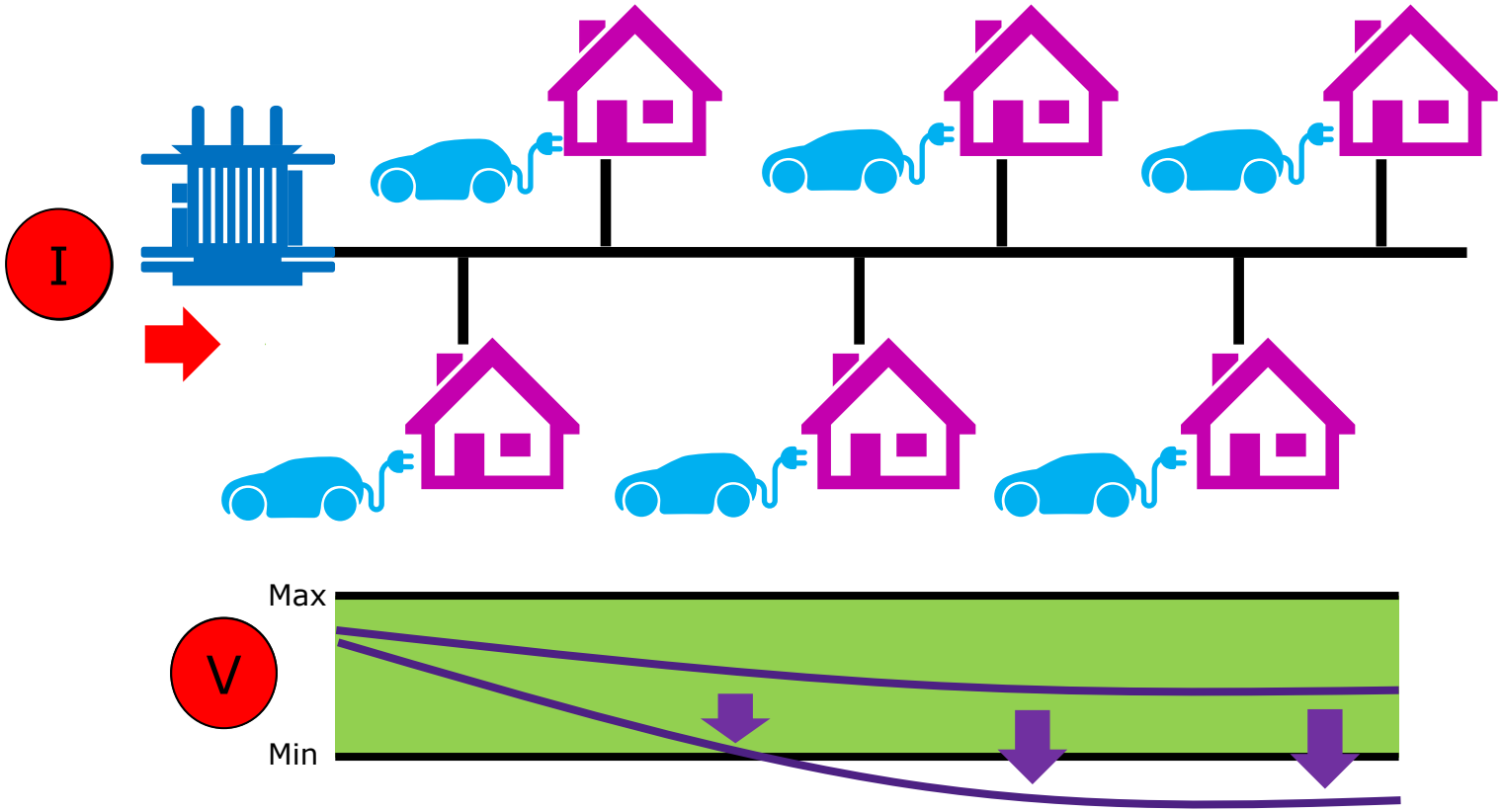
1 in 5 houses in Victoria will have one EV by 2030 [2]

Quickly, EVs will be a huge DER technology.

[1] Integrated System Plan (ISP), AEMO, 2022
[2] CER projections by 2031, AusNet, 2023

1 Context: EVs and the Grid

What will happen if everyone has a EV?



IEC 61851-1 Single-phase 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 demand, New challenges!**

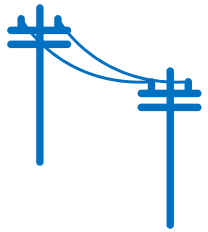
1 Context: EVs and the Grid

Any solution for new challenges?

- *With existing assets*
  - **Better settings** for existing voltage regulation devices (e.g., LV Off-LTCs, HV OLTCs)

V✓ I✗ $$$

- *With new assets*
  - **Reinforcements** (transformer, conductors)

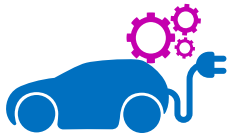


V? I✓ $$$

  - **New voltage regulation devices** (e.g., HV/LV OLTCs)

V✓ I✗ $$$

  - **EV management** (direct/indirect)



V✓ I✓ $$$

So, the management of EVs might be a good option ☺
But to what extent? And what about EV users?

1 Context: EVs and the Grid

New opportunities: Vehicle-to-Grid (V2G)

EVs are just batteries with wheels…

System Operator

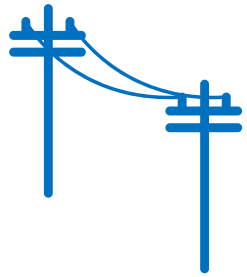
Transmission Company

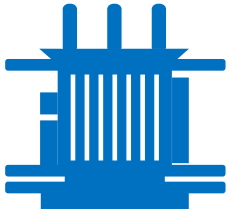
Distribution Company

Aggregators

Network Integrity?

With V2G technology, EVs can provide new *opportunities* to the grid ☺
But…to what extent?





2 Challenges on Distribution Networks

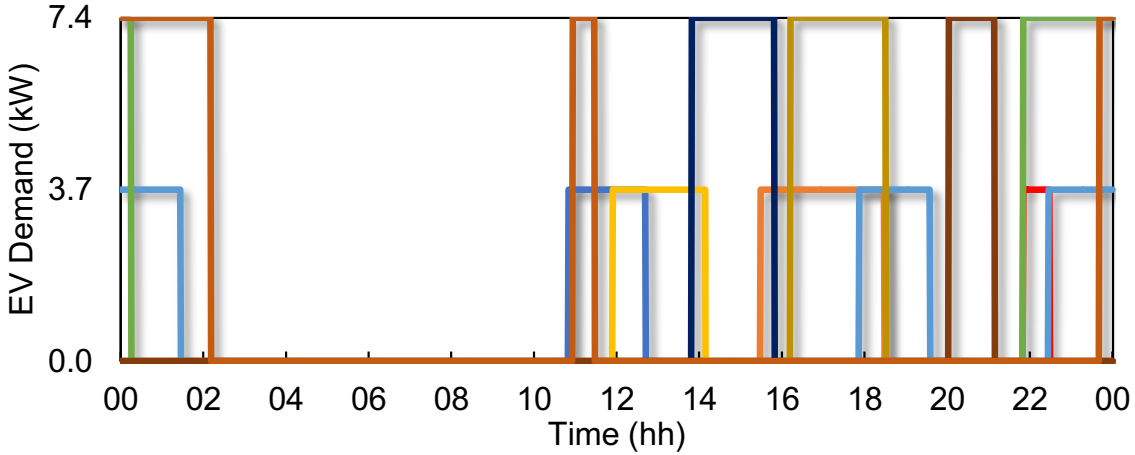
J. Zhu, W. J. Nacmanson and L. F. Ochoa, "*Producing realistic EV demand profiles for distribution network studies*," CIRED Porto Workshop 2022, 2022, pp. 706-710 (DOI and ResearchGate)

J. Zhu, W. J. Nacmanson, L. F. Ochoa and B. Hellyer. "*Assessing the EV Hosting Capacity of Australian Urban and Rural MV-LV Networks*." Electric Power Systems Research 212 (2022): 108399. (DOI and Research Gate).

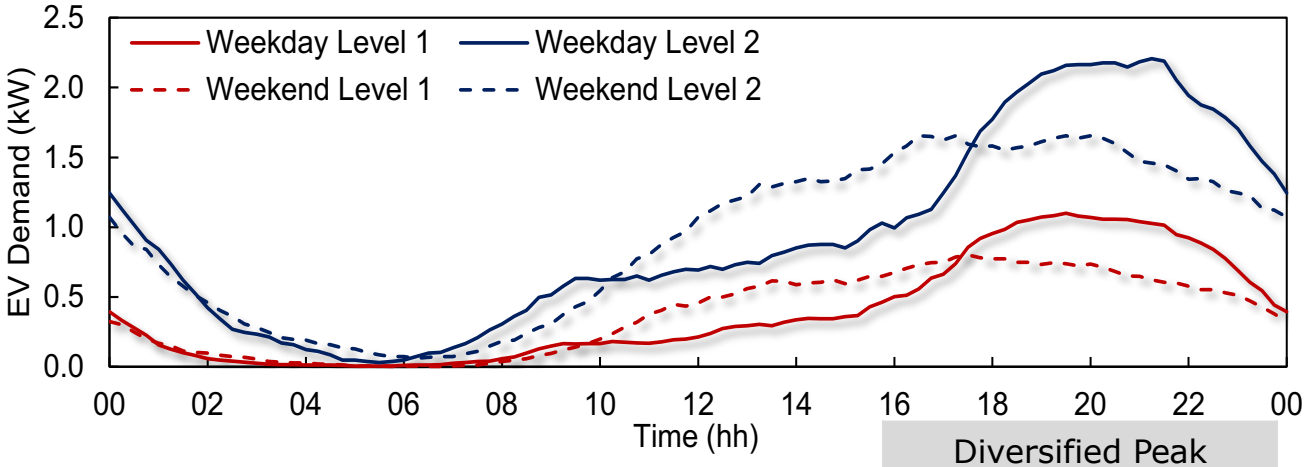
2 Challenges on Distribution Networks

EV Profiles – UK "Electric Nation"[3]

Individual EV Profiles



Diversified EV Profiles
(avg of 1,200)



Diversified Peak	
Level 1	~1 kW
Level 2	~2 kW

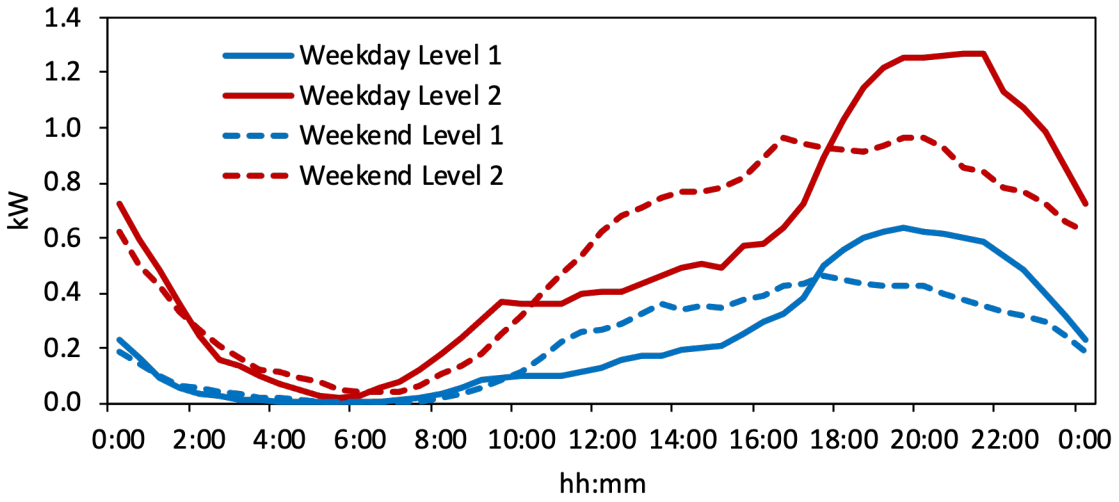
But EV charging behaviour is evolving. *Late charging* and *lower diversified peaks* are being reported in New Zealand (Vector[4]) and Australia (Ergon/Energex[5]).

[3] Smart Charging Project (2016-2019), Electric Nation. (https://electricnation.org.uk/resources/smart-charging-project/)
[4] EV Smart Charging Trial Webinar, Vector Limited. (https://www.youtube.com/watch?v=aqyB72BwnIc&t=2s)
[5] EV SmartCharge Queensland Insights Report, Ergon/Energex.

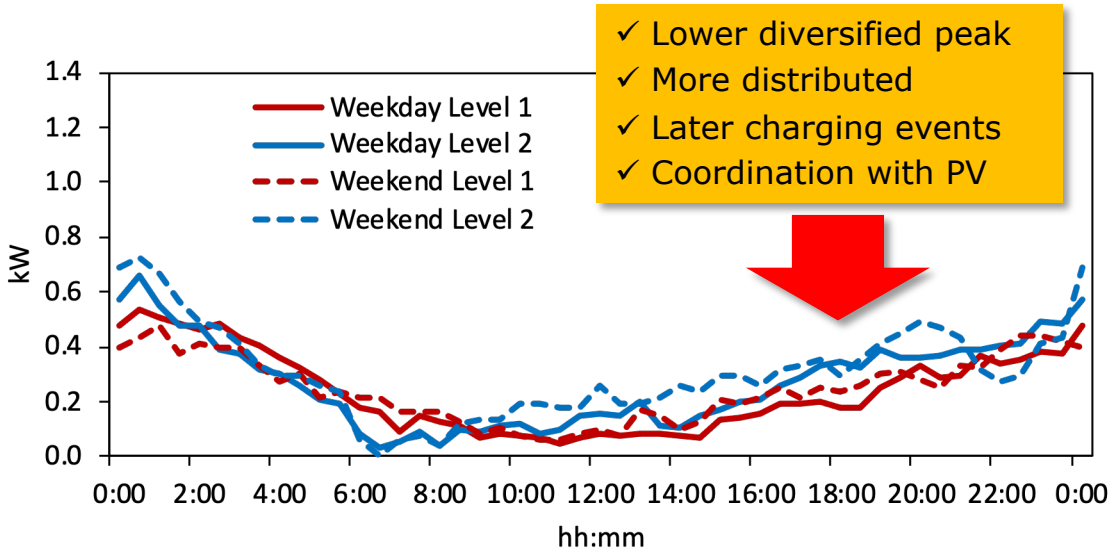
2 Challenges on Distribution Networks

EV Profiles – Evolving behaviours in AU[6]

UK Diversified EV Profiles [7]



Australian Diversified EV Profiles



Local data from normal EV users **matters**

Good news for Aussie distribution companies!

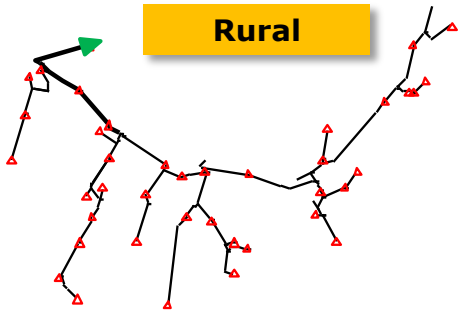
→ **Our networks can accommodate more EVs** ☺

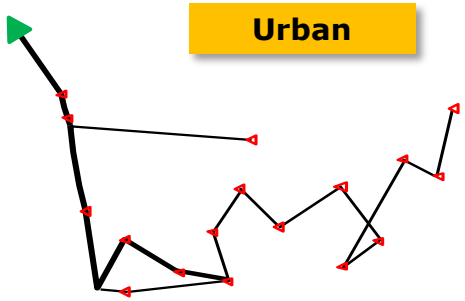
[6] Based on Victorian smart meter data 2021-2022

[7] UK diversified profile is considering an average demand using daily plug-in factor of 58%

2 Challenges on Distribution Networks

How many EVs can we have now?



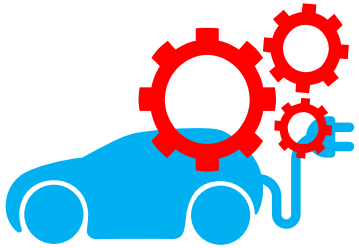


All within limit
Marginally exceeding limit
Significantly exceeding limit

HV-LV Network *(11/0.4 kV)*	EV Penetration							
	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

Asset congestion is the predominant limiting factor

EV impacts will vary depending on the type of network → **Require detailed assessment**



3 EV Management & Customer Impacts

J. Zhu, W. J. Nacmanson and L. F. Ochoa, "*Understanding the Effects of EV Management and TOU Tariffs on Customers and Distribution Networks*," CIRED 2023, Rome, Italy, 2023, pp. 2465-2469 (DOI and ResearchGate)

3 EV Management & Customer Impacts

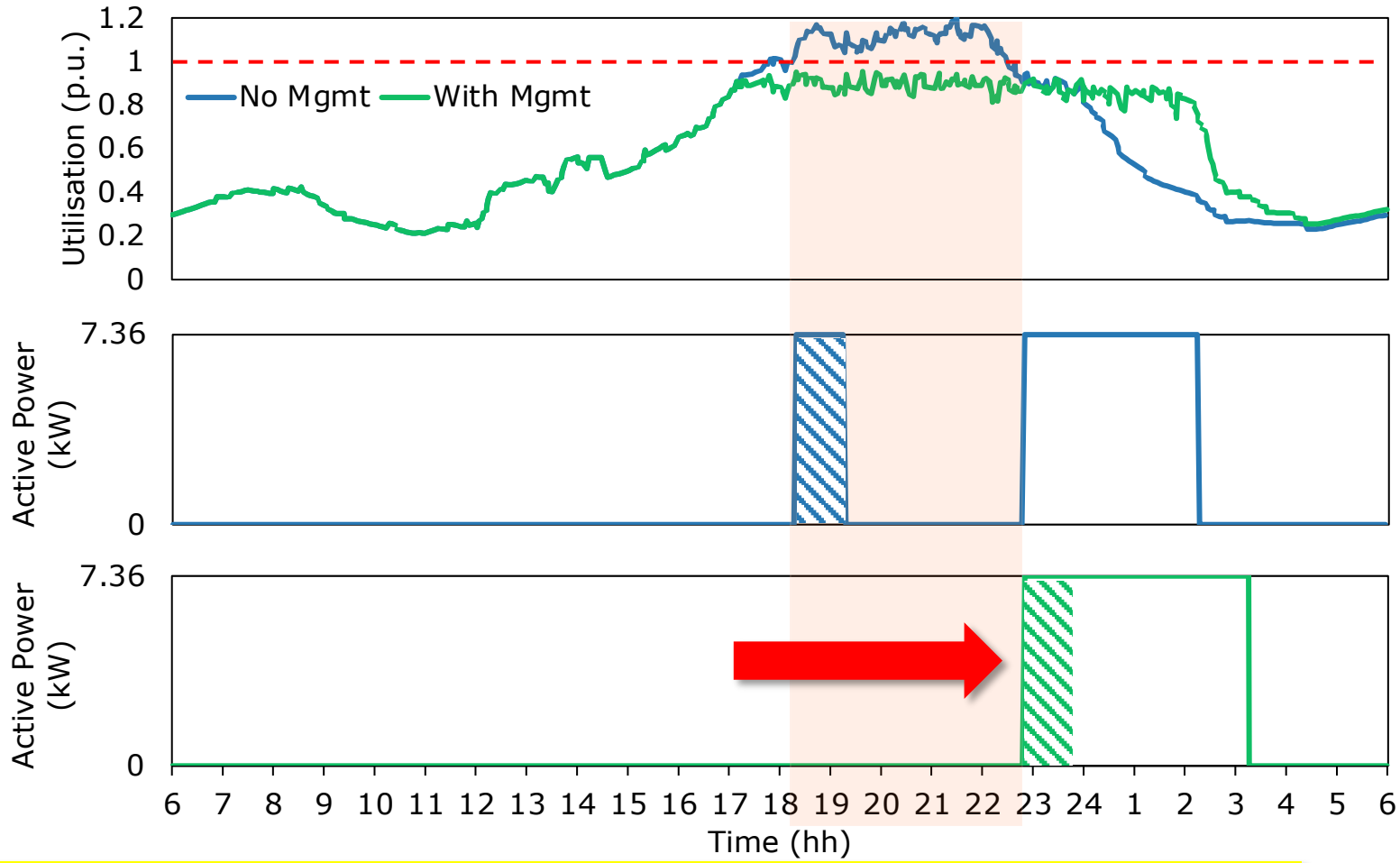
Direct EV Management: The Basics

Disconnect Reconnect

LV Transformer Utilisation

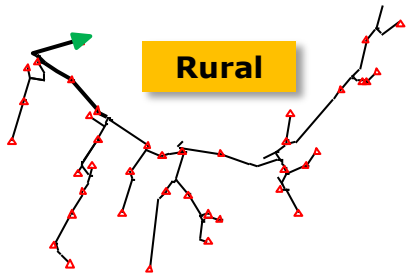
No EV Management

With EV Management



Direct EV Management → Longer charging duration

Effects on customers need to be captured

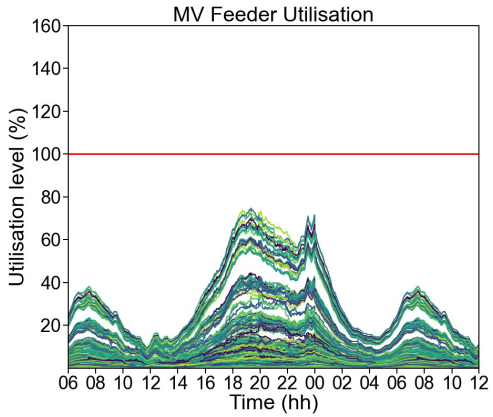


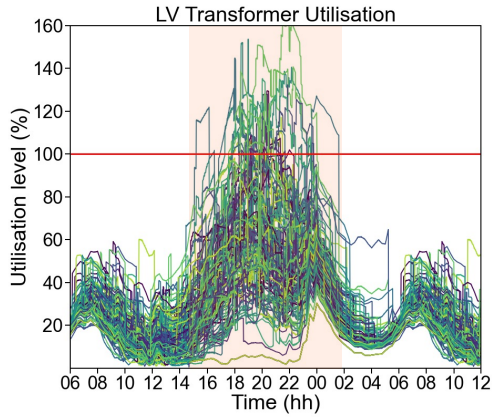
3 EV Management & Customer Impacts

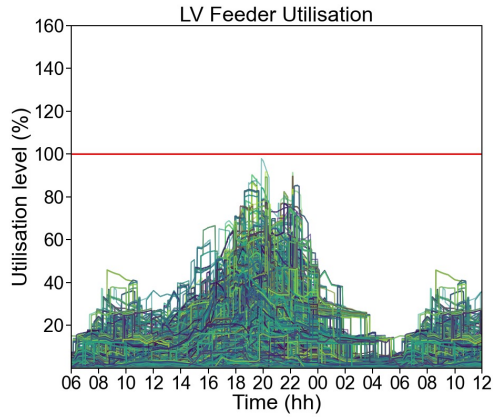
Direct EV Management: Technical Performance

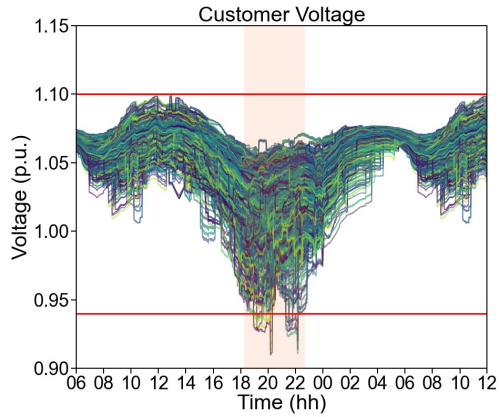
THE UNIVERSITY OF MELBOURNE

No EV Management

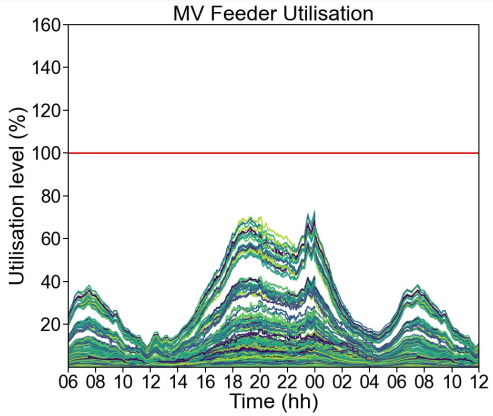


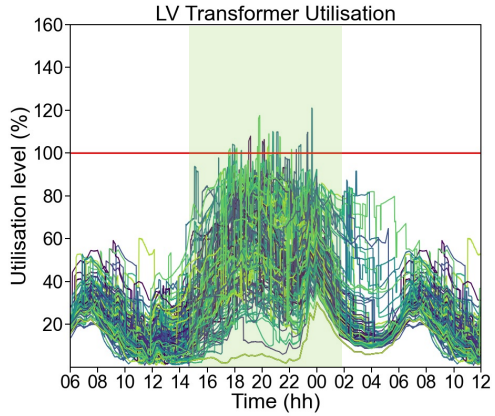


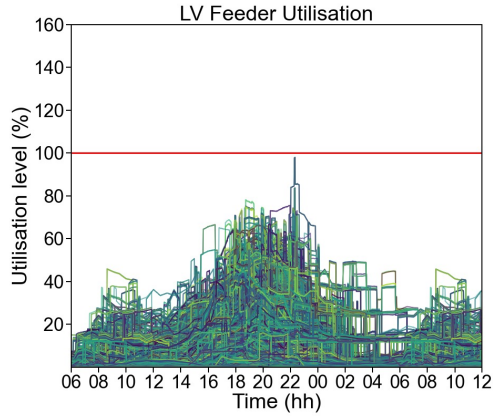


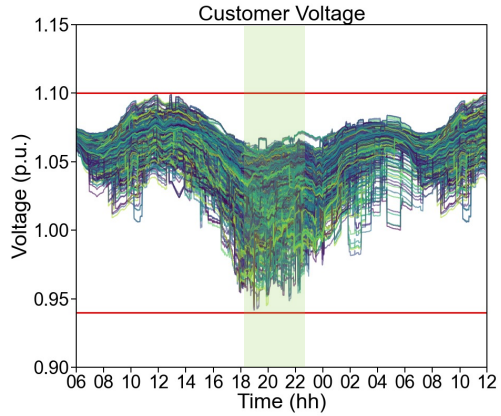


With EV Management





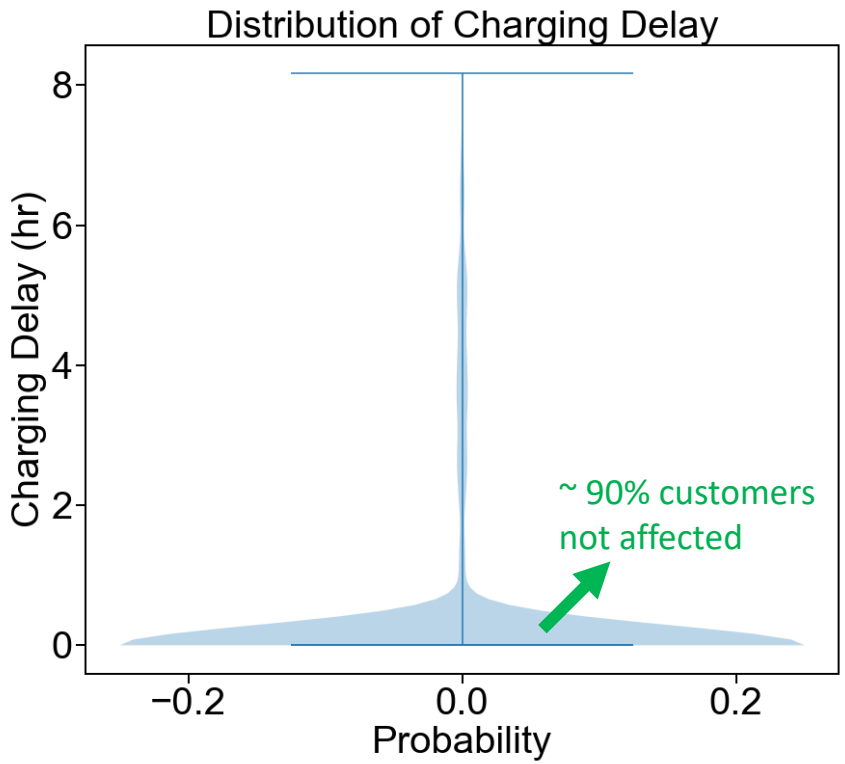


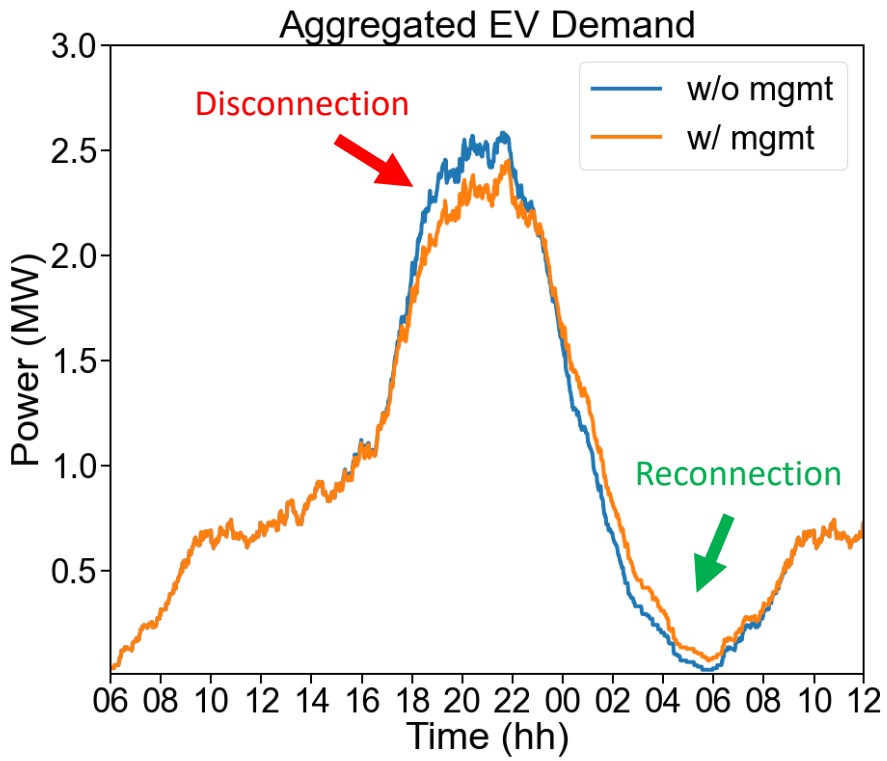


No more congestion or voltage issue ☺

3 EV Management & Customer Impacts

Direct EV Management: Customer Charging Delay





Most EV users are not affected
… and charging delays happens mostly at night

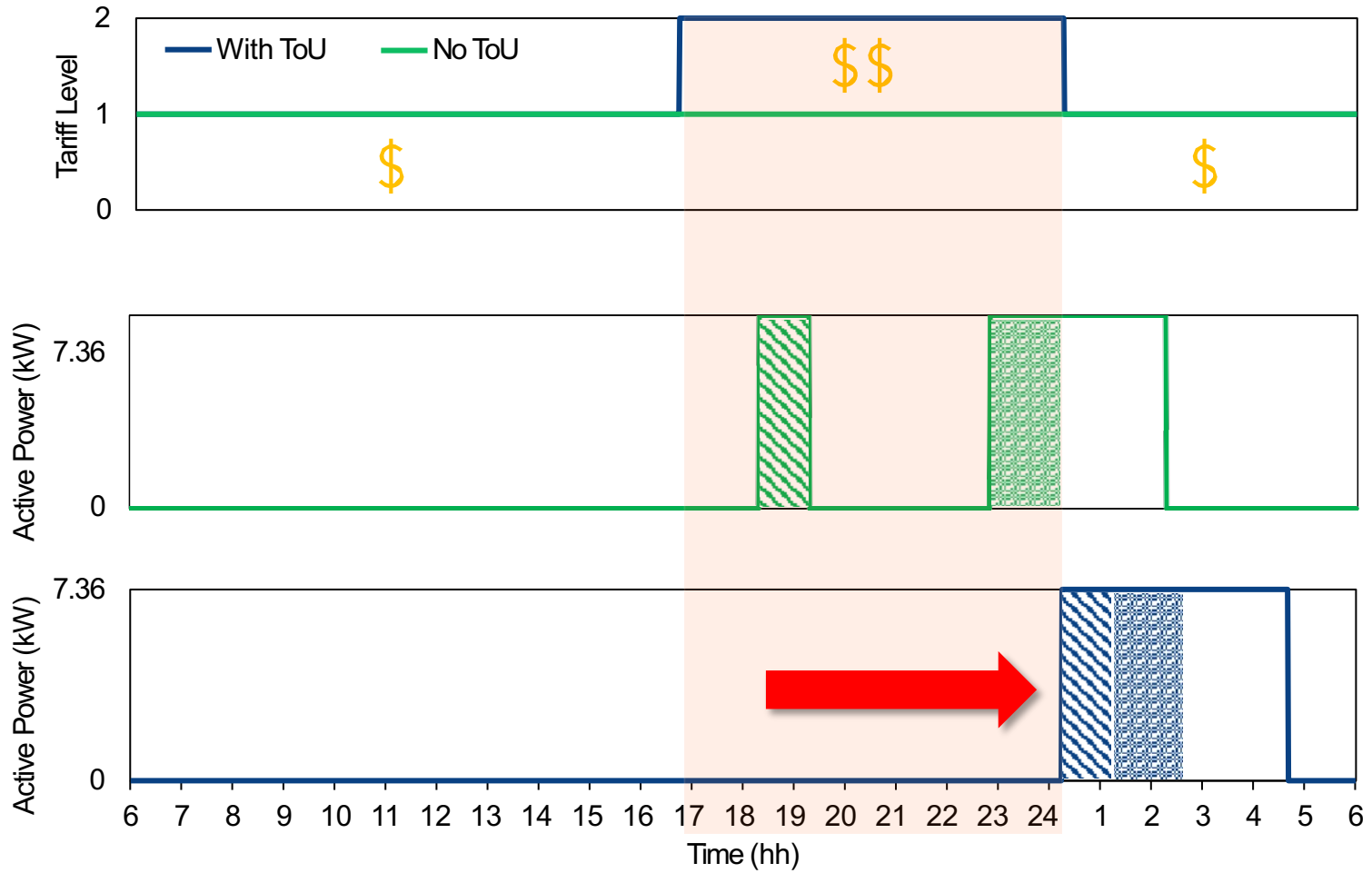
3 EV Management & Customer Impacts

ToU Tariffs: The Basics

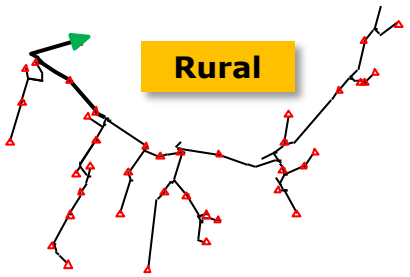
ToU Tariff

No ToU Tariff

With ToU Tariff

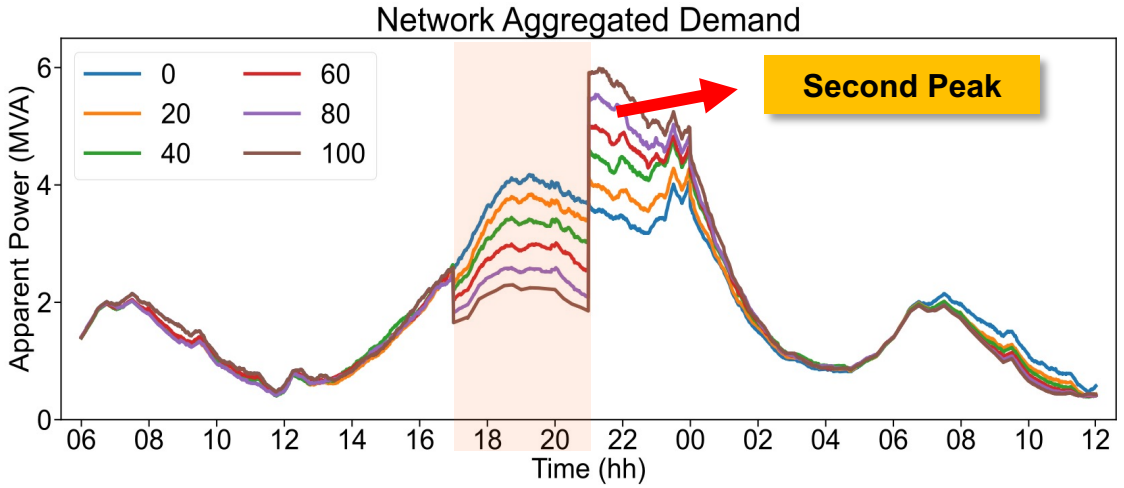


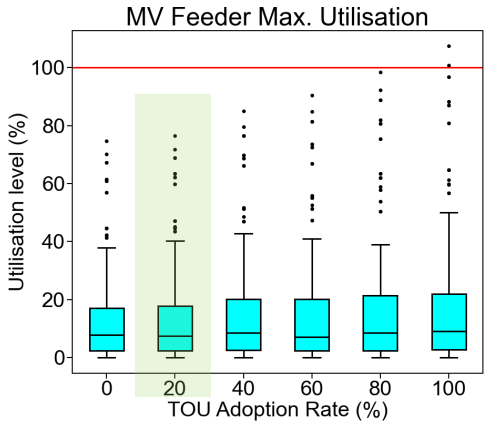
ToU Tariffs ➔ EV charging occurs outside the normal peak
➔ **Distribution Network is fine ☺**

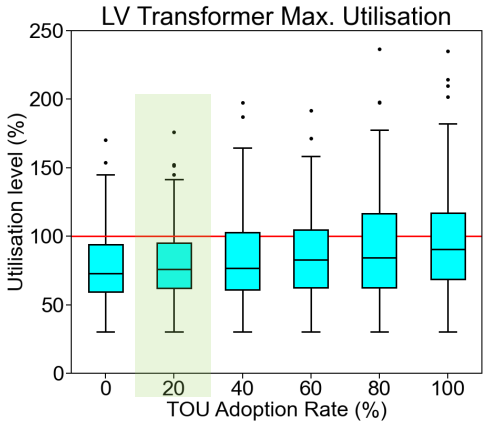


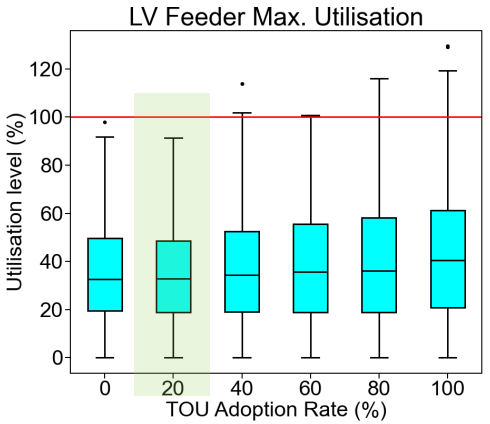
3 EV Management & Customer Impacts

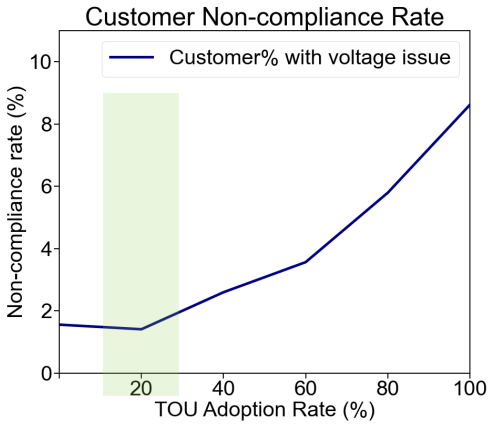
ToU Tariffs: Second Peak









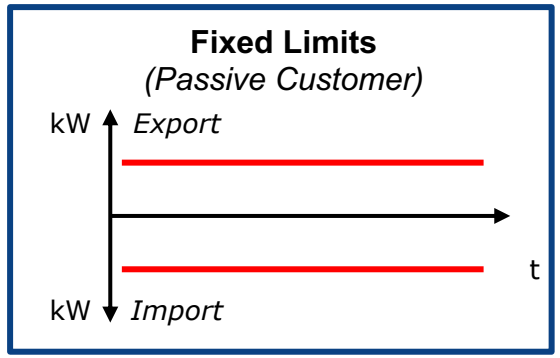


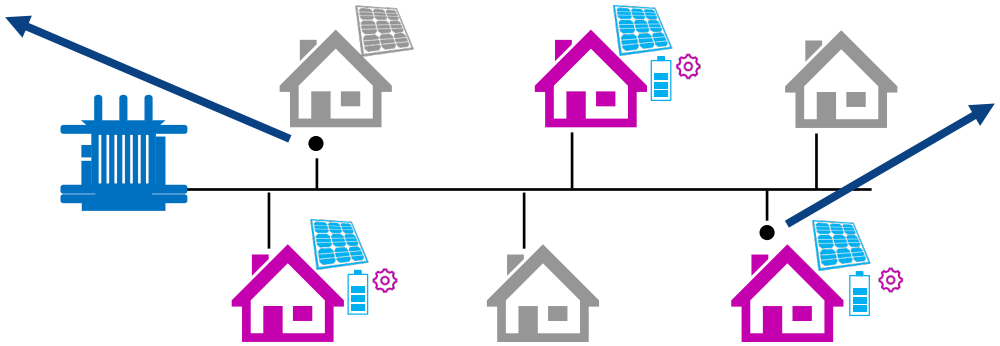
Second peak will cause new problems
→ Benefits with 20% ToU adoption rate

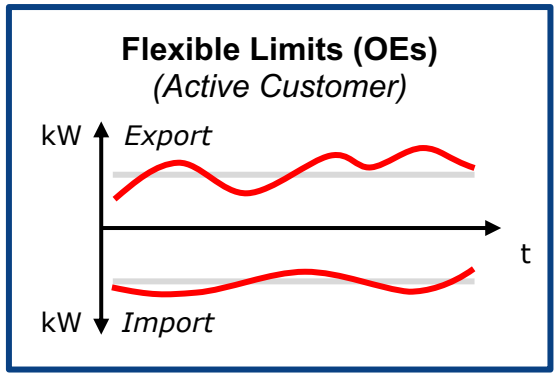
3 EV Management & Customer Impacts

From Fixed to Flexible Limits

- As solar PV uptake continues, *Fixed export limits* are getting smaller (e.g., 2 kW)
  → Next regulatory period: distribution companies will offer *Flexible export limit* [8]
- **What about a flexible import limit?**

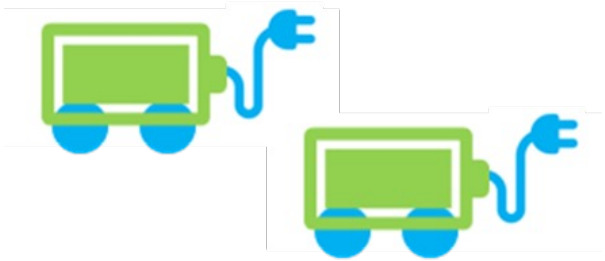






Flexible import limit for EVs is an option
→ Meter-level? DER-level? Charging point?

[8] Released by Australian Energy Regulator on 31 July 2023



3 V2G Opportunities

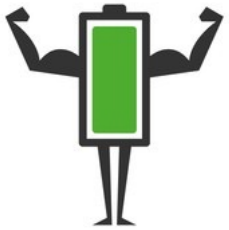
J. Zhu, and L. F. Ochoa, "*Quantifying V2G Response Capabilities Considering MV-LV Distribution Network Constraints*," 2023 IEEE Power & Energy Society General Meeting (PESGM), Orlando, FL, USA, 2023, pp. 1-5 (DOI and ResearchGate)

3 V2G Opportunities
Why V2G?

- ***Some interesting facts*** [9]
  - Only *1/3 of the EV battery capacity* is actively used (short travel distance)

  - It takes *2-5 hours* to charge the battery, But plug-in for *10-24 hours*

  - The battery remains *70-80% State of Health* after *10 years*

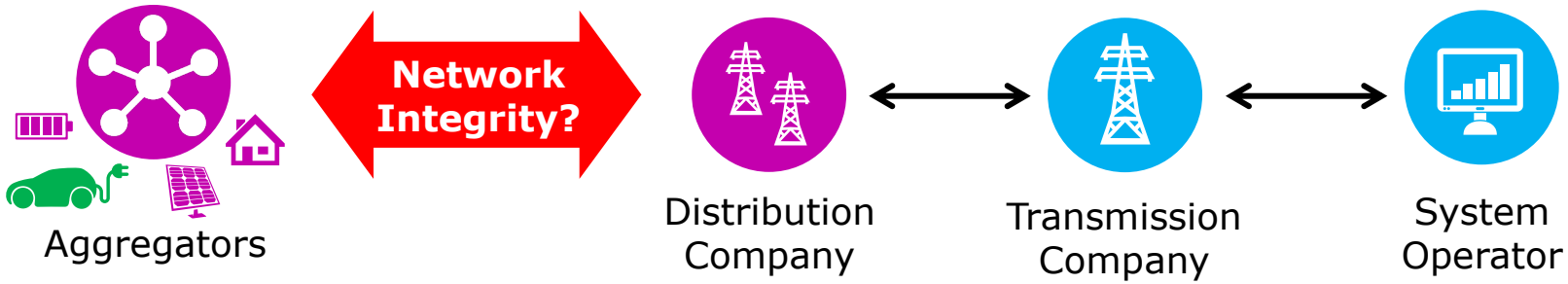


We are asking for larger EV batteries, but use very little…
Besides using the EV as a car, let's use it as residential storage!

[9] Collaboration work with Dr Lluc Canals Casals, Universitat Politècnica de Catalunya

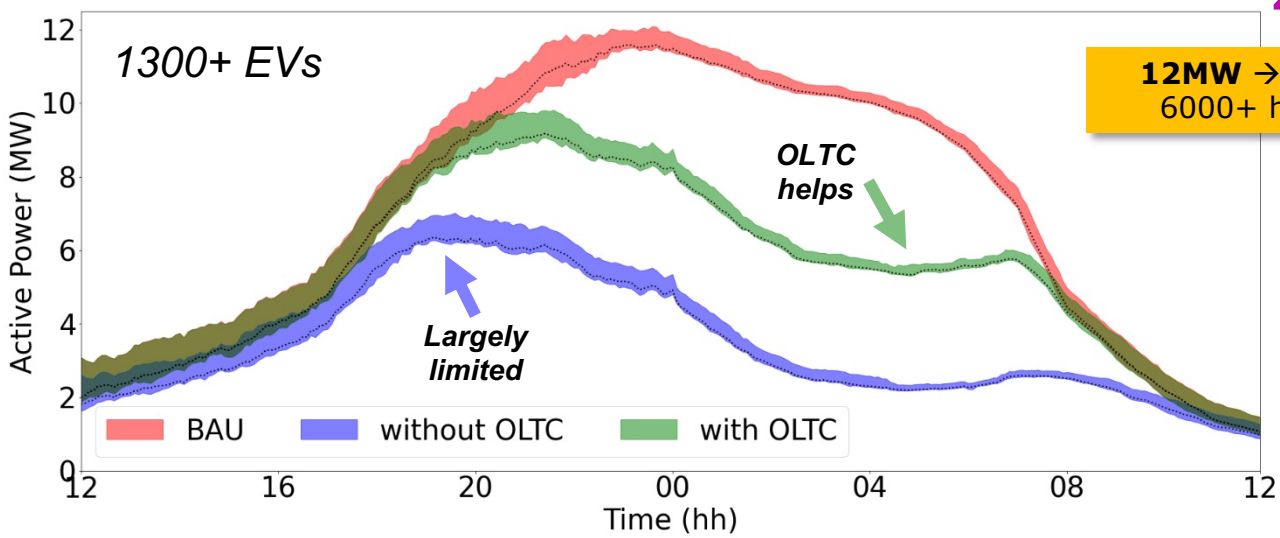
3 V2G Opportunities

How much V2G response can be provided to the grid?



V2G Response Capabilities

	Network Constraint	On-Load Tap Changer (OLTC)
Scenario 1 (BAU)	×	×
Scenario 2 (w/o OLTC)	√	×
Scenario 3 (with OLTC)	√	√



12MW → Supply 6000+ houses

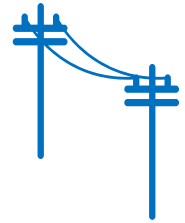
Network constraints considered → **Limited V2G response capacity**
OLTC can help voltage rise issues → **More headroom for export**

4 Key Remarks

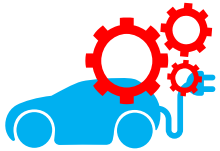
4 Key Remarks

- Quickly, EVs will be a huge DER technology.

- The ***new peak demand*** will bring ***new challenges*** to distribution networks.
  - E.g., congestions issues on poles and wires, voltage drop issues.



- To accommodate more EVs, ***EV management*** can be adopted; The impacts on the networks and customers need be assessed.



- The ***V2G technology*** offers ***new opportunities*** to the grid; however, V2G response should consider the integrity of distribution networks.

➢ *"The future is bright - if we can make EVs and the grid work together!"*

EV Integration

Our Latest Webinar: Managing EVs in Australian Urban and Rural Grids (Slides)
Our Latest Report: EV Management and Time-of-Use Tariff Profiles
Our Latest Papers: Assessing the EV Hosting Capacity of Australian Urban and Rural MV-LV Networks and Producing Realistic EV Demand Profiles for Distribution Network Studies

Timeline Resources

Energy Networks Australia
The Australian Power Institute
THE UNIVERSITY OF MELBOURNE
C4NET Centre for New Energy Technologies

Scan me!

https://electrical.eng.unimelb.edu.au/power-energy/projects/ev-integration

Thanks! Questions?

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