Impact of Fairness on Dynamic Operating Envelopes

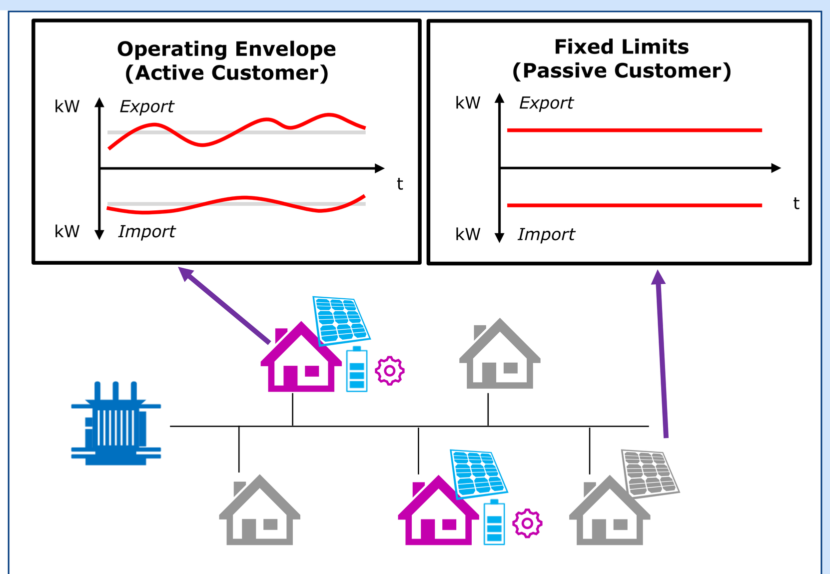
James Naughton, Pierluigi Mancarella – *The University of Melbourne*

1 Introduction

- Increasing amounts of Distributed Energy Resources (**DER**) are adding **strain to distribution networks**, but also represent **untapped potential** for market participation.
- Currently imposed static limits are very conservative, and do not consider the locational or temporal aspects of DER power injection.
- Project EDGE (Energy Demand and Generation Exchange) is trialling an innovated approach called **Dynamic Operating Envelopes (DOEs).**
- DOEs are **dynamic export/import limits** at customers' connection points. This means that customers are **only constrained** by the Distribution Network Service Provider (DNSP) **when absolutely necessary** for safe network operation.

2 How DOEs Work

- Customers actively participating in the DER Marketplace receive DOEs, others get static limits.
- When network is **not congested** (often), DOE customers can export unconstrained (**DOEs greater than static limit**).



M. Z. Liu *et al.*, "Grid and Market Services From the Edge: Using Operating Envelopes to Unlock Network-Aware Bottom-Up Flexibility," in *IEEE Power and Energy Magazine*, vol. 19, no. 4, pp. 52-62, July-Aug. 2021

- When network is **constrained, DOEs** are reduced, **possibly below static limits**.

Key Questions

How does the DNSP divide this capacity amongst participating customers?

How does the DNSP assess the fairness of the allocation?

Should the DNSP divide this capacity to be fair from the perspective of the participating customers, or to maximise system efficiency?

3 Fairness in DOE

Objective Functions

Efficiency-focused

Maximise NEM Export: Maximises the capacity that can be exported upstream.

Policy Based: DNSP assigns weightings to customers and maximises their weighted sum.

Fairness-focused

Proportional Asset: Each DER is assigned *X%* of their rated capacity.

Equal Individual Conservation: Each DER is curtailed by *Y kW.*

Shared Equal Individual Allocation: Each DER is assigned the smaller of *Z kW* or their rated capacity.

Absolute Equal Individual Allocation: Each DER is assigned *Z kW*.

Metrics (Values from 0 – 1)

Technical

Network Utilisation: % of transformer capacity being allocated

DER Capacity Utilisation: % of total capacity of participating DER fleet being allocated.

Renewables Utilisation: % of participating renewable generation being allocated capacity.

Economic

Relative Social Welfare: Additional economic value unlocked for the participating DER.

Fairness

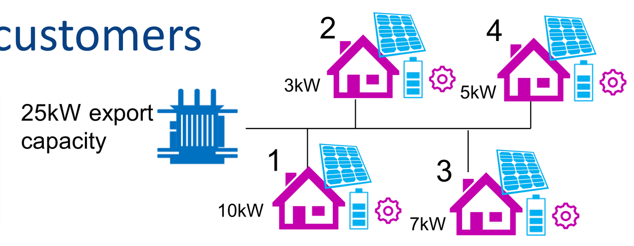
Quality of Service: Fairness based on the coefficient of variation.

Quality of Experience: Fairness based on the standard deviation.

Min-Max Fairness: Fairness based on the range.

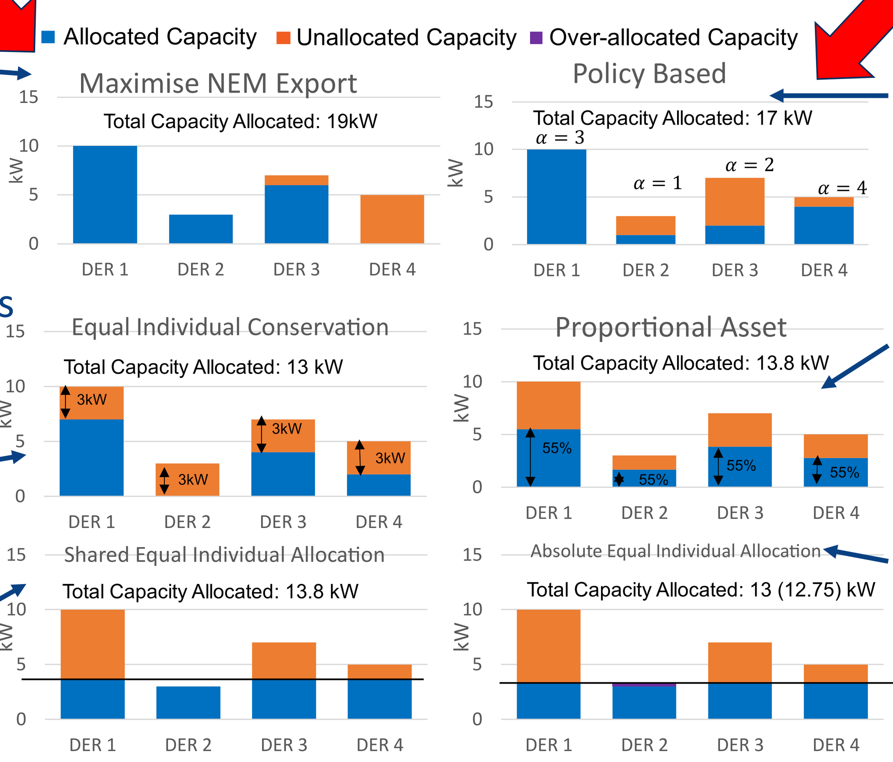
4 Illustrative Network Example

Four participating customers



Most capacity allocated

Capacity allocated based on DER weightings and network physics



Customers nearest the transformer prioritised

Customers with highest weighting α prioritised (not guaranteed more capacity)

Each customers has capacity reduced by 3kW. DER 2 has no capacity allocated

Each customers has 55% of rated capacity allocated

All customers allocated 3.6 kW, except DER 2 that is assigned 3 kW (rated capacity)

All allocated 3.25 kW. **DER 2 cannot use 0.25 kW** of that

Least capacity allocated

- Even some fairness-focussed DOE objective functions have **winners and losers** (*Equal Individual Conservation* is a good example of this here).
- Changing the **location/size** of the DER can have **significant impact** on capacity allocated by **fairness-focused DOE** objective functions, as they are **limited by the most constrained customer** in the network.

5 General Results from Real World Networks

- The DOE objective functions were tested on a number of **real world / representative networks** – taken from the EDGE field trial or the CSIRO LV Taxonomy Report[1]. They were also tested on a **range of DER penetrations and levels of DER participation** in the DER Marketplace[2].
- **Efficiency-focused** objective functions **outperform fairness-focused** objective functions in technical and economic metrics. The more constrained the network, the larger the difference.
- **Additional** uptake in **DER participation** will further **widen the difference in technical and economic performance** between these two groups of DOE objective functions. So the gap in performance will increase into the future with more DER in the network and more DER actively participating.
- In general, it appears that **fairness for the participating customers** comes at the **cost of the total capacity allocated**. From a **NEM-wide customer perspective**, they may be better served by **more efficient capacity allocation to drive down market prices**, and retail tariffs.

[1]Geth F, Brinsmead TS, West S, Goldthorpe P, Spak B, Cross G and Braslavsky J (2021) *National Low Voltage Feeder Taxonomy Study*. CSIRO, Australia https://arena.gov.au/assets/2022/08/national-low-voltage-feeder-taxonomy-study.pdf

[2]J. Naughton and P. Mancarella (2022) *Fairness in Dynamic Operating Envelope Objective Functions.* AEMO, Australia, (In Progress)

6 Applications

- The outcomes of this work will be used to inform **market bodies and regulators** as to the role and most suitable forms and applications of dynamic operating envelopes in the context of DER marketplaces.
- **Network operators** will be able to make more informed decisions on DER capacity allocation options.
- **Customers/customer advocate groups** will be able to better understand the rationale and evidence behind the decisions on how to assess the network capacity provided to DER.

7 Acknowledgement

The authors would like to acknowledge the EDGE project partners for their continuous support: AEMO, AusNet Services, and Mondo.

For more information contact:

James Naughton
Research Fellow in Distributed Energy Markets
The University of Melbourne
E: james.naughton@unimelb.edu.au

Pierluigi Mancarella
Chair Professor of Electrical Power Systems
The University of Melbourne
E: pierluigi.mancarella@unimelb.edu.au