DER Market Integration Consultative Forum

17 November 2022

We acknowledge the Traditional Owners of country throughout Australia and recognise their continuing connection to land, waters and culture.

We pay respect to their Elders past, present and emerging.

AEMO Competition Law Meeting Protocol

AEMO is committed to complying with all applicable laws, including the Competition and Consumer Act 2010 (CCA). In any dealings with AEMO regarding proposed reforms or other initiatives, all participants agree to adhere to the CCA at all times and to comply with this Protocol. Participants must arrange for their representatives to be briefed on competition law risks and obligations.

Participants in AEMO discussions **must**:

- Ensure that discussions are limited to the matters contemplated by the agenda for the discussion
- Make independent and unilateral decisions about their commercial positions and approach in relation to the matters under discussion with AEMO
- Immediately and clearly raise an objection with AEMO or the Chair of the meeting if a matter is discussed that the participant is concerned may give rise to competition law risks or a breach of this Protocol

Participants in AEMO meetings **must not** discuss or agree on the following topics:

- Which customers they will supply or market to
- The price or other terms at which Participants will supply
- Bids or tenders, including the nature of a bid that a Participant intends to make or whether the Participant will participate in the bid
- Which suppliers Participants will acquire from (or the price or other terms on which they acquire goods or services)
- Refusing to supply a person or company access to any products, services or inputs they require

Under no circumstances must Participants share Competitively Sensitive Information. Competitively Sensitive Information means confidential information relating to a Participant which if disclosed to a competitor could affect its current or future commercial strategies, such as pricing information, customer terms and conditions, supply terms and conditions, sales, marketing or procurement strategies, product development, margins, costs, capacity or production planning.

Today's meeting

Time	Item	Speaker
11:00 – 11:05	Welcome and Introductions	Rachel Rodrigues McGown (AEMO)
11:05 - 11:15	Project EDGE Trial Update	Nick Regan (AEMO)
11:15 – 12:00	Data Exchange Use Cases	Nick Regan (AEMO)
12:00- 12:25	DOE Objective Function Study	Dr James Naughton (University of Melbourne)
12:25 -12:30	Q&A & Meeting Close	All

Project EDGE Trial Update

Nick Regan (AEMO)

Project EDGE update

- Presented at two international forums – the Association of Power Exchanges & the Integration of Renewable and Distributed Energy Resources Conference
- Final CBA methodology becoming available from late November – thanks for your input
- More field test data becoming available from late October (relating to data exchange and aggregator performance)
- Ongoing results analysis and input into reform such as Scheduled Lite
- With the release of Gamma, we now have the capability to test Local Services Trials and simulating pricing events
- Building from the feedback received, creating use cases from the explored Data Exchange Problem statements to test with stakeholders

Scalable Data Exchange Use Cases

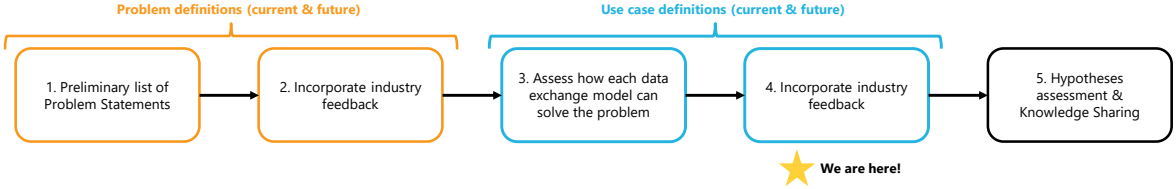
Project EDGE focus area

Nick Regan (AEMO)

Industry stakeholder feedback is key to clarifying problems & use cases so that assessment of EDGE's hypotheses is based on a relevant foundation

Assessing scalable data exchange models requires clear problems to solve before jumping to solution mode – this is why we're talking to you today!

- EDGE Field Trial includes transactional DER use cases: DOEs, Bi-directional offers, Dispatch Instructions, Telemetry
- Appropriately assessing models for scalable DER data exchange needs to consider current and anticipated future problems.
- Project team (AEMO, AusNet, Mondo) have created a preliminary list of problem statements that cover transactional and standing data which, we'd like feedback on over the next couple of months.

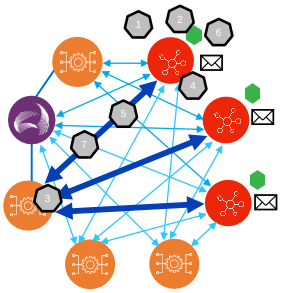


Data Exchange Problem Statements Recap

Use Case	I have a problem that	Therefore, I want to	So that I can
Identity Management	I need to participate in multiple, separate and bespoke organisation identity verification processes with DNSPs to deliver 'similar but different' B2B services across the NEM as well as AEMO to provide wholesale market services. This adds to my compliance burden and cost to serve customers	have a single process to verify my organisation identity that can be used across all energy market actors	minimise my administration overhead and barriers to accessing non-market revenue opportunities to recruit more customers by sharing greater financial value with them.
DOEs	I need to integrate into multiple, separate, and bespoke data exchange systems with each DNSP to know which Dynamic Operating Envelopes to apply in operating my portfolio in addition to integrating with AEMO to provide wholesale market services. This adds to my compliance burden and cost to serve customers	Be able to access all DOEs that relate to my portfolio across different DNSP jurisdictions in the NEM via one integration point	minimise my operational costs and cost to serve customers
Zero Export	I need to integrate into multiple, separate, and bespoke data exchange systems with Aggregators and customer agents to request 'zero exports' at my retail sites during negative spot market prices to avoid paying for these (up to $1,000/MWh). This is in addition to integrating with AEMO to provide wholesale market services. This adds to my cost of managing risk and cost to serve customers	Be able to broadcast my zero exports need to a single market interface	Access many potential zero export limit providers including new ones that emerge through a single integration point, lowering my cost of managing spot price risk and serving customers.
LSE	I need to integrate into multiple, separate, and bespoke data exchange systems with DNSPs to deliver 'similar but different' local network services across the NEM in addition to integrating with AEMO to provide wholesale market services. This complexity means it's difficult, and potentially not scalable or economic, for me to deliver these services using my portfolio or participate in new B2B services as the arise.	Be able to access a market interface to discover and bid on local network support opportunities and wholesale market services across the NEM via one integration point	Maximise service revenue opportunities for my customers, minimise market operational costs, and so make local services economic for my portfolio

Data Exchange Use Case 1: Dynamic Operating Envelopes

I have a problem that	Therefore, I want to	So that I can
I need to integrate into multiple, separate, and bespoke data exchange systems with each DNSP to know which Dynamic Operating Envelopes to apply in operating my portfolio in addition to integrating with AEMO to provide wholesale market services. This adds to my compliance burden and cost to serve customers	Be able to access all DOEs that relate to my portfolio across different DNSP jurisdictions in the NEM via one integration point	minimise my operational costs and cost to serve customers



Point to Point Process:

1. DNSP notified of an aggregator site
2. Aggregator registers Portfolio and Identity
3. Integration established between aggregator and DNSP
4. DNSPs map NMIs to portfolios and send a packet of DOEs
5. Aggregator receives and operates within DOEs
6. Aggregator updates their portfolio information
7. This process repeats with any updates to an Aggregator's Portfolio

Data Hub Process

1. DNSP notified that a site needs a DOE
2. Aggregator registers Portfolio and Identity
3. Integration established between DNSP and DER Data Hub
4. Integration established between aggregator and DER Data Hub and DNSP
5. DNSPs add new NMIs to batch of DOEs and send one packet of DOEs to the hub
6. The Hub broker takes the single DOE packet based on portfolio information and sends the correct DOEs to their site aggregator
7. Aggregator receives and operates within DOEs
8. Aggregator updates their portfolio information
9. This process repeats with any updates to an Aggregator's Portfolio

EDGE

Retailer | Customer agent/ aggregator | DNSP | Market Operator | Identity | DOE Packets

Dynamic Operating Envelopes Use Cases

The following steps outline the **Point to Point process** for a DOE use case visual above.

1. DNSP notified of a site with an aggregator (aka customer agent) that DOEs must be delivered to
2. The Aggregator then undertakes an organisation identity and portfolio registration process with each party

Callout: *It is worth noting the following*

   1. The Identity verification process may not be standardised across parties
   2. Several identities can exist for one aggregator, and be managed by different parties
   3. The verification process may be in addition to the existing identity held with AEMO for Market Participation

3. Single integration established between Aggregator and DNSP. **Callout:** *For the Aggregator, integration is required per DNSP connection and this may not be standardised*
4. DNSPs map NMIs to portfolios and send a packet of DOEs per aggregator. **Callout:** *DNSPs have a constant re-mapping process and must send multiple DOE packets*
5. Aggregator receives and operates within DOEs
6. The Aggregator updates their portfolio information as sites and DER change with each party. **Callout:** *The Aggregator makes DER portfolio updates with each counterparty. This process may not be standardised*
7. DNSP re-maps NMIs to portfolio updates and send a packet of DOEs per aggregator.

The following steps outline the **Data Hub process** for a DOE use case visual above.

1. DNSP notified that a site needs a DOE

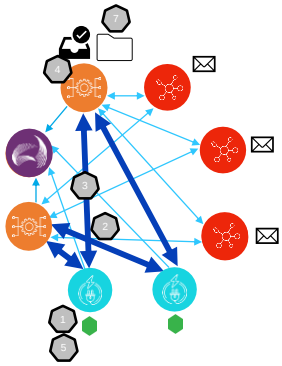
2. The Aggregator then undertakes an organisation identity and portfolio registration process with each party.
   Callout: *It is worth noting the following*

    1. The established identity is managed by one party (e.g. AEMO) and then utilised by other parties. This reduces duplicating processes and thereby enhancing marketplace trust.

3. Integration established between DNSP and DER Data Hub. **Callout:** *Any existing Hub integration mat be leveraged throughout all use cases.*
4. Integration established between the Aggregator, DER Data Hub and DNSP.
5. DNSPs add new NMIs to batch of DOEs and send one packet of DOEs to the hub
6. The Hub broker takes the single DOE packet based on portfolio information and sends the correct DOEs to their site Aggregator
7. Aggregator receives and operates within DOEs
8. Aggregator updates their portfolio information as sites and DER changes with AEMO. **Callout:** *The Hub maintains participants and portfolio mapping to facilitate B2B interactions.*
9. This process repeats with any updates to an Aggregator's Portfolio. **Callout:** *DNSPs can always send one DOE packet without maintaining and managing frequent aggregator portfolio updates.*

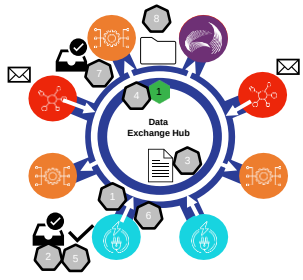
Data Exchange Use Case 2: Retailer Zero Export Limit (ZEL)

I have a problem that	Therefore, I want to	So that I can
I need to integrate into multiple, separate, and bespoke data exchange systems with Aggregators and customer agents to request 'zero exports' at my retail sites during negative spot market prices to avoid paying for these (up to $1,000/MWh). This is in addition to integrating with AEMO to provide wholesale market services. This adds to my cost of managing risk and cost to serve customers	Be able to broadcast my zero exports need to a single market interface	Access many potential zero export limit providers including new ones that emerge through a single integration point, lowering my cost of managing spot price risk and serving customers.



Point to Point Process

1. Customer Agent approached by a retailer to curtail solar generation (ZEL) at some of their sites during negative spot prices
2. Single integration established between aggregator and Retailer
3. Retailers map NMIs to portfolios and send a ZEL request per aggregator
4. Aggregator receives and executes ZEL
5. Retailer re-maps NMIs to portfolio updates ready to send new ZEL request per aggregator
6. The retailers repeats this process with any updates to the Aggregators Portfolio
7. Service verification obtained through smart meter data or file transfer



Data Hub Process

1. Integration established between Retailer and DER Data Hub
2. Retailer establishes ZEL channel(s) to signal ZEL needs.
3. Retailer uses broadcast messenger function to notify registered aggregators on the hub and facilitate connection
4. Aggregator existing integration to the hub used to apply to subscribe to retailer ZEL channel(s)
5. Retailer approves access to their ZEL channel based on aggregator credentials
6. Retailer sends ZEL request to channel
7. Aggregator receives request and actions ZEL at their sites
8. Service verification obtained through smart meter data or file upload via data hub

EDGE

Retailer | Customer agent/ aggregator | DNSP | Market Operator | Identity | DOE Packets | Zero Export Limit | Messages

Retailed Zero Export Use Case

The following steps outline the **Point to Point process** for a Retailer Zero Export Limit use case visual above.

1. Customer Agent / Aggregator or OEM is approached by a retailer to curtail solar generation (ZEL) at some of their sites during negative spot prices.
2. The Aggregator then undertakes an organisation identity and portfolio registration process with each party

Callout: *It is worth noting the following*

1. The Identity verification process may not be standardised across actors .
2. Several identities can exist for one aggregator, and be managed by different parties.
3. The verification process may be in addition to the existing identity held with AEMO for Market Participation

3. Single integration established between Aggregator and Retailer. **Callout:** *For the Aggregator, a single integration is required per retailer and this may not be a standardised process.*
4. Retailers map NMIs to portfolios and send a ZEL request per Aggregator.
5. Aggregator receives and executes ZEL.
6. Retailer re-maps NMIs to portfolio updates ready to send new ZEL request per Aggregator. **Callout:** *Retailers have a constant remapping process and must send multiple ZEL requests per event.*
7. The retailers repeats this process with any updates to the Aggregator's Portfolio. **Callout:** *Aggregator makes DER portfolio updates with each counterparty, this process may not be*

standardised.

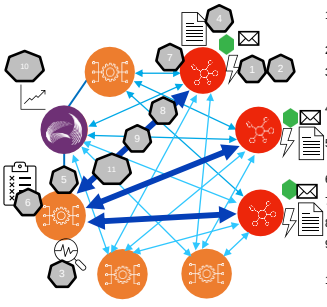
8. Service verification obtained through smart meter data or file transfer.

The following steps outline the **Data Hub process** for a Retailer Zero Export Limit use case visual above.

1. Integration established between Retailer and DER Data Hub. **Callout:** *Any existing Hub integration can be leveraged in this use case including the existing retailer identity managed by AEMO.*
2. Retailer establishes ZEL channel(s) to signal ZEL needs.
3. Retailer uses broadcast messenger function to notify registered aggregators on the hub and facilitate connection. **Callout:** *It is worth noting the following*
    1. The established identity is managed by one party (e.g. AEMO) and then utilised by other parties. This reduces duplicating processes and thereby enhancing marketplace trust.
4. Aggregator existing integration to the hub used to apply to subscribe to retailer ZEL channel(s). **Callout:** *Configuration of channels is easier than integrating with other organisations.*
5. Retailer approves access to their ZEL channel based on aggregator credentials. **Callout:**
    1. *The Retailer controls how the ZELs are distributed.*
    2. *The mapping of NMIs by a Retailer may exist in the Retailer's system or this could be leveraged by portfolio Management system linked to the Hub in the future.*
    3. *The Hub maintains participants and portfolio mapping to facilitate B2B interactions.*
6. Retailer sends ZEL request to channel.
7. Aggregator receives request and actions ZEL at their sites.
8. Service verification obtained through smart meter data or file upload via data hub.

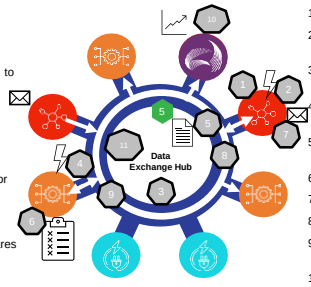
Data Exchange Use Case 3: Local Service Exchange

I have a problem that	Therefore, I want to	So that I can
I need to integrate into multiple, separate, and bespoke data exchange systems with DNSPs to deliver 'similar but different' local network services across the NEM in addition to integrating with AEMO to provide wholesale market services. This complexity means it's difficult, and potentially not scalable or economic, for me to deliver these services using my portfolio or participate in new B2B services as the arise.	Be able to access a market interface to discover and bid on local network support opportunities and wholesale market services across the NEM via one integration point	Maximise service revenue opportunities for my customers, minimise market operational costs, and so make local services economic for my portfolio



Point to Point process

1. DNSP establishes a Local Services Exchange interface
2. DNSPs post service needs
3. Aggregators search DNSP website or exchange to discover local network service opportunities
4. Aggregator negotiates and contracts with each DNSP they want to service
5. Integration established between aggregator and DNSP
6. Aggregators bid on services they are qualified for
7. DNSP awards successful bid
8. DNSP issue service activation notice
9. Aggregator receives activation notice and prepares portfolio
10. Aggregator updates market offer to AEMO that includes capacity committed to DNSPs and provides service
11. Service verification obtained through smart meter data or other method if required



Data Hub Process

1. DNSP establishes a Local Services Exchange interface
2. Using existing integration, DNSP establishes LSE channel to signal service needs.
3. DNSP uses messenger function to notify registered aggregators about services and connection
4. Aggregator existing integration to the hub used to apply to subscribe to DNSP LSE channel(s)
5. DNSP approves access to their LSE channel based on aggregator credentials
6. Aggregators bid on services they are qualified for
7. DNSP awards successful bid
8. DNSP issue service activation notice
9. Aggregator receives activation notice and prepares portfolio
10. Aggregator updates market offer to AEMO that includes capacity committed to all DNSPs through existing hub integration and provides service
11. Service verification obtained through smart meter data or other method if required

Local Services Exchange Use Cases

The following steps outline the **Point to Point process** for a Local Services Exchange use case visual above.

1. Each DNSP establishes a Local Services Exchange interface.
2. DNSPs post service needs. **Callout:** *Service definitions may not be standardised across the DNSPs for Aggregators.*
3. Aggregators search each DNSP website or exchange to discover local network service opportunities. **Callout:** *The service discovery is Aggregator driven.*
4. Aggregator negotiates and contracts with each DNSP they want to service. **Callout:** *For Aggregators, the contracts across each DNSPs may not be standardised.*
5. The Aggregator then undertakes an organisation identity and portfolio registration process with each party

Callout: *It is worth noting the following*

   1. The Identity verification process may not be standardised across actors
   2. If several identities exist for one aggregator, it can be managed by different parties

6. Single integration established between aggregator and DNSP. **Callout:** *For Aggregators, an integration per DNSP is required and may not be standardised.*
7. Aggregators bid on services they are qualified for
8. DNSP awards contract
9. DNSP issue service activation notice
10. Aggregator receives activation notice and prepares portfolio
11. Aggregator updates market offer to AEMO that includes capacity committed to all DNSPs through separate integration. **Callout:** *When provided to AEMO, it through the existing*

separate integration for market services assuming the material portfolio size.

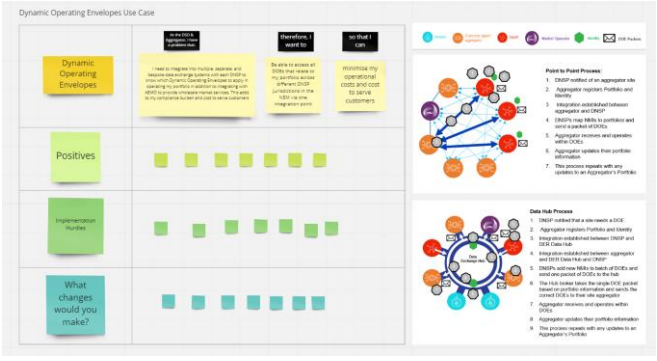
12. Service verification obtained through smart meter data or other method if required. **Callout:** *The Service verification data requitements may not be standardised for similar services across the DNSPs.*
13. This process repeats with any updates to the Aggregators Portfolio. **Callout:** *Aggregator makes DER portfolio updates with each counterparty, this process may not be standardised.*

The following steps outline the **Data Hub process** for a Local Services Exchange use case visual above.

1. Each DNSP establishes a Local Services Exchange interface.
2. Using existing hub integration, DNSP establishes LSE channel(s) to signal service needs. **Callout:** *Any existing Hub integration can be leveraged in this use case including existing identities managed by AEMO. This example assumes DNSPs and Aggregators are already integrated to the Hub for the DOE use case.*
3. DNSP uses broadcast messenger function to notify registered Aggregators/Agents on the hub of the channel, service opportunities, contract terms and how to connect. **Callout:** *Service discovery can be promoted by the DNSP.*
4. Aggregator existing integration to the hub used to apply to subscribe to DNSP LSE channel(s).
5. DNSP approves access to their LSE channel based on aggregator credentials. Aggregators bid on services they are qualified for.
6. DNSP awards contract.
7. DNSP issue service activation notice.
8. Aggregator receives activation notice and prepares portfolio.
9. Aggregator updates market offer to AEMO that includes capacity committed to all DNSPs through existing hub integration.
10. Service verification obtained through smart meter data or other method if required.
11. This process repeats with any updates to the Aggregators Portfolio. **Callout:** *The Hub maintains participants and portfolio mapping to facilitate B2B interactions.*

We will use Mural to work through the Data Exchange Use Cases and gather relevant feedback

Link: Data Exchange Use Cases
Password: EDGE-MICF-2022



Move post-it note responses through the exercises

What are we trying to achieve?

As we walk through each use case, we are looking for targeted feedback to determine if we have captured and understood the feedback correctly.

Feedback Questions:

1. What positives do you see from these steps?
2. What implementation hurdles do you see?
3. What would you change or add to this use case?

AEMO and Industry stakeholder feedback is paramount to understanding the merit and costs of a future DER Data Hub, centralized or decentralized.

Project EDGE | DOE Objective Functions

Market Integration Consultative Forum | 17 November 2022

Dr James Naughton, Prof. Pierluigi Mancarella
james.naughton@unimelb.edu.au ; pierluigi.mancarella@unimelb.edu.au

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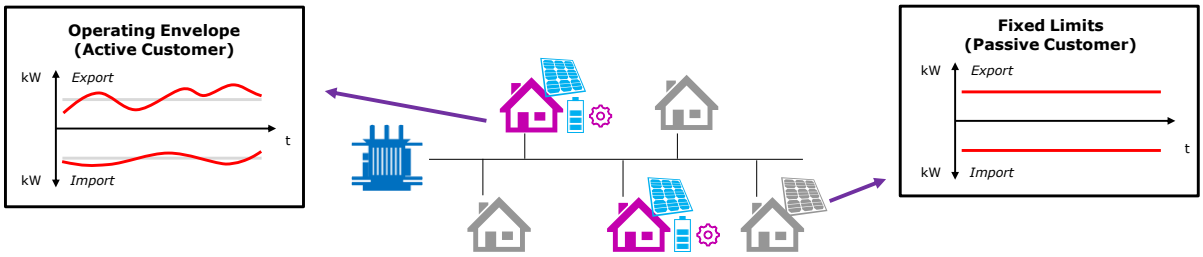
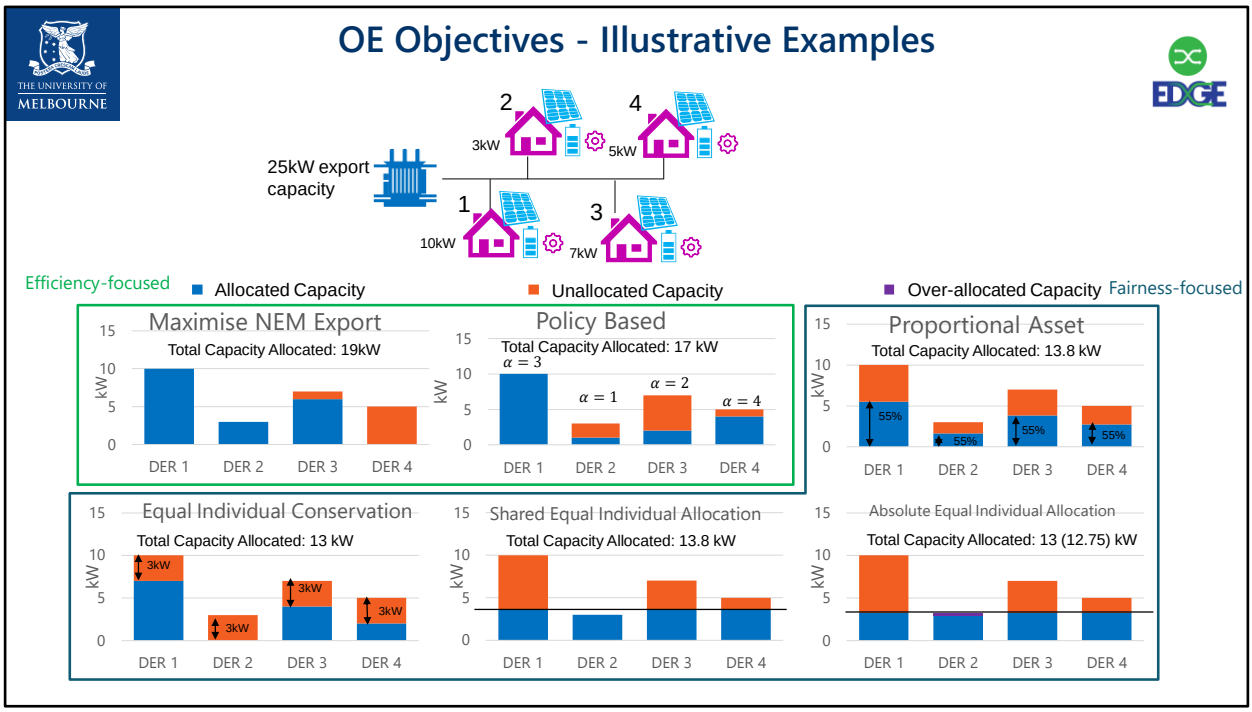
Context



- How should capacity be allocated?
- Should the allocation methodology be "fair" to participating customers or "fair" to all NEM customers by maximising efficiency?
- How does this align with the NEO?
- **Aim: Assess a broad spectrum of possible Operating Envelope objectives across technical, economic, and fairness metrics**



These are the operating envelopes objectives considered in this preliminary work

Maximise NEM Export – No fairness. DER closer to the head of the feeder will benefit from greater allocated capacity. Here it is assumed that DER 1 is closest to the head of the feeder, and DER 4 is furthest away. This OE unlocks the most capacity.

Policy Based– Higher weighted DER **should** get higher capacity. Here it is assumed that the highest weighted DER is DER 4, and the lowest weighted is DER 2. Total capacity allocated is slightly less than Maximise NEM Export, and it is not guaranteed that the DER with the highest weighting receive the most capacity.

Proportional Asset – DER allocated a set percentage (55%) of rated capacity.

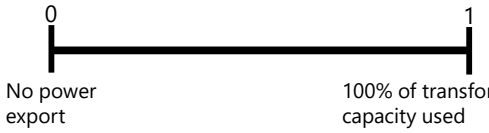
Equal Individual Conservation – Each DER has the same amount of unallocated capacity (3kW).

Shared Equal Individual Allocation – DSO sets a capacity level *Y* kW. Each DER is allocated that or their rated capacity, whichever is smaller. DER 2 is allocated their rated capacity, as it is smaller than the capacity level *Y.*

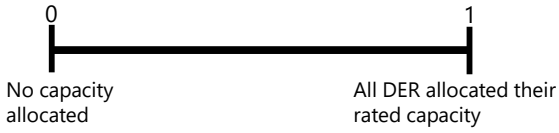
Absolute Equal Individual Allocation – DSO sets a capacity level *Y* kW. Each DER allocated that amount, which can lead to over allocation. It can be seen that DER 2 is over-allocated capacity. Note that the level of capacity allocated is less than in Equity due to this over-allocation. Note also that the amount of capacity the OE algorithm believes it has unlocked (13kW) is less than the maximum actual capacity it has unlocked (12.75kW)

Assessment Metrics – Technical

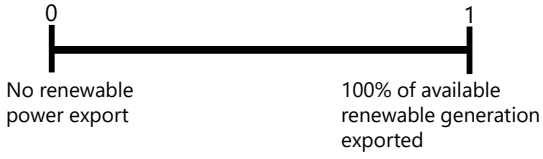
- **Network Utilisation**
  - Tells you how much of the network export/import capacity is being used



- **DER Capacity Utilisation**
  - Tells you how much of the available DER capacity is unlocked



- **Renewables Utilisation**
  - Tells you how much of the available renewable generation is assigned capacity



The metrics proposed on this slide are metrics to analyse the technical performance of the OEs and can be associated with network efficiency. All of the metrics operate on a scale from [0,1], where 1 is the best result.

Network Utilisation
This metric shows how much of the capacity of the upstream transformer is being utilised to export capacity. 0 indicates that there is no export capacity being utilised, and 1 indicates that all of the transformer's capacity is being utilised for export capacity from OEs. Useful to understand if the network is thermally constrained or voltage constrained

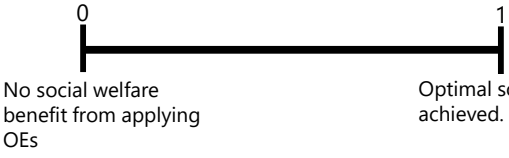
DER Capacity Utilisation
This metric shows how much of the capacity that is available from the participating DER is being allocated through the OE. 1 indicates that all of the available DER capacity is allocated through the OE. Important to compare scenarios with different DER penetrations and participations. Shows how much of the potentially available capacity is utilised

Renewables Utilisation
This metric shows how much of the participating renewable energy sources (RES) capacity in the network is being allocated through the OE. 1 indicates that all of the available RES is allocated through the OE. This looks at the amount of renewable generation is being used (and therefore the remaining that is potentially wasted) in the system.

Assessment Metrics – Economic

- Local Network Social Welfare: ∑ DER revenue – ∑ DER cost
- Optimal Social Welfare: Social welfare achieved by centralised combined network and market optimisation
- **Relative Social Welfare**

• Tells you how effective the OE is at unlocking economic value



Value of **relative social welfare** dependent on market price.

Higher **relative social welfare** likely to have wider system benefits (e.g., reduced market clearing prices)

The metric proposed on this slide is to analyse the economic performance of the OEs and can be associated with market efficiency.

Relative Social Welfare
This metric determines how close to its optimal social welfare the network is operating when a specific OE is applied. The optimum social welfare is calculated through a combined network and market centralised optimisation. The "No Active Participation" social welfare is calculated when the capacity allocated to participating DER is equal to 0. Therefore, a 0 for relative social welfare indicates that there is no social welfare benefit from the capacity that is assigned by the OE. A 1 for relative social welfare indicates that the social welfare of the network could not be any higher with a different allocation of capacity.

Assessment Metrics – Fairness

Specifically fairness for the subset of customer with DER signed up with a trader

- Min-Max Ratio

0 — 1

Any DER is assigned no capacity

All DER assigned capacity proportional to their rated capacity

- Quality of Service

0 — 1

All DER assigned 0 capacity

All DER assigned capacity proportional to their rated capacity

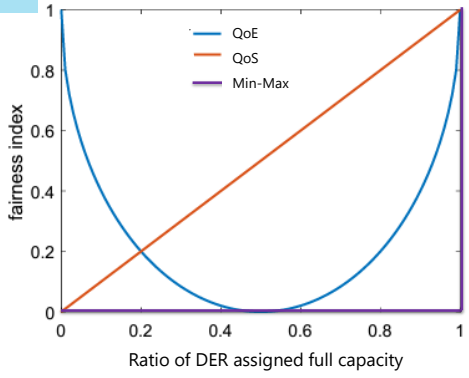
- Quality of Experience

0 — 1

Half DER assigned full capacity, half assigned no capacity

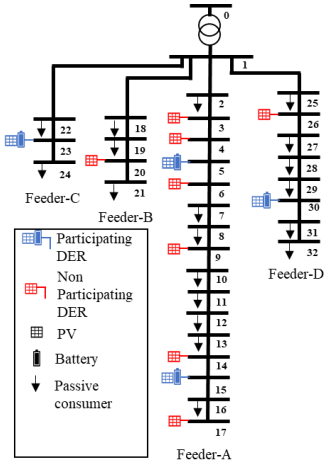
All DER assigned capacity proportional to their rated capacity

Example: DER either assigned full capacity or no capacity



Hoßfeld, T., Skorin-Kapov, L., Heegaard, P.E. et al. A new QoE fairness index for QoE management. Qual User Exp 3, 4 (2018). https://doi.org/10.1007/s41233-018-0017-x

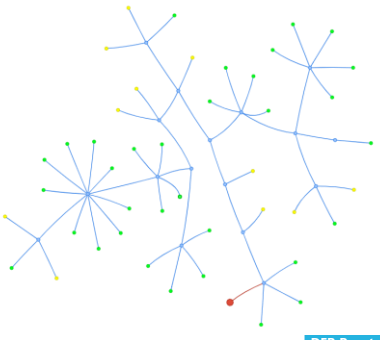
Test Network Results



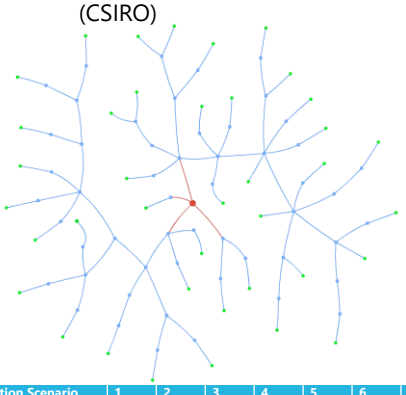
- The **more constrained** the network, the **larger negative impact** "fairness" has on technical and economic metrics.
- There is **significant negative correlation** between the fairness metrics and the technical metrics (and some economic metrics), most strongly for QoE.
- **High participation** levels benefit *Maximise NEM Export* & *Policy Based* but **can have negative impact on other OEs**.
- Increasing "fairness" to participating DER owners will directly reduce the total capacity that can be allocated, and the social welfare of the network.
- Impact worse for higher participation and penetration levels as "fair" allocations are limited by the most constrained participating customer.
- **Fairness allocation objectives applied only to DER customers would appear to be in inefficient under NEO efficiency principles that benefit all electricity consumers.**

More In-Depth Studies on Representative Networks

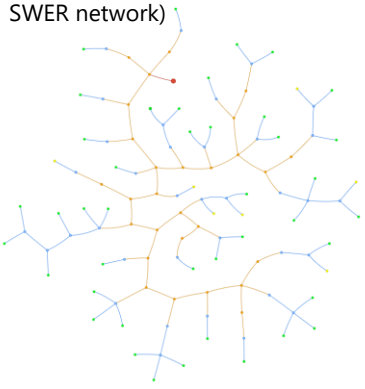
City Network (CSIRO)



Suburban Network (CSIRO)



Regional Network (Trial SWER network)



- **Real world / Representative Networks**, taking guidance from the CSIRO LV Network Taxonomy Report
- Wider **DER Penetration** and **Participation** considerations, including impact of **changing static limits**

DER Penetration Scenario	1	2	3	4	5	6	7	8
PV Penetration	20%	25%	30%	35%	45%	60%	70%	100%
Storage Penetration	1%	5%	10%	20%	30%	40%	50%	100%
Participation Level - Low	5%	10%	15%	20%	25%	30%	35%	40%
Participation Level - Mid	20%	25%	30%	35%	40%	45%	50%	55%
Participation Level - High	35%	40%	45%	50%	55%	60%	65%	70%
Participation Level – 100%	100%	100%	100%	100%	100%	100%	100%	100%

red node is the head of the feeder,
green nodes are residential customers,
yellow nodes are commercial customers
orange lines are MV network

Wanted to run model on representative networks and with a wider range of DER penetration and participation scenarios
Mix of network types, configurations, and residential/commercial customer splits

Changing Static Limits

Regional Network Scenario 5: Some DER introduced in Scenario 5 happen to be near the end of a long feeder. Static limit dependant on location of DER as well as %.

Scenario	1	2	3	4	5	6	7	8
PV Penetration	20%	25%	30%	35%	45%	60%	70%	100%
Storage Penetration	1%	5%	10%	20%	30%	40%	50%	100%
Static Limit - Regional (SWER)	3.5kW (6.44kW)	3.5kW (5.65kW)	3.5kW (5.05kW)	3.5kW (4.79kW)	1.52kW	1.38kW	1.16kW	0.88kW
Static Limit - City	5kW (10.91kW)	5kW (9.68kW)	5kW (7.84kW)	5kW (6.83kW)	5kW (5.74kW)	4.01kW	3.74kW	2.59kW
Static Limit - Suburban	5kW (7.72kW)	5kW (7.19kW)	5kW (5.61kW)	4.89kW	4.52kW	5kW (7.87kW)	5kW (6.53kW)	3.35kW

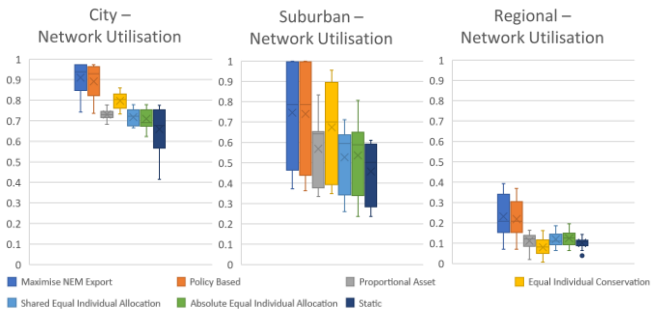
Regional (SWER) network static limits drop so low due to combination of MV and LV network. LV transformers boost voltage.

Figures in brackets show the *Absolute Equal Individual Allocation* results if it is greater than current static limit (3.5kW for SWER, 5kW for 3-phase)

Suburban Network Scenario 6: Previously there was a large imbalance in the phase connections of participating customers. Imbalance is reduced, resulting in additional capacity unlocked.

Location and phase of new DER can have significant impact on *Static Limit*

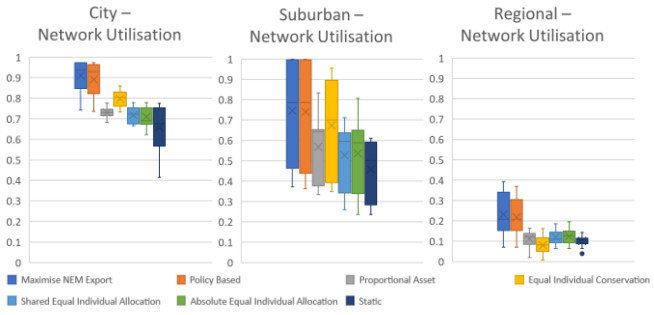
Results – Network Utilisation & DER Capacity Utilisation



Network Utilisation

- Step-change in performance between *Maximise NEM Export / Policy Based* and "fairness-focussed" OE objectives (11%-22% drop in average *Network Utilisation*).
- *Equal Individual Conservation* volatile.
- *Network Utilisation* higher in *City* network due to high number of commercial customers -> larger DER capacity.
- *Regional* (SWER) network constrained by thermal rating of LV transformers, not the isolation transformer.

Results – Network Utilisation & DER Capacity Utilisation



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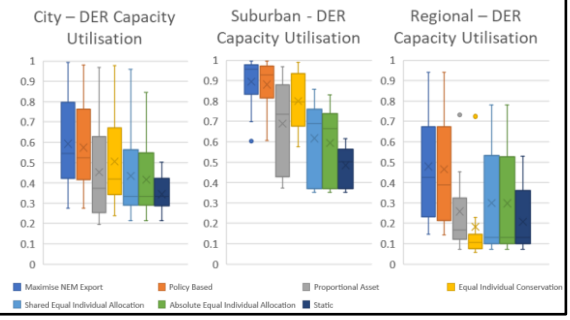
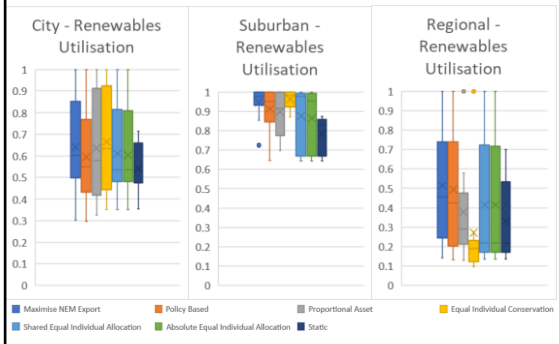
- *Network Utilisation* higher in *City* network due to high number of commercial customers -> larger DER capacity.
- *Regional* (SWER) network constrained by thermal rating of LV transformers, not the isolation transformer.

DER Capacity Utilisation

- Step-change in performance between *Maximise NEM Export / Policy Based* and "fairness-focussed" OE objectives (9%-30% drop in average *DER Capacity Utilisation*).
- *Equal Individual Conservation* volatile – very poor performance in *Regional*. Combination of constrained network and large range of DER sizes.
- *DER Capacity Utilisation* higher in *Suburban* network due to lack of commercial customers -> smaller DER capacity -> less curtailment.

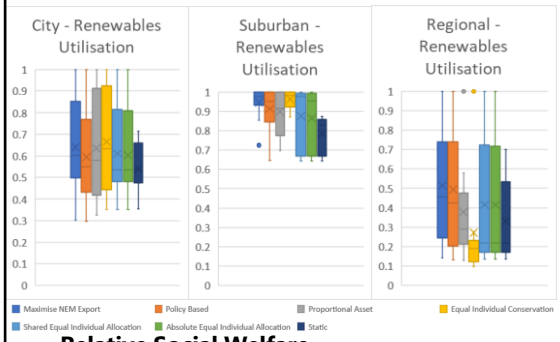


Results – Renewables Utilisation & Relative Social Welfare



- Assumed for customers with PV & Storage, PV will be prioritised for export.
- Renewables Utilisation only technical/economic metric where *Maximise NEM Export* doesn't consistently perform best – still performs very highly.
- Ensuring all customers are allocated some capacity helps to boost performance in *Renewables Utilisation*.

Results – Renewables Utilisation & Relative Social Welfare



Renewables utilisation

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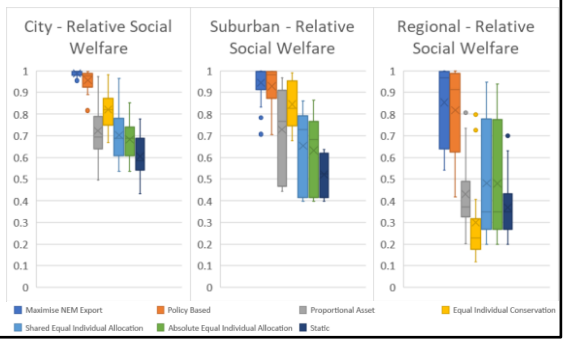
- Ensuring all customers are allocated some capacity helps to boost performance in *Renewables Utilisation*.

Relative Social Welfare

- Step-change in performance between *Maximise NEM Export / Policy Based* and "fairness-focussed" OE objectives (10%-55% drop in average *Relative Social Welfare*).
- Even when *Maximise NEM Export* has a low value for *Network Utilisation* or *DER Capacity Utilisation* (*Regional* network), it still performs well in *Relative Social Welfare*.
- Shows that *Maximise NEM Export* is performing well within the network constraints



Results - Fairness

- *Maximise NEM Export* & *Policy Based* perform poorly in all three fairness metrics. Best performance is in *Quality of Service,* due to the link with technical performance.
- Due to poor technical performance, *Equal Individual Conservation* performs poorly in *Regional* network for *Quality of Service* and *Min-Max Fairness Ratio.* Performs better in *Quality of Experience.*
- *Proportional Asset* performs perfectly across all fairness metrics

Results – Correlation Between Metrics

City	*NU*	*DCU*	*RU*	*QoS*	*QoE*	*MMF*	*RSW*
Network Utilisation	1.00						
DER Capacity Utilisation	-0.03	1.00					
Renewables Utilisation	-0.29	0.92	1.00				
Quality of Service	-0.77	0.20	0.42	1.00			
Quality of Experience	-0.74	-0.05	0.19	0.89	1.00		
Min-Max Fairness	-0.61	0.14	0.31	0.79	0.87	1.00	
Relative Social Welfare	0.74	0.56	0.29	-0.52	-0.60	-0.39	1.00

Suburban	*NU*	*DCU*	*RU*	*QoS*	*QoE*	*MMF*	*RSW*
Network Utilisation	1.00						
DER Capacity Utilisation	0.15	1.00					
Renewables Utilisation	-0.01	0.86	1.00				
Quality of Service	-0.28	0.18	0.36	1.00			
Quality of Experience	-0.27	-0.05	0.11	0.88	1.00		
Min-Max Fairness	-0.26	0.08	0.21	0.74	0.89	1.00	
Relative Social Welfare	0.17	0.99	0.85	0.11	-0.12	0.01	1.00

Regional	*NU*	*DCU*	*RU*	*QoS*	*QoE*	*MMF*	*RSW*
Network Utilisation	1.00						
DER Capacity Utilisation	0.33	1.00					
Renewables Utilisation	0.26	0.97	1.00				
Quality of Service	-0.12	0.33	0.43	1.00			
Quality of Experience	-0.64	-0.22	-0.07	0.57	1.00		
Min-Max Fairness	-0.23	0.29	0.40	0.77	0.64	1.00	
Relative Social Welfare	0.59	0.88	0.79	0.14	-0.58	0.04	1.00

- In *City*, strong negative correlation between *Network Utilisation* and fairness metrics -> increasing *Network Utilisation* = decreasing fairness.
- Correlation weaker in *Suburban* network as *Suburban* is less constrained, so often allocates high % of capacity, so performs well in fairness metrics.
- In *Regional* only negative correlation between *Network Utilisation* and *Quality of Experience* is significant. This is because *Equal Individual Conservation* bucks the trend and performs poorly in both *Network Utilisation* **and** *Quality of Service / Min-Max Fairness.*
- *Network Utilisation* and *DER Capacity Utilisation* not strongly correlated as, once network is congested, increasing DER may not increase *Network Utilisation*, but will result in a reduction in *DER Capacity Utilisation.*
- In general strong positive correlation between *Network Utilisation / DER Capacity Utilisation* and *Relative Social Welfare.*
- **In general, trade of between fairness and network utilisation is seen.**

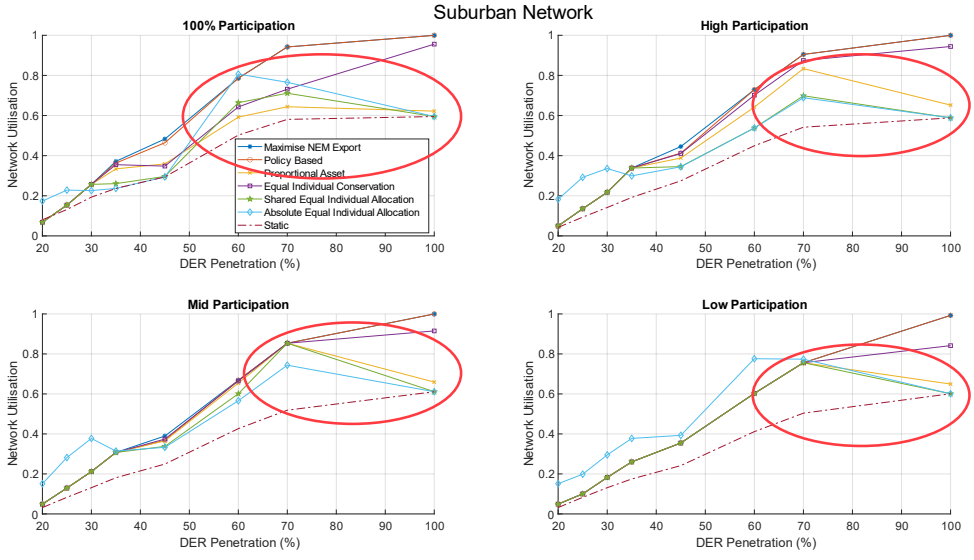
In *City,* there is a significant negative correlation between *Network Utilisation* and the three fairness metrics. This aligns with the results that we have observed thus far. For the *Suburban* network, this negative correlation occurs, but is much less significant. This is due to the fact that the *Suburban* network is less constrained and has a more gradual introduction of DER (due to the lack of commercial DER customers). Therefore, *Maximise NEM Export* and *Policy Based* manage to perform well in the fairness metrics for a more significant portion of the studied scenarios. Thus, the trade-off between technical perform and fairness occurs later in the DER penetration levels, and so is a smaller proportion of the results, leading to a weaker correlation. For the *Regional* network the negative correlation between *Network Utilisation* and *Quality of Experience* is significant, but for the other two fairness metrics it is less so. This can be attributed to the *Equal Individual Conservation* DOE objective. This objective performs so poorly in *Network Utilisation* in the *Regional* network that it also performs very poorly in *Quality of Service* and *Min-Max Fairness Ratio.* This does not fit the pattern of poor performance in *Network Utilisation* leading to high performance in the fairness metrics. However, in *Quality of Experience, Equal Individual Conservation* does perform well, and so we see the strong negative correlation.

Network Utilisation and *DER Capacity Utilisation* are not strongly positively correlated because, once a network is congested, adding additional DER may not result in significant additional *Network Utilisation,* but will result in a reduction of *DER Capacity Utilisation*. This changing behaviour in *DER Capacity Utilisation* once the network is heavily congested means that it does not have a strong correlation with *Network Utilisation* or any of the fairness metrics. This is similarly why *Renewables Utilisation* does not have a strong positive correlation.

It is expected that *Network Utilisation* and *DER Capacity Utilisation* would have significant positive correlation with *Relative Social Welfare*. This is true in most cases, except for *Suburban* network, where the positive correlation between *Network Utilisation* and *Relative Social Welfare* isn't very strong. This can be attributed to the more gradual increase in total DER capacity installed in the *Suburban* network (due to the lack of commercial customers with DER). This means that for lower DER penetrations, *Network Utilisation* would be low, but *DER Capacity Utilisation* and *Relative Social Welfare* very high. As DER penetration increases, *Network Utilisation* increases but the network will start becoming more constrained. This is where it is likely that the drops in *Relative Social Welfare* will occur, where centralised control of DER would assist in unlocking additional capacity. So as *Network Utilisation* increases, *Relative Social Welfare* remains fairly constant, and once *Network Utilisation* becomes fairly constant, *Relative Social Welfare* starts decreasing. This is why a strong correlation is not seen in this case.

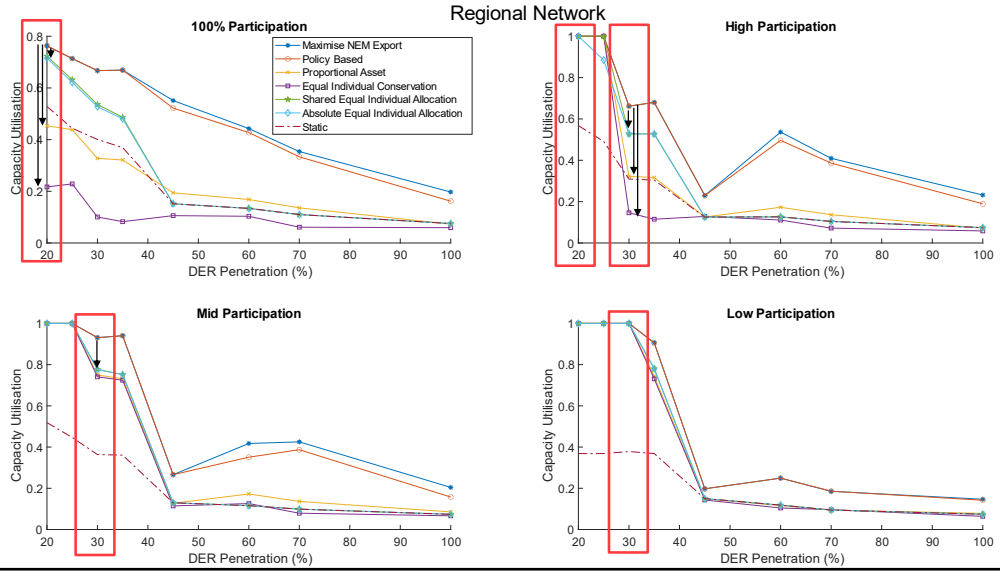
Impact of Changing DER Penetration

- "Fairness-focused" DOE objectives can lead to reduced *Network Utilisation* at higher DER Penetration levels.



Impact of Changing DER Participation

- Increased DER Participation can reduce the DER Capacity that "fairness-focused" DOE objectives can allocate



Key Takeaways

- ***Reminder:*** *Fairness metrics are measuring the fairness of the capacity allocation from the point of view of the participating customers only. The "fairness-focused" DOE objectives are only trying to be fair to actively participating customers (who have DER).*

- *Maximise NEM Export* and *Policy Based* **consistently outperform** *Equal Individual Conservation, Proportional Asset, Shared Equal Individual Allocation*, and Absolute Equal Individual Allocation in Network Utilisation and DER Capacity Utilisation **by 7– 30%** on average depending on the network and DOE objective chosen.
- A similar jump in performance is seen for *Relative Social Welfare* with **an average difference of 10-55%** depending on network and DOE objective.
- The trade-off is poor performance in the fairness metrics – although it is seen that some "fairness-focused" DOE objectives can perform worse in the fairness metrics too.
- **Additional DER participation** in the DER marketplace can cause a **drop in the capacity allocated** from the **"fairness-focused"** DOE objectives
- **High DER penetration** can cause "**fairness-focused**" DOE objectives to become **less effective** at **unlocking network exports**.
- When the network becomes constrained, there is **a negative correlation** between *Network Utilisation* and the three-fairness metrics.
- It seems that **considering the "fairness"** of the capacity allocation **only from the point of view of a small subset of DER customers** is **not in the interest of all customers in the NEM**. Increasing system technical and economic efficiency is likely to maximise fairness from a whole-of-system perspective.

Any other business

Next meeting:
8 December 2022

Future Meetings & Close

Project EDGE Publications

Publications	Publication Date
Project EDGE: Community Perceptions of DER & Aggregation Services	November 2022
Project EDGE: Literature Review : DER Customer Insights Research	October 2022
Project EDGE CBA Methodology Consultation Paper	July 2022
Project EDGE Public Interim Report	June 2022
Project EDGE Customer Insights Study	June 2022
Project EDGE Research Plan	March 2022
Project EDGE MVP Showcase	December 2021
Project EDGE Lessons Learned Report #1	May 2021
Project EDGE Public Webinar #1	March 2021
Project EDGE Factsheet	January 2021

For further news and knowledge sharing publications, please visit the Project EDGE website

For any questions, comments or feedback please contact: EDGE@aemo.com.au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