THE UNIVERSITY OF MELBOURNE

Melbourne Energy Institute

Public lecture: renewing the social contract for interacting with the grid

energy.unimelb.edu.au

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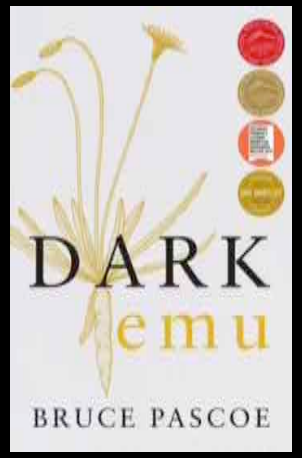
A DER Bill of Rights and Responsibilities

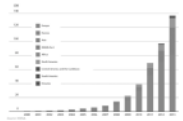
Dr Niraj Lal, Visiting Fellow ANU Centre for Sustainable Energy Systems

I acknowledge the traditional owners of this land,
and pay my respects to Elders



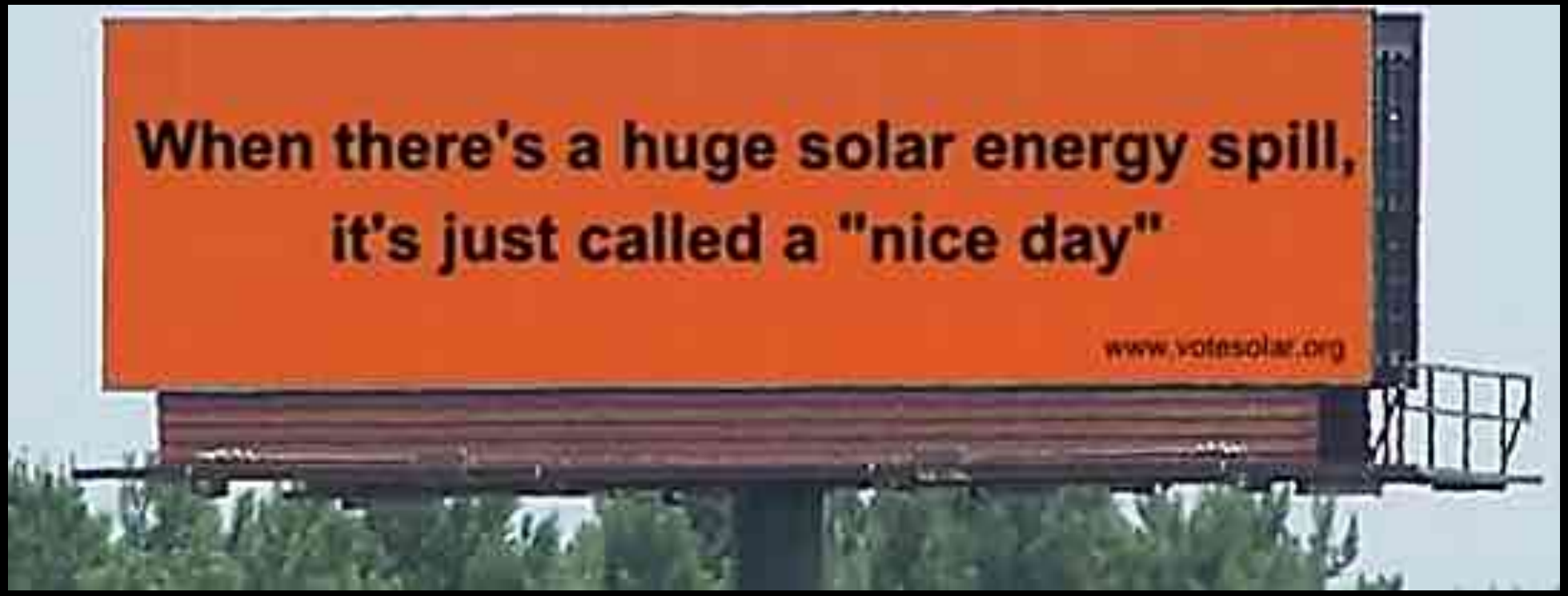
Outline

- Context
- Current status
- International progress
- Principles for DER integration
- An Australian DER Bill of Rights and Responsibilities
  - Consumption, Generation, Storage, Data, Default Settings
- Pathways, implications, and next steps

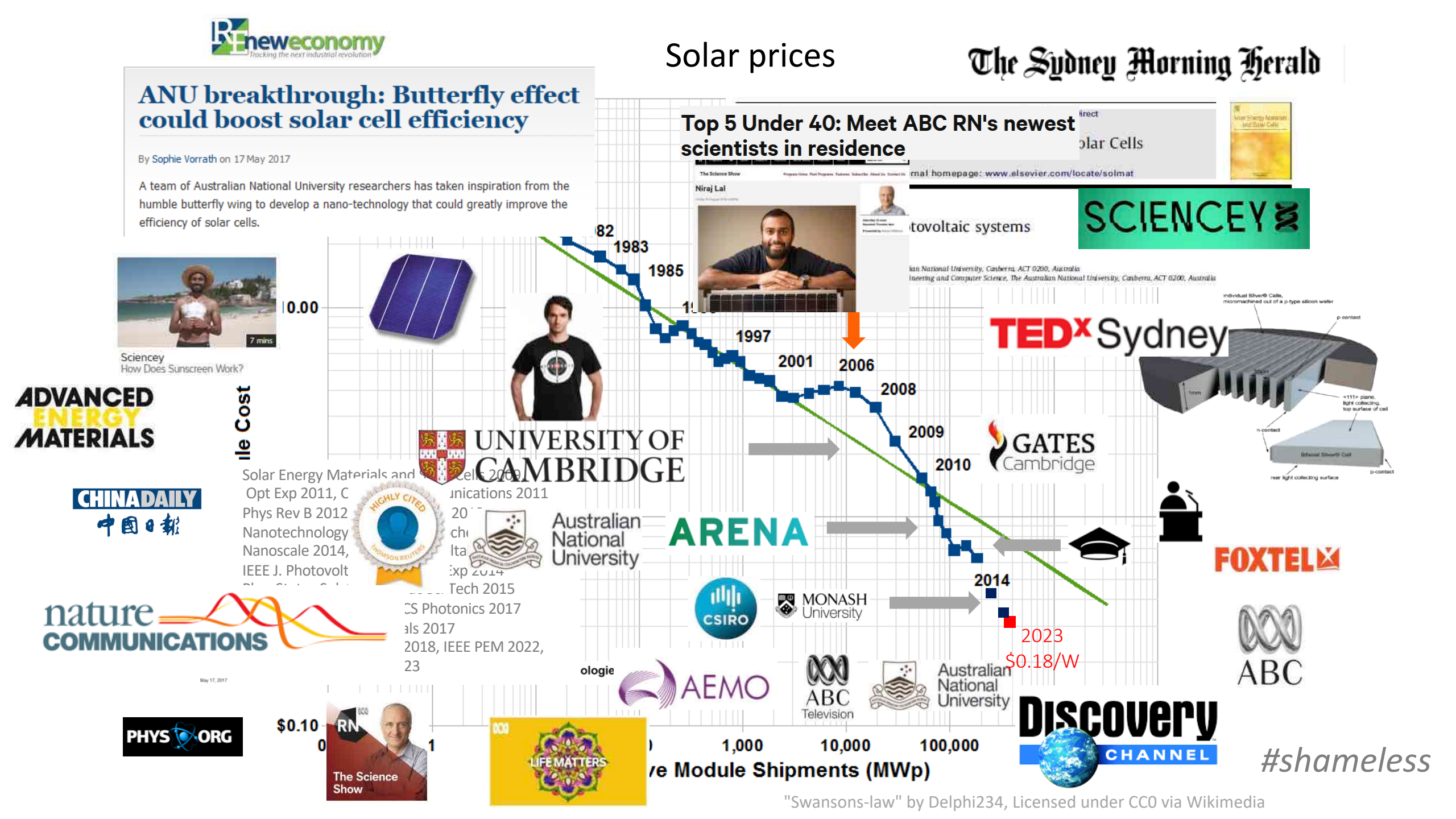


STANDARDS Australia

ENERGY SECURITY BOARD

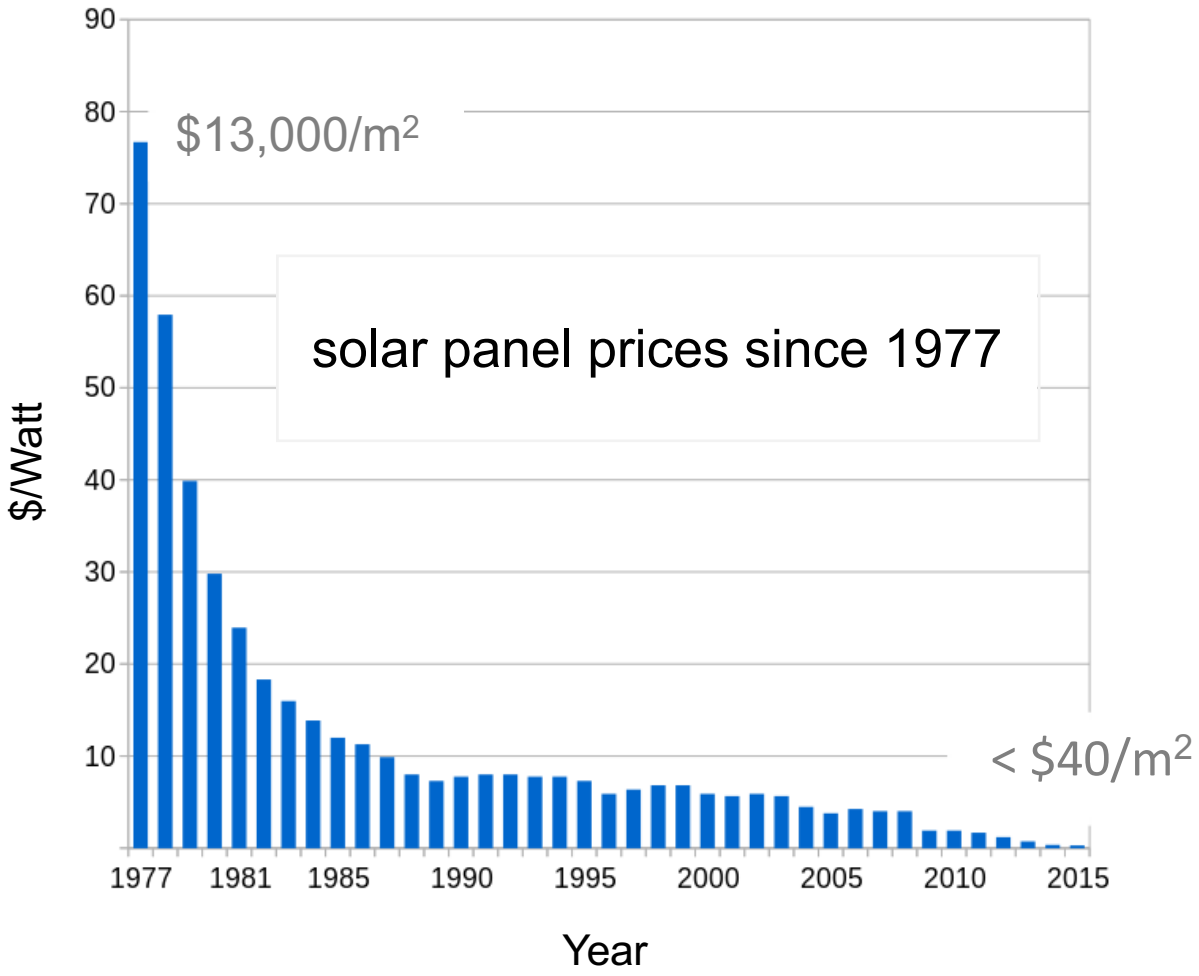

When there's a huge solar energy spill,
it's just called a "nice day"
www.votesolar.org

Solar prices



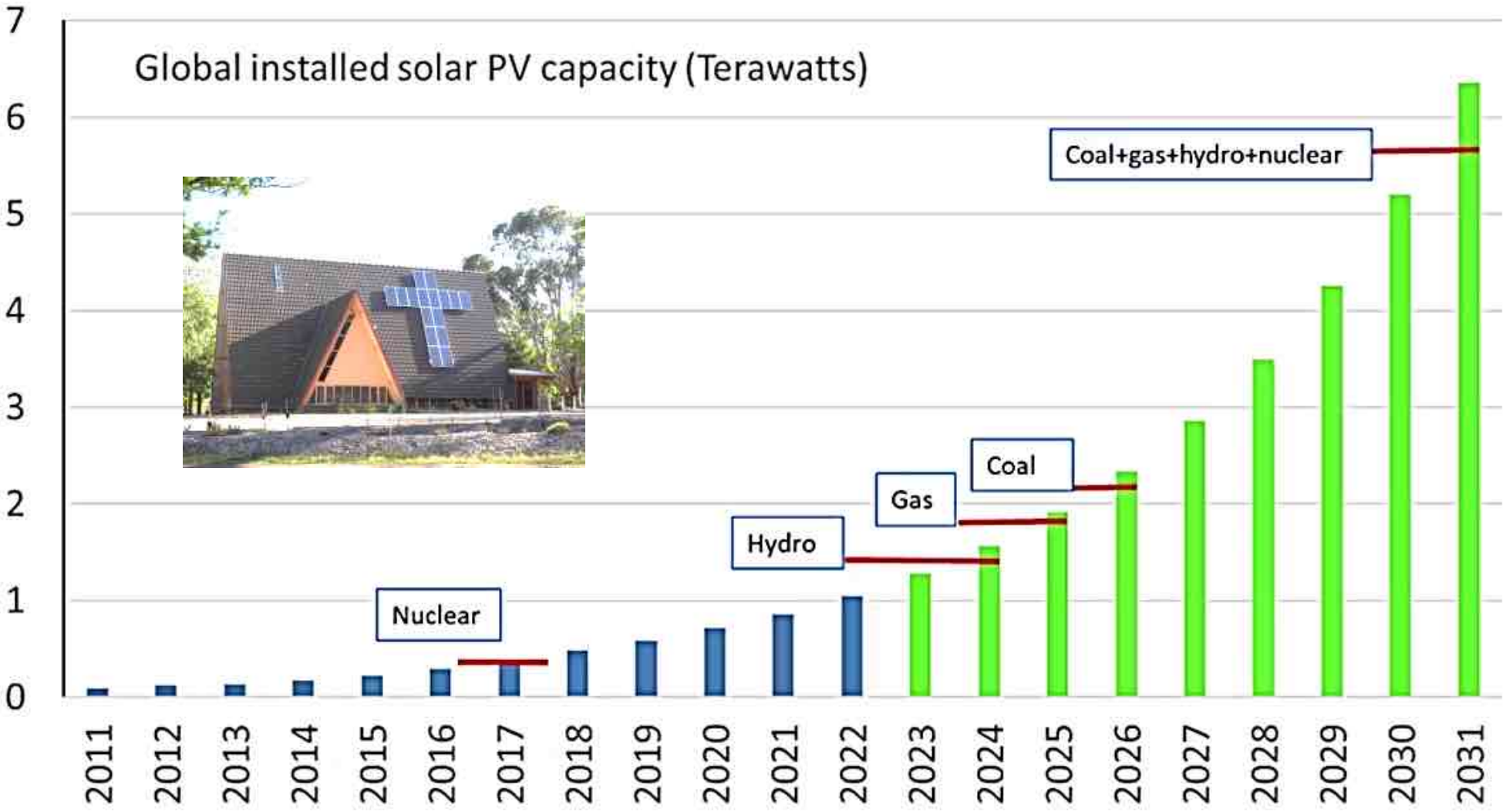
"Swansons-law" by Delphi234, Licensed under CC0 via Wikimedia

solar panels are cheaper than marine-grade plywood



Source: Bloomberg New Energy Finance

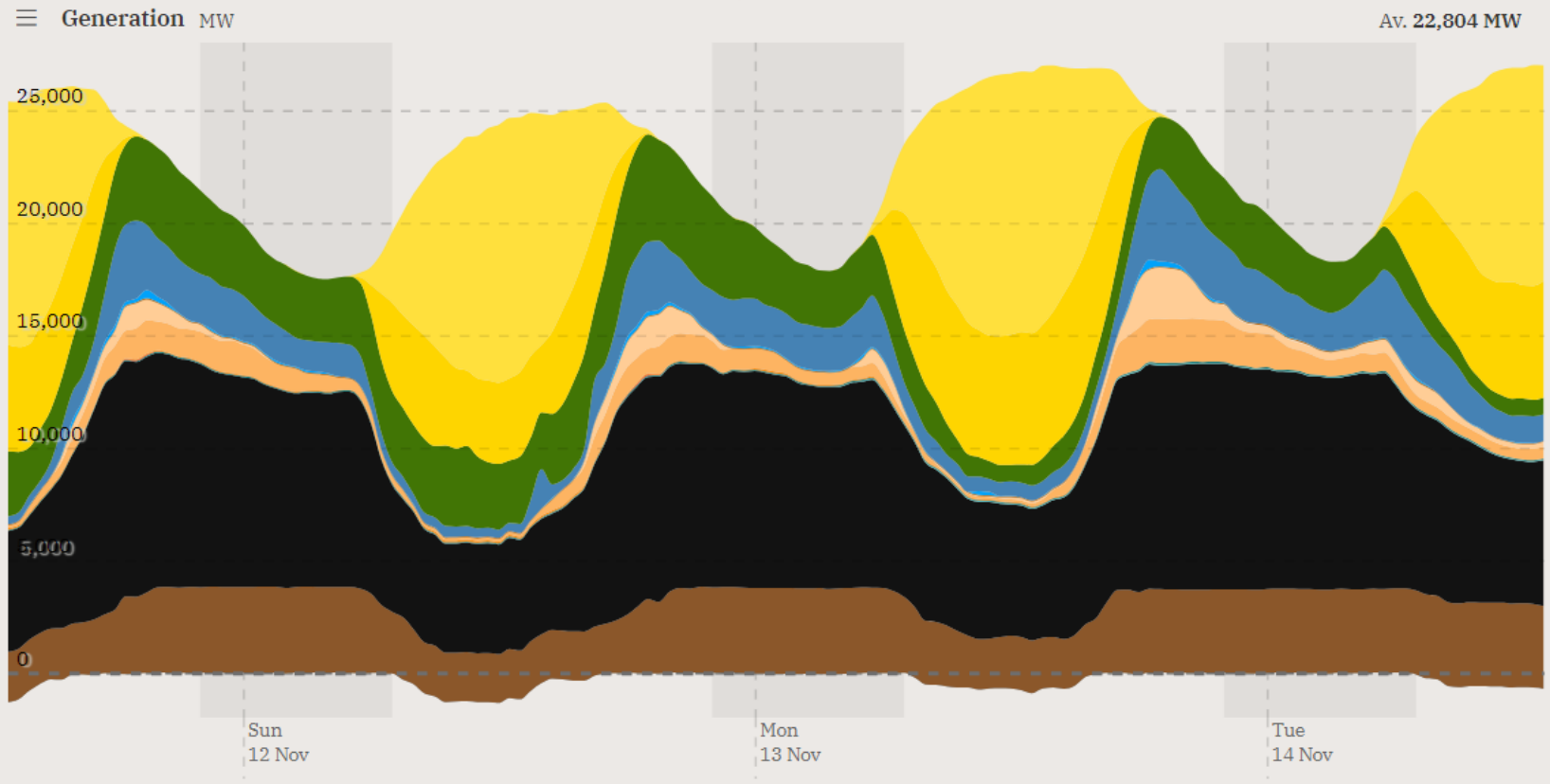
more solar now being installed than anything else

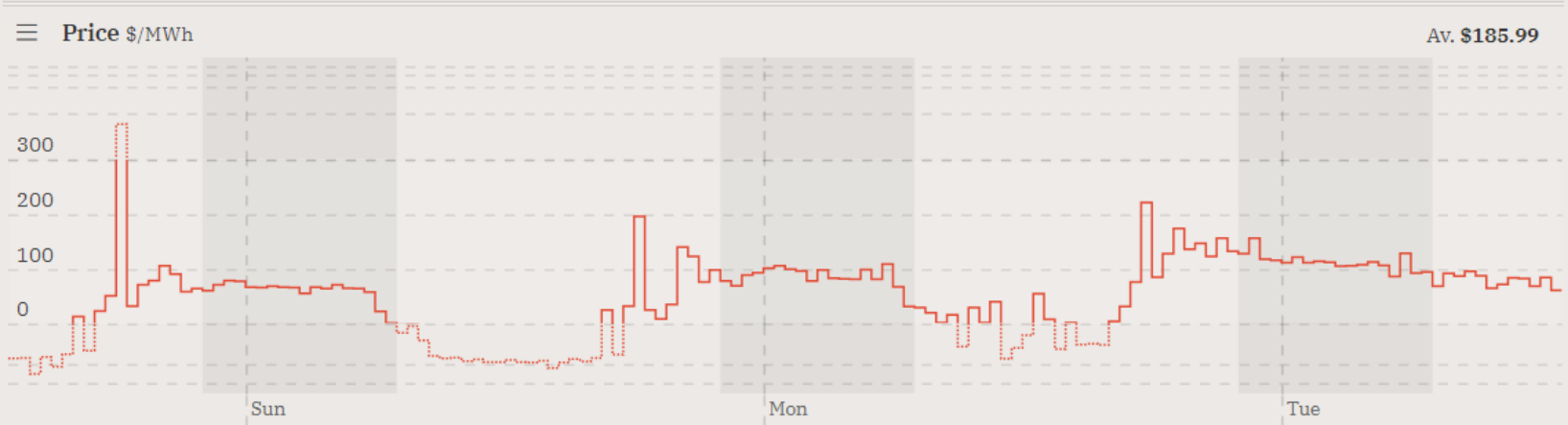


from Blakers, A. 2023, IRENA, GEM

IRENA
International Renewable Energy Agency

the current generation mix



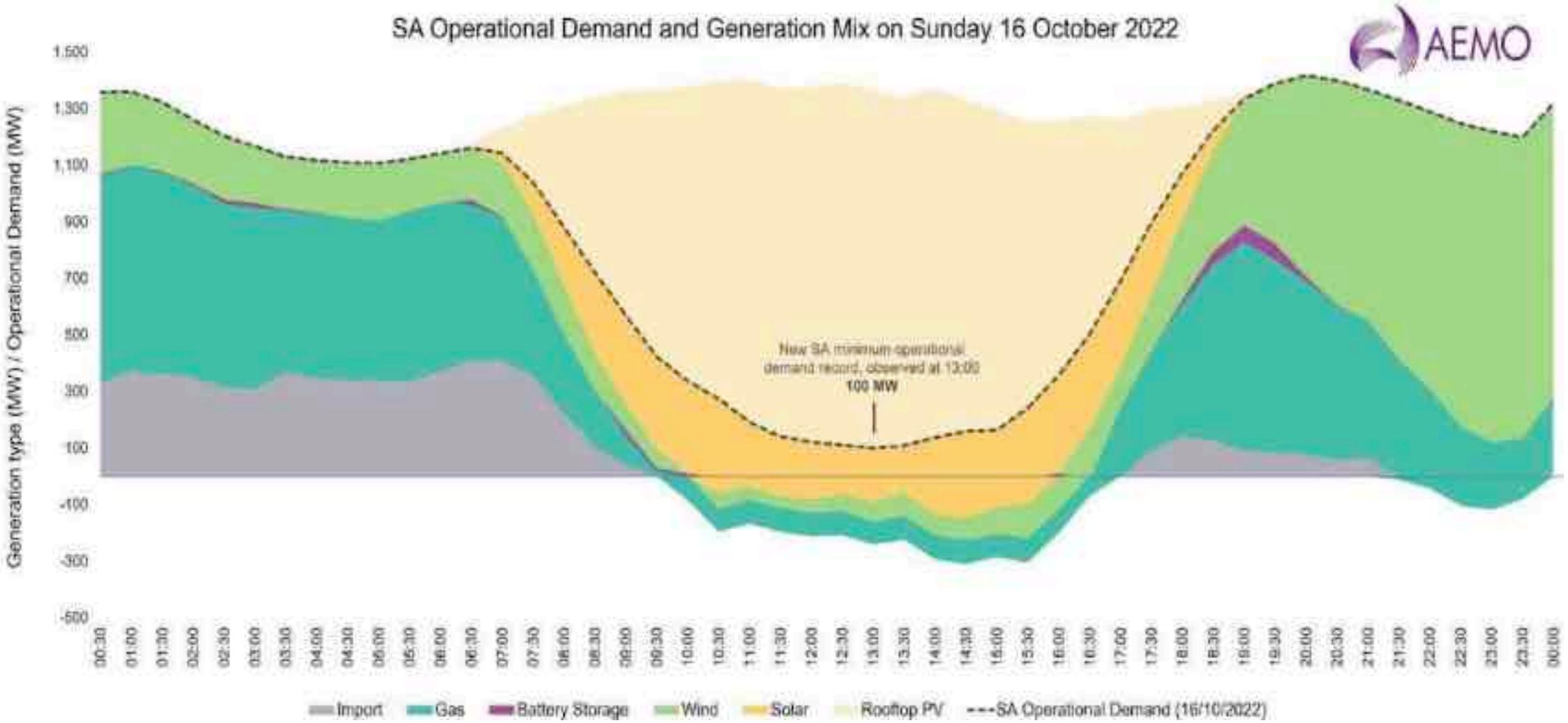


11 Nov 2023, 1:00 PM – 14 Nov 2023, 1:00 PM AEST

Detailed

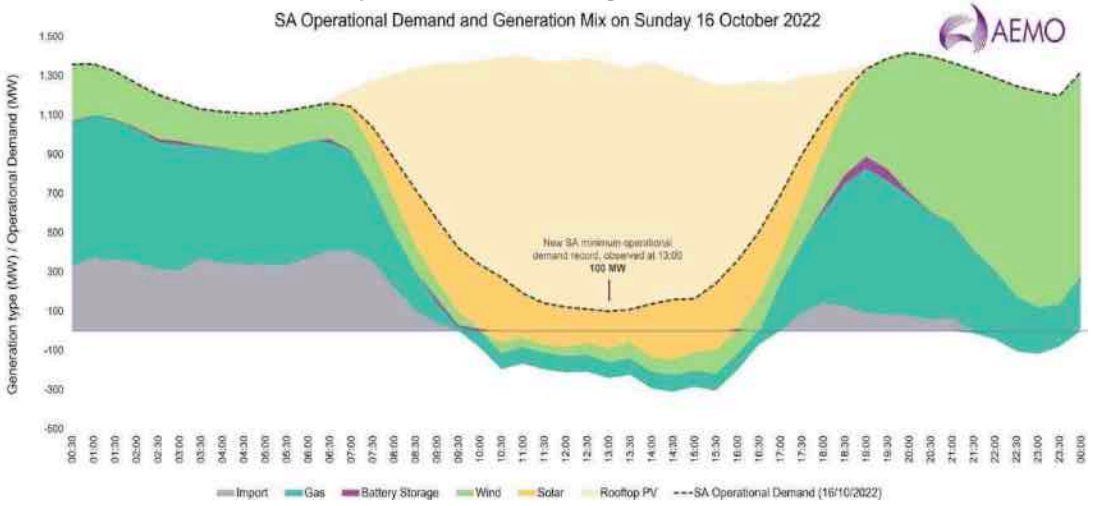
	Energy GWh	Contribution to demand	Av.Value $/MWh
Sources			
Solar (Rooftop)	273	16.4%	$1.29
Solar (Utility)	163	9.8%	$14.52
Wind	190	11.5%	$63.15
Hydro	120	7.2%	$93.42
Battery (Discharging)	4.0	0.2%	$105.38
Gas (Waste Coal Mine)	3.2	0.2%	$60.32
Gas (Reciprocating)	0.2	0.01%	$105.74
Gas (OCGT)	26.4	1.6%	$108.77
Gas (CCGT)	56	3.4%	$91.14
Gas (Steam)	2.8	0.2%	$25.96
Distillate	0.1	0.009%	$73.43
Bioenergy (Biomass)	3.5	0.2%	$66.41
Bioenergy (Biogas)	1.5	0.09%	$63.32
Coal (Black)	583	35.1%	$72.89
Coal (Brown)	232	14.0%	$69.18
Loads	**19.5**		
Pumps	14.7	0.9%	-$7.69
Battery (Charging)	4.9	0.3%	$7.61
Net	**1,678**		
Renewables	**760**	**45.4%**	

the new generation mix in South Australia

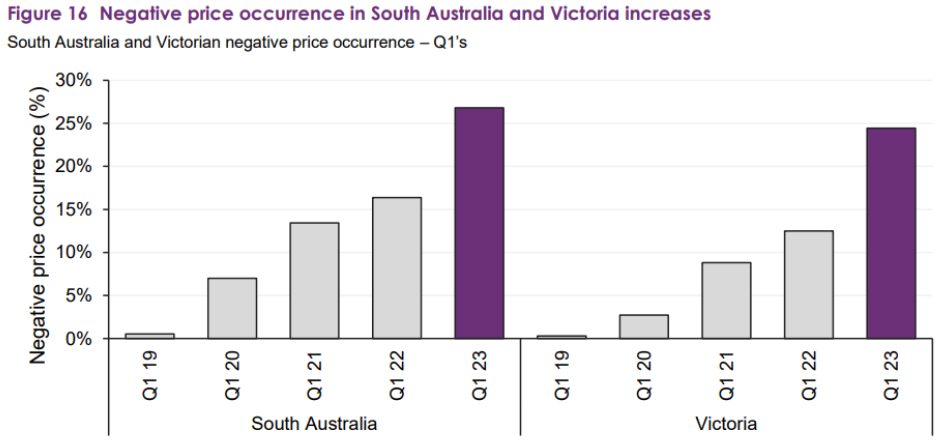


Solar PV penetration in Australia is now impacting grid security

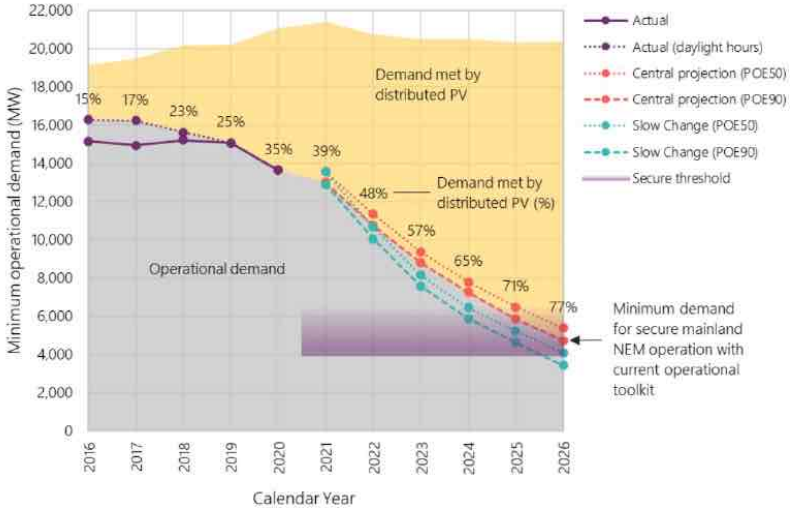
Rooftop solar reaching 100% of demand in SA



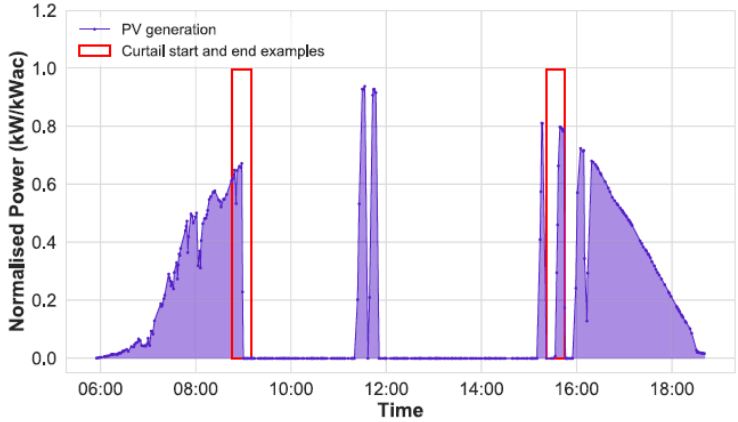
Prices were < 0, more than half of all daylight hrs in SA & VIC in Q1 - Q2 2023



Rooftop PV projected to supply 70-80% of NEM mainland demand by 2026



Rooftop PV curtailment due to high network voltages $1.2-4.5m in lost generation over a year in SA



Stringer et al. Renewable Energy 173 (2021) 972-986

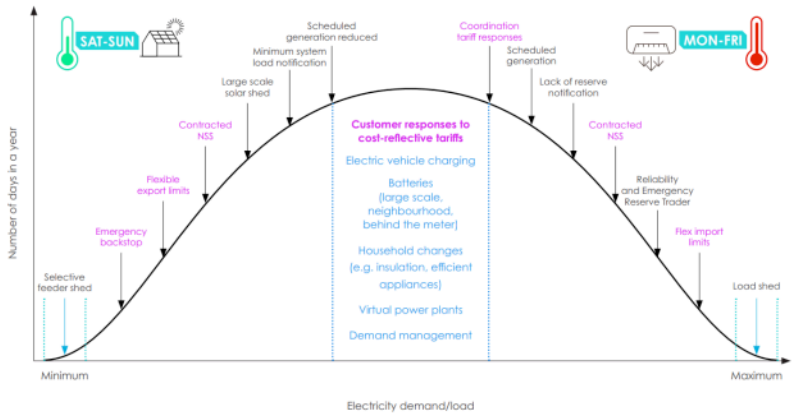
Managing high DER penetration: new functional requirements

What's fair?

New Minimum System Load procedures

A DER-*dominated* grid will require

- Emergency disconnection capability
- Export curtailment
- Mandatory technical system support
- Additional cybersecurity
- Visibility and forecasts of DER operation
- + …



How fair is it if:

- Solar owners aren't always able to self-consume generated energy due to curtailment.
- Solar owners get paid to export electricity when prices are negative, with costs borne by all.
- Non-solar owners pay the costs of distribution build to accommodate solar PV exports, without seeing a reduction in bills.

Rooftop solar switched off in South Australia, as state isolated after storm damage to network

Giles Parkinson 13 November 2022 81

Solar switch-off a must for all states, says AEMO, to control "seven Erarings" of rooftop PV

Sophie Vorrath 9 October 2023 43

Power to the people: Why rooftop solar is key to Australia's renewables target

Rachel Williamson 9 October 2023 30

The regulatory environment was not designed for high DER penetration
Reform is occurring at pace, challenges with customer engagement

AEMC

National Energy Customer Framework

Scheduled Lite

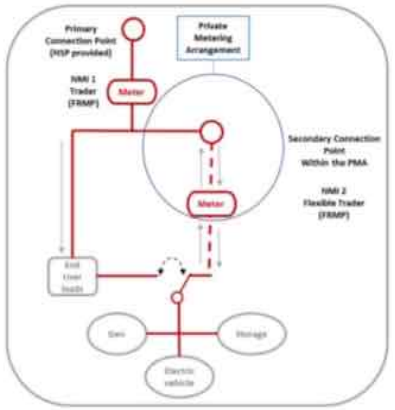
ENERGY SECURITY BOARD

MATURITY PLAN
PILOT
CO-DESIGN
KNOWLEDGE SHARE

The Energy Charter

Access, pricing and incentive arrangements for distributed energy resources

Flexible Trading Arrangements



STANDARDS Australia

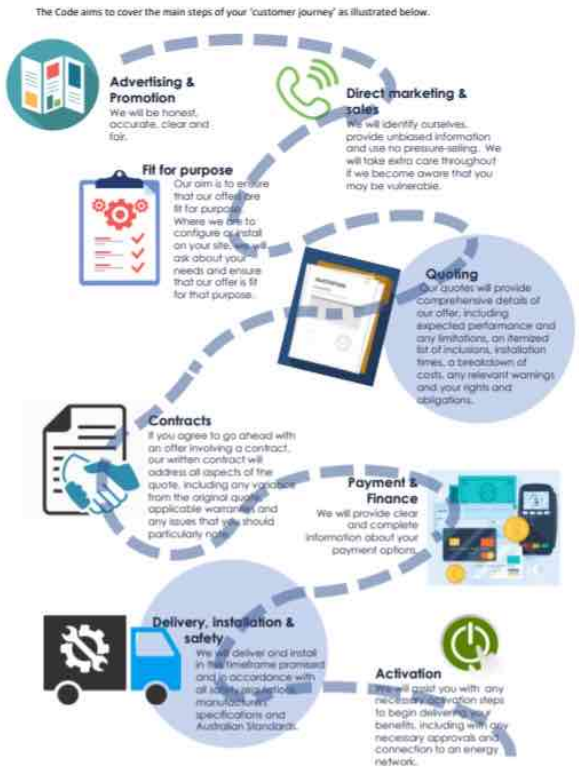
Australian/New Zealand Standard™

Grid connection of energy systems via inverters

Part 2: Inverter requirements

IEEE 2030.5-2018 - IEEE Standard for Smart Energy Profile Application Protocol

New Energy Tech Consumer Code



Consumer Data Right for Energy

ARENA

Distributed Energy Integration Program (DEIP)

AUSTRALIAN ENERGY REGULATOR

AEMO Consumer Forum

Simple policy questions remain unanswered

- What should a customer's right be to self-consume the electricity they've generated with their own panels?
- What obligations should accompany customers who want to make money in energy markets?
- How should networks allocate export capability to customers?
- How should networks accommodate fast-chargers for EVs?
- How much should non-DER owners bear the costs of network build?

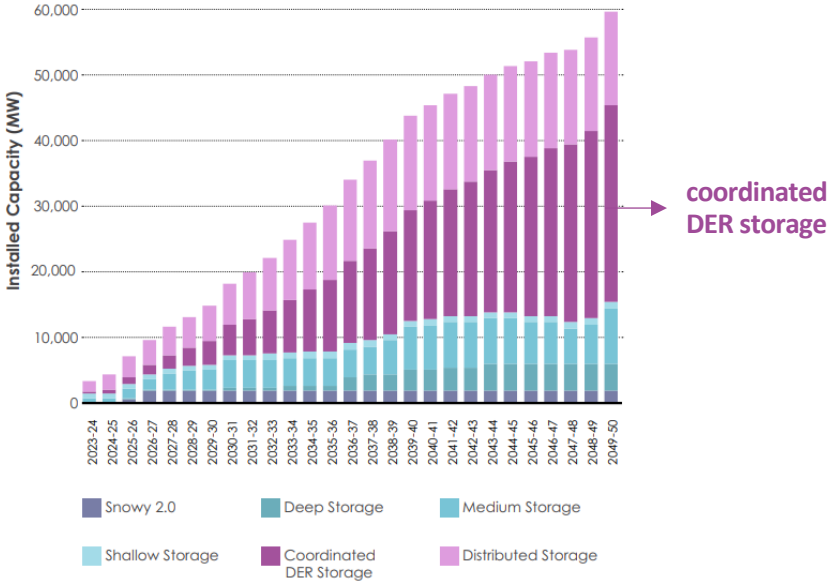
AEMO's latest Electricity Statement of Opportunities:

"There is an opportunity for consumers' rooftop solar, batteries and electric vehicles to actively participate in the power system to further reduce reliability risks."

But also

"Solutions which coordinate consumers' energy storage devices (e.g., batteries for solar) to support reliability are coming online at a lower rate than previously assumed."

AEMO 2022 Integrated System Plan



Current status

Solar owners get paid to export electricity when prices are negative, with costs borne by all.

Solar owners aren't always able to self-consume generated energy due to curtailment.

Non-solar owners pay the costs of distribution build to accommodate solar PV exports, without seeing a reduction in bills.

Status quo

Network continues to be built to accommodate solar exports and EV charging, costs recovered regressively through network fees

Rooftop solar is increasingly curtailed impacting both self-consumption and export. Feed-in tariffs continue to decrease.

Introduction of various time-of-use tariff structures and charges, slower-than-expected third-party aggregation/retail takeup

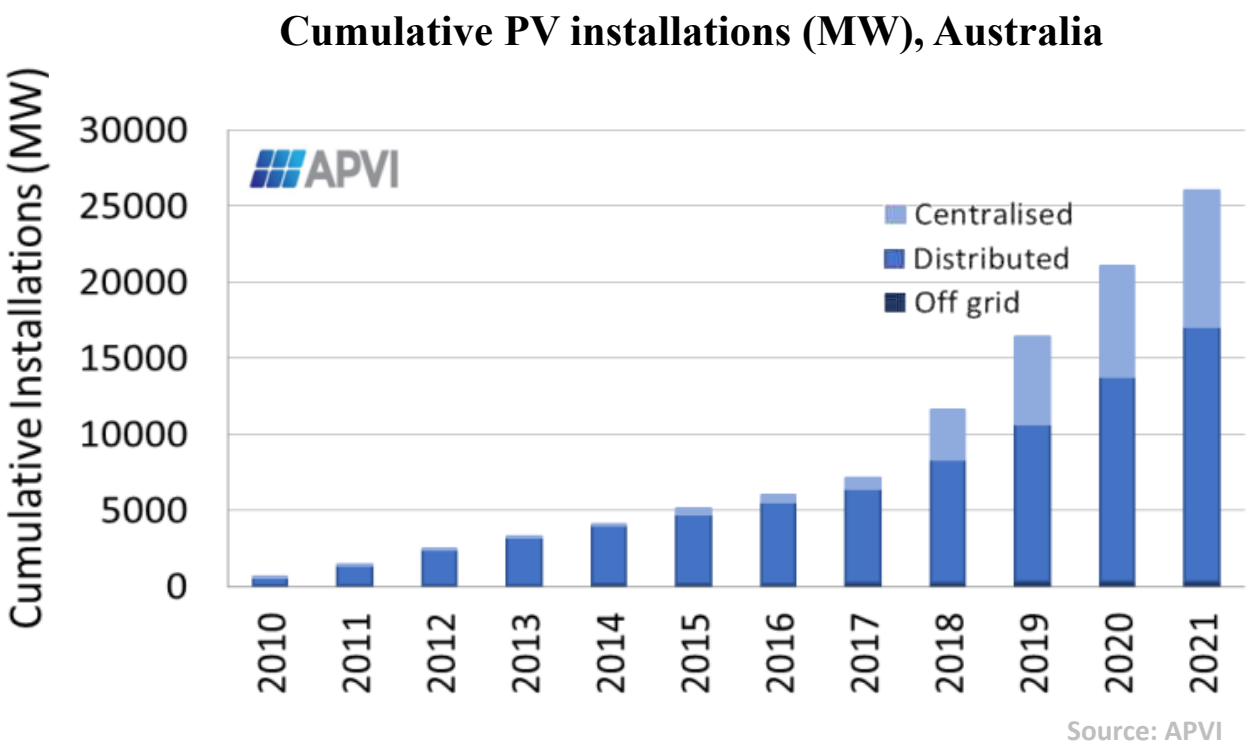
Dynamic network connections support flexible exports, unclear translatability to flexible imports (e.g., EV charging)

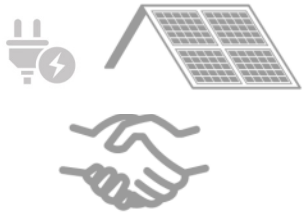
Options for decision makers

1. Continue with the status quo framework of feed-in-tariffs, ad-hoc curtailment and shared distribution costs, with associated cross-subsidies and injustices, or

2. Support DER to contribute to lower system costs for all (including non-DER owners). This will require a new social contract with DER owners to support mutually beneficial interaction with the electricity system without requiring increased technical, financial or regulatory engagement.

The social contract of connecting to the grid must evolve with high DER penetration





1888	1970s	2000s	2010s	2020s+
First grid Tamworth, NSW	first solar PV connections	PV uptake accelerates	Australia global leader in PV penetration	distributed PV regularly providing majority generation
reliability standard	**inverter standards**	**PV subsidies + feed in tariffs**	**feed in tariffs decrease curtailment commences**	**rapid feed-in tariff decrease regular DER curtailment** **need for a two-way social contract >>**

USA jurisdictions have progressed with rights of DER connection and export…
…but haven't considered DER-*dominated* grids

New York, 2021

Homeowner Associations are prohibited from adopting "any rules or regulations that would effectively prohibit, or impose unreasonable limitations on, the installation or use of solar power systems".

Unreasonable limitations include (1) Limitations that inhibit the solar power system from functioning at maximum efficiency, and (2) Limitations that increase costs greater than 10% of the total cost of the installation of the solar power system (State of New York 2021).

California

Solar Bill of Rights S-288 proposed in 2019. Final passed bill removed all references to 'Solar Rights'.

Nevada – Renewable Energy Bill of Rights, 2017

1. Generate, consume and export renewable energy and reduce his or her use of electricity that is obtained from the grid.
2. Use technology to store energy at his or her residence.
3. If the person generates or stores energy be allowed to connect his or her system:
   (a) In a timely manner;
   (b) In accordance with requirements established by the electric utility to ensure the safety of utility workers; and
   (c) After providing written notice to the electric utility providing service in the service territory and installing a nomenclature plate on the electrical meter panel indicating that a system that generates renewable energy or stores energy, or any combination thereof, is present if the system:
   (1) Is not used for exporting renewable energy past the electric utility meter on the customer's side; and
   (2) Meets all applicable state and local safety and electrical code requirements.
4. Fair credit for any energy exported to the grid.
5. Consumer protections in contracts for renewable energy.
6. Have his or her generation of renewable energy given priority in planning and acquisition of energy resources by an electric utility.
7. Remain within the existing broad rate class to which the resident would belong in the absence of a net metering system or a system that generates renewable energy or stores energy, or any combination thereof, without any fees or charges that are different than the fees and charges assessed to customers of the same rate class, regardless of the technologies on the customer's side of the electricity meter, including, without limitation, energy production, energy savings, energy consumption, energy storage or energy shifting technologies, provided that such technologies do not compromise the safety and reliability of the utility grid.

Nevada: 70,000 solar DPV systems - 400 MW capacity

Grid: 3.1million customers, peak demand ~ 12 GW

South Australia: 300,000 solar DPV systems - 1.5 GW capacity

Grid: 1.7million customers, peak demand ~ 3.5 GW.

Who gets to decide? Who's listening to people?

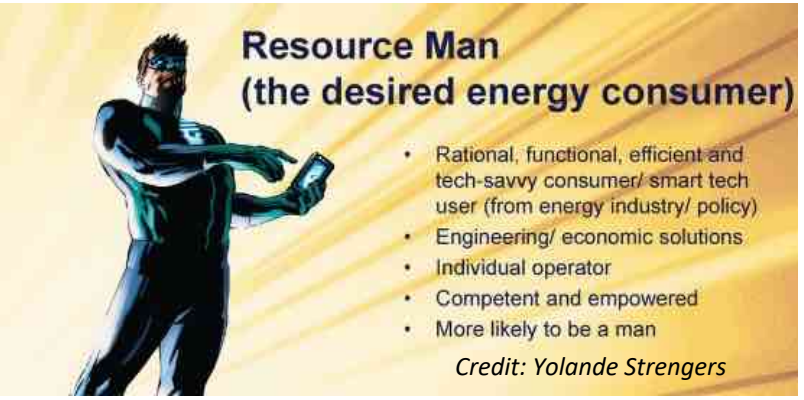
ELSEVIER

Energy Research & Social Science
Volume 102, August 2023, 103191

Original research article

Automated and absent: How people and households are accounted for in industry energy scenarios

F. Kaviani, Y. Strengers, K. Dahlgren, H. Korsmeyer



Credit: Yolande Strengers

*"My own view is that the idea of **people participating in markets with their CER/DER is bonkers** (that's my newly coined technical term!)...*

*"I don't think we can have a conversations about rights responsibilities without an exploration and an understanding of the institutional/governance structure that could resolve the fundamentals of what DER technologies throw up (**namely equity, governance and generating values in a simple way that make sense for system integrity and for people**.*

***A market structure is patently unable to resolve these issues**; and neither are there technological or tariff solutions to them."*

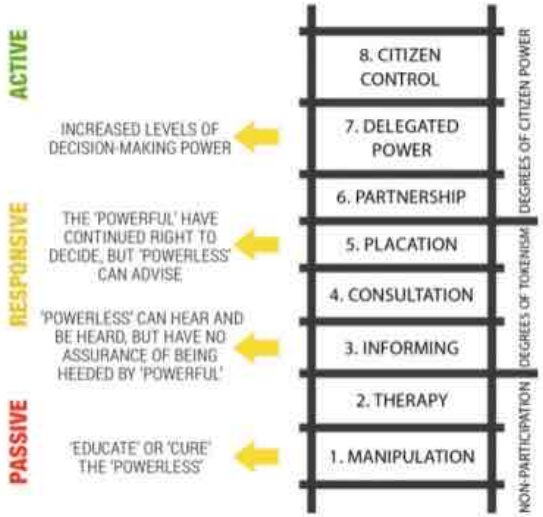
*"I think state governments should know better as should consumer groups. I think they are starting to, but have no ready solutions. They are trying to protect people from the market but do this in a piece-meal, hodge podge way that doesn't resolve the fundamental contradictions**. The bureaucrats at least have been sadly distracted by ideas like VPPs** which simply will not work/create new policy problems. They suffer from being convinced by **shiny innovation talk**."*

"**Consumers tend not to be included until very late** after the main decisions are made" … "Just about every reform I have seen over the past few years has "increasing choice" as a stated objective. Which often translates into **more decisions to be made by consumers**. "

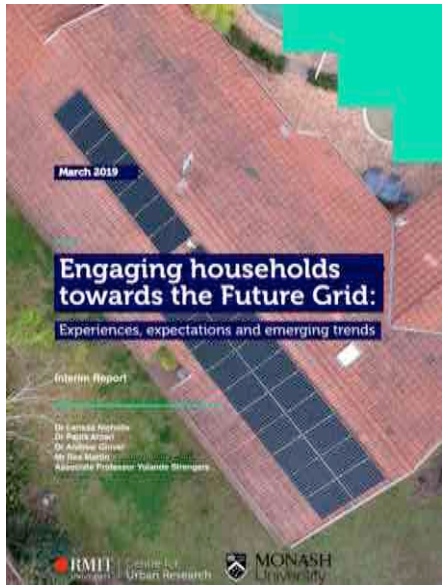
- Leading energy social science researchers

The approach

Source: Co-Creating Well-Being Learning Hub



Ladder of Participation
Source: Arnstein 1996



Customers in mind:

Low-income households with English as a second language. Distrustful of energy companies, not on the cheapest tariff and unlikely to switch. DER-owners have solar panels and are under mortgage-stress. DER non-owners are renting and under renting stress.

apples

an analogy for DER owners to support fairness for all

Solar panels should probably one day be thought of more like apple trees:

- Guaranteed rights to eat your own apples, make crumble, cider, whatever you'd like.
- Selling apples for profit comes with responsibilities to not carry Codling Moth, meet quality requirements, schedule pickups with trucks, interact with the market, etc.
- Prices depend on the availability of trucks and local market value. Tricky if you live in an apple district and no-one wants your apples.
- Maybe you or our government could pay more for trucks for everyone to be able to sell apples all the time but it probably wouldn't be efficient or fair.
- No worries to share or store apples with your local co-op if you can wheelbarrow them down there.

The main distinction is between growing for yourself and selling for profit.

“give a little to get a little"

(The analogy obviously falls apart somewhere – apples aren’t an essential service, supply/demand of apples doesn't need to be balanced every second, Volt-Var for apples is strange, but perhaps the fundamental principles remain - especially for a future where apple trees and apple warehouses are absolutely everywhere….)

DER Bill of Rights and Responsibilities

Principles

1. Support system security and reliability with high DER penetration.
2. Preserve the precedent of fair energy use by reasonable passive loads.
3. Allow the self-use of self-generated electricity.
4. Additional obligations for customers that wish to participate actively
5. Symmetric treatment between large-scale and small-scale resources.
6. Right to privacy, access, and fair share of value of data
7. Passive options are the default, active settings enacted only if net customer benefit, right to revert
8. To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
1. Energy Consumption	1.1 (normal loads)	1.2 (active loads)
2. Energy Generation	2.1 (self-consumption)	2.2 (exports)
3. Energy Storage	3.1 (storing own energy)	3.2 (storing grid energy)
4. Energy Data	4.1 (rights to privacy)	4.2 (obligations)
5. Default Settings	5.1 (passive as default)	5.2 (right to revert)

Lal, N.N. and Brown. L, (2023), The Electricity Journal

An Australian DER Bill of Rights and Responsibilities

Energy Consumption

Principles

- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
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- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default, active settings enacted only if net customer benefit, right to revert
- To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
1. Energy Consumption	Right to connect and consume energy at fair prices for reasonable passive loads that do not participate in energy markets. Some loads may be required to be actively connected based on threshold kW/kWh consumption*. Electricity supply for passive loads should meet the Reliability Standard. Example passive loads include hair-dryers, toasters or dialysis machines. *For example, electric vehicle charging points. ?Right to resilience – including to not be susceptible to undue third-party control ?Right to repair - products should be able to be repaired by a third-party at a fair price.	Right to own active loads that participate in energy markets. When connected, active loads may be subjected to obligations to: i) meet additional technical standards for active grid support ii) register resource details at time of connection iii) allow remote control and/or disconnection for credible risks to system security iv) provide good-faith scheduling information to market and/or network operators. Right to switch active loads back to passive settings (noting that some loads may be required to be active) Active loads are treated and remunerated symmetrically with large-scale loads where possible and efficient. Example active loads include electric hot-water storage systems, pool pumps, or electric vehicle charging points that participate in grid demand management programs or are otherwise market responsive.

Lal, N.N. and Brown, L., (2023), The Electricity Journal

An Australian DER Bill of Rights and Responsibilities

Energy Generation

Principles

- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
- Allow the self-use of self-generated electricity.
- Additional obligations for customers that wish to participate actively
- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default, active settings enacted only if net customer benefit, right to revert
- To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
2. Energy Generation	Right to install renewable energy generation resources, subject to relevant requirements for safety and quality. Right to consume energy generated on-site with minimal restriction. Energy generation systems may be subjected to obligations to: i) meet minimum technical standards for passive grid support ii) register system details at time of connection iii) provide visibility of system operation to market and/or network operators iv) allow remote control and/or disconnection for non-credible risks to system security Curtailment of self-consumption to not exceed the unserved energy provision in the Reliability Standard. An example energy generation system is a solar PV system.	Right to own generation systems that participate in energy markets Energy generation systems capable of participating in energy markets may be subjected to additional obligations to: i) meet additional technical standards for active grid support ii) provide details of system operation iii) provide forecasts of system operation to market and/or network operators iv) allow adjustment and curtailment of exported energy to support system and network performance v) allow remote control and/or disconnection for credible risks to system security Generating systems that participate in energy markets have a right to symmetric treatment and remuneration with large-scale generation where possible and efficient Right to switch actively participating systems back to passive settings, with minimal restriction of operation.

Lal, N.N. and Brown, L., (2021), An Australian DER Bill of Rights and Responsibilities, https://arxiv.org/abs/2112.04855

An Australian DER Bill of Rights and Responsibilities

Energy Storage

Principles

- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
- Allow the self-use of self-generated electricity.
- Additional obligations for customers that wish to participate actively
- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default, active settings enacted only if net customer benefit, right to revert
- To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
3. Energy Storage	Right to store energy generated on-site for later self-consumption. Storage systems may be subjected to obligations to: i) meet minimum technical standards for grid support ii) register system details at time of connection iii) provide visibility of system operation to market and/or network operators An example energy storage system is a home battery.	Right to own storage systems that participate in energy markets Where capable of storing energy from the grid, operating as active load or participating in energy markets, storage systems may be subjected to additional obligations to: i) meet additional technical standards for active grid support ii) provide visibility of system operation to market and/or network operators iii) allow remote control and/or disconnection for credible risks to system security iv) provide good-faith scheduling information to market and/or network operators Active storage systems include home batteries or electric vehicle batteries capable of charging/discharging from/to the grid.

Lal, N.N. and Brown, L., (2021), An Australian DER Bill of Rights and Responsibilities, https://arxiv.org/abs/2112.04855

An Australian DER Bill of Rights and Responsibilities

Energy Data

Principles

- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
- Allow the self-use of self-generated electricity.
- Additional obligations for customers that wish to participate actively
- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default, active settings enacted only if net customer benefit, right to revert
- To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
4. Energy Data	Right to privacy through their energy data Right to access their energy data Right to be informed about the uses of their energy data Right to a fair share in the value of third-party licensing of their energy data Right to revoke consent of the use of their energy data Energy data includes consumption data, billing data, resource settings and operational data, and forecasted operational data.	Where customers are actively interacting with the grid, they may have obligations to provide energy data relating to resource and/or system details, current operation, and forecast operation.

Lal, N.N. and Brown, L., (2021), An Australian DER Bill of Rights and Responsibilities, https://arxiv.org/abs/2112.04855

An Australian DER Bill of Rights and Responsibilities

Default settings

Principles

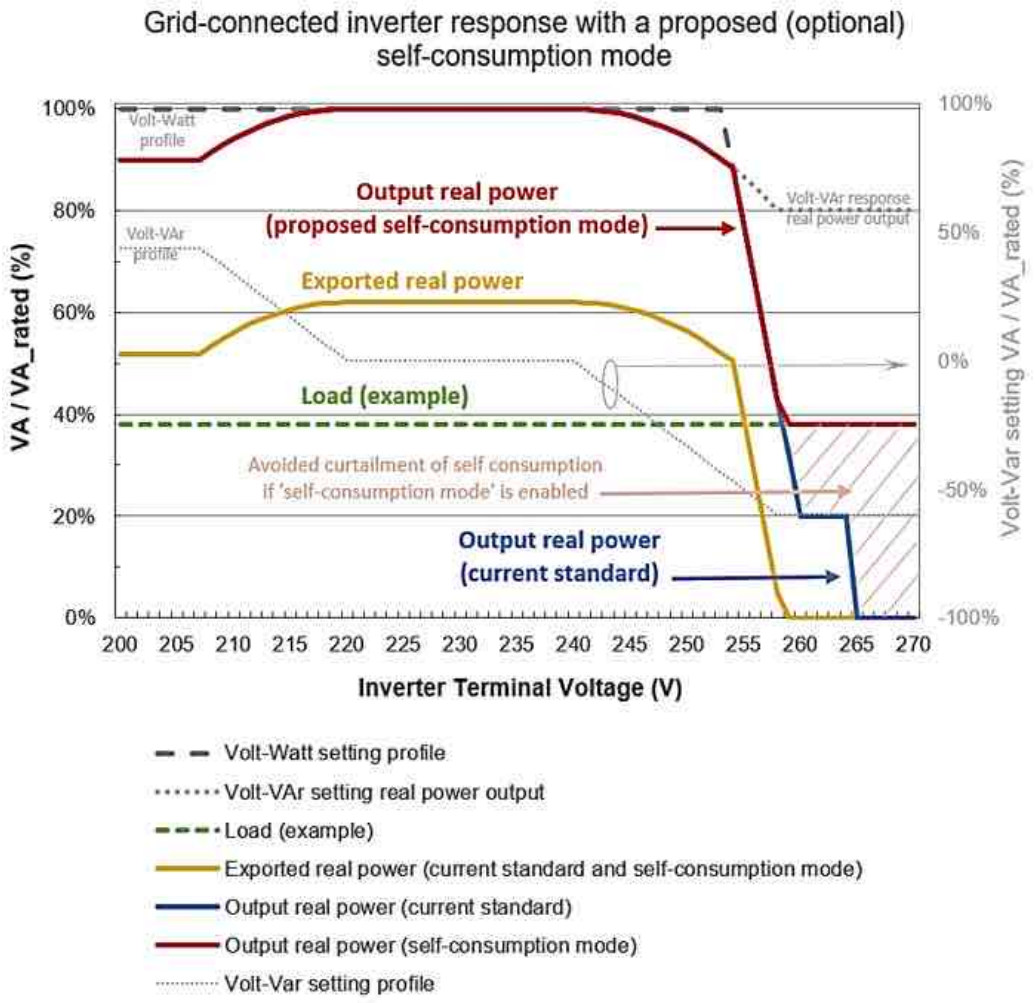
- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
- Allow the self-use of self-generated electricity.
- Additional obligations for customers that wish to participate actively
- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default, active settings enacted only if net customer benefit, right to revert
- To be written simply

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
4. Default Settings	Passive options are set as default for DER Informed customer choice is required for DER to participate actively	Active options should only be enabled where there is net benefit to the customer. Right for customers to revert to passive settings Passive settings may be reverted to in the event of: i) Loss of communication with DER ii) Loss of compliance by DER iii) Cybersecurity compromise

Lal, N.N. and Brown, L., (2021), An Australian DER Bill of Rights and Responsibilities, https://arxiv.org/abs/2112.04855

Example of implementation

- When network voltages are high, total PV inverter output is curtailed (not just export). This unfairly restricts a customer's self-consumption.
- Self-consumption may be included in an AS 4777.2 self-consumption mode (P. Kilby)



DER Bill of Rights and Responsibilities

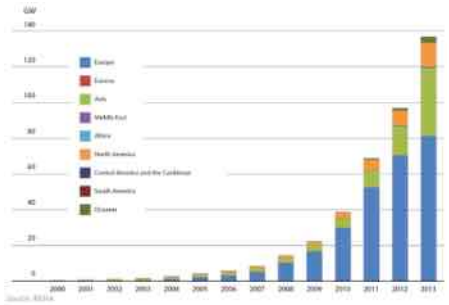
Paths forward:

- Expanded flexible export limits approach
- Adoption by policy makers and jurisdictions – voluntary sign-on by DNSPs, aggregators
- Introduction within NER, inclusion of "equity" within the NEO, state-government legislation for a Duty of Care
- Implementation through existing instruments (e.g., AS 4777.2 self-consumption mode)
- Facilitate structures to support customers + communities in staying on-grid

DER Bill of Rights and Responsibilities

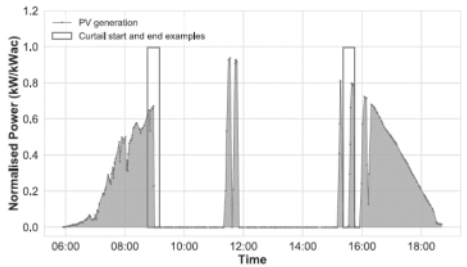
Conclusion

Future grids likely dominated by DER



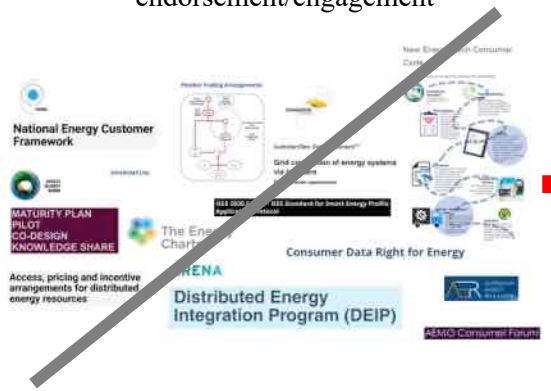
IRENA

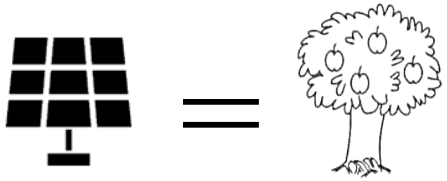
Curtailment is already happening



Stringer et al. Renewable Energy 173 (2021)

Regulatory reform occurring at pace but struggling for consumer endorsement/engagement





A DER Bill of Rights

Energy activity / Grid interaction	Passive interaction *Energy use without active market participation. Generation and storage for self-consumption.*	Active interaction *Energy use with active market participation. Generation and storage for export and service provision.*
1. Energy Consumption	1.1.1 Rights and responsibilities	1.2.1
2. Energy Generation	2.1.1	2.2.1
3. Energy Storage	3.1.1	3.2.1
4. Energy Data	4.1.1	4.2.1
5. Default Settings	5.1.1	5.2.1

- Clarifies simple guiderails of DER interaction
- Supports customers to trust regulatory reform process
- Supports swifter, broadly endorsed, energy sector reform

Principles

- Support system security and reliability with high DER penetration.
- Preserve precedent of fair energy use by reasonable passive loads.
- To allow the self-use of self-generated electricity.
- Additional obligations for customers that wish to participate actively
- Symmetric treatment between large-scale and small-scale resources.
- Right to privacy, access, and fair share of value of data
- Passive options are the default
- Written simply

Implementation

- Largest impact with Bill as a regulatory instrument, supporting legal recourse if potential breaches.
- Clear implementation pathways
- Avenue to build social license
- Necessary for global DER-dominated futures, initially with solar PV, and subsequently with EVs and additional distributed storage.

Lal, N.N. and Brown, L., (2023), The Electricity Journal

Further information

ELSEVIER

The Electricity Journal
Volume 36, Issue 4, May 2023, 107265

Give a little to get a little: A DER Bill of Rights and Responsibilities provides the social license for participation and control in DER-dominated grids - an Australian example

N.N. Lal [a], L. Brown [b]

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LIFE MATTERS

How to make rooftop solar work for everyone

ABC RN

Guests:

Dr Alan Finkel, author *Powering Up: Unleashing the Clean Energy Supply Chain*

Dr Niraj Lal, Visiting Fellow at the ANU Centre for Sustainable Energy Systems

THE CONVERSATION

Think of solar panels more like apple trees – we need a fairer approach for what we use and sell

Published: June 2, 2023 2.01pm AEST

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As we race to decarbonise by electrifying everything, solar panels – now cheaper per square metre than marine-grade plywood – will do much of the heavy lifting. But if we don't rethink how our rooftop panels plug into the grid, the transition will be unfair and costly – for both people who own solar panels (and electric cars and smart appliances) and people who don't.

Australia has the world's highest solar installation rate per person. When solar panels generate more energy than a household is using, the excess electricity can

Author

Niraj Lal
Visiting Fellow at the ANU Centre for Sustainable Energy Systems, Australian National University

Disclosure statement

This article was co-authored by Lee Brown Specialist – Market Design and Development at the Australian Energy Market Operator (AEMO), where he is leading Australia's reforms of DER access and pricing. Niraj Lal and Lee Brown both work at AEMO.

#shameless

DER Bill of Rights and Responsibilities

Energy activity / Grid interaction	**Passive interaction** *Energy use without active market participation. Generation and storage for self-consumption.*	**Active interaction** *Energy use with active market participation. Generation and storage for export and service provision.*
1. Energy Consumption	**1.1 (normal loads)** Right to connect Supply to meet reliability standard Some loads may need to be actively connected (e.g. EVs)	**1.2 (active loads)** Right to own Possible additional obligations (tech standards, registration, remote control for credible risks, providing scheduling) Symmetric remuneration/cost with large-scale loads Right to switch back to passive
2. Energy Generation	**2.1 (self-consumption)** Right to install Right to consume self-generated electricity with minimal restriction Minimum obligations (tech standards, registration, visibility, remote control for non-credible risks) Curtailment of self consumption to not exceed the unserved energy provision in the reliability standard	**2.2 (exports)** Right to own Possible additional obligations (additional tech capability, forecast provision, allow control for system and network performance and credible risks) Symmetric remuneration with large-scale generation Right to switch back to passive
3. Energy Storage	**3.1 (storing own energy)** Right to store energy generated on-site for later self-consumption Minimum obligations (as above)	**3.2 (storing grid energy)** Right to own Where storing energy from the grid, possible additional obligations (as above)
4. Energy Data	**4.1 (rights to privacy)** Right to privacy Right to access own energy data Right to be informed about the uses of their energy data Right to a fair share in the value of third-party licensing of data Right to revoke consent of the use of energy data	**4.2 (obligations)** Where actively interacting with the grid, possible additional obligations to provide energy data (e.g., system details, current + future operation)
5. Default Settings	**5.1 (passive as default)** Passive options are the default for DER Informed customer choice required for DER to participate actively	**5.2 (right to revert)** Active options only enabled where there is net benefit to the customer Right for customers to revert to passive settings Passive settings may be applied in the event of: • Loss of communication • Loss of compliance • Cybersecurity compromise

Socio-techno-economic aspects of DER: Results and considerations from project EDGE

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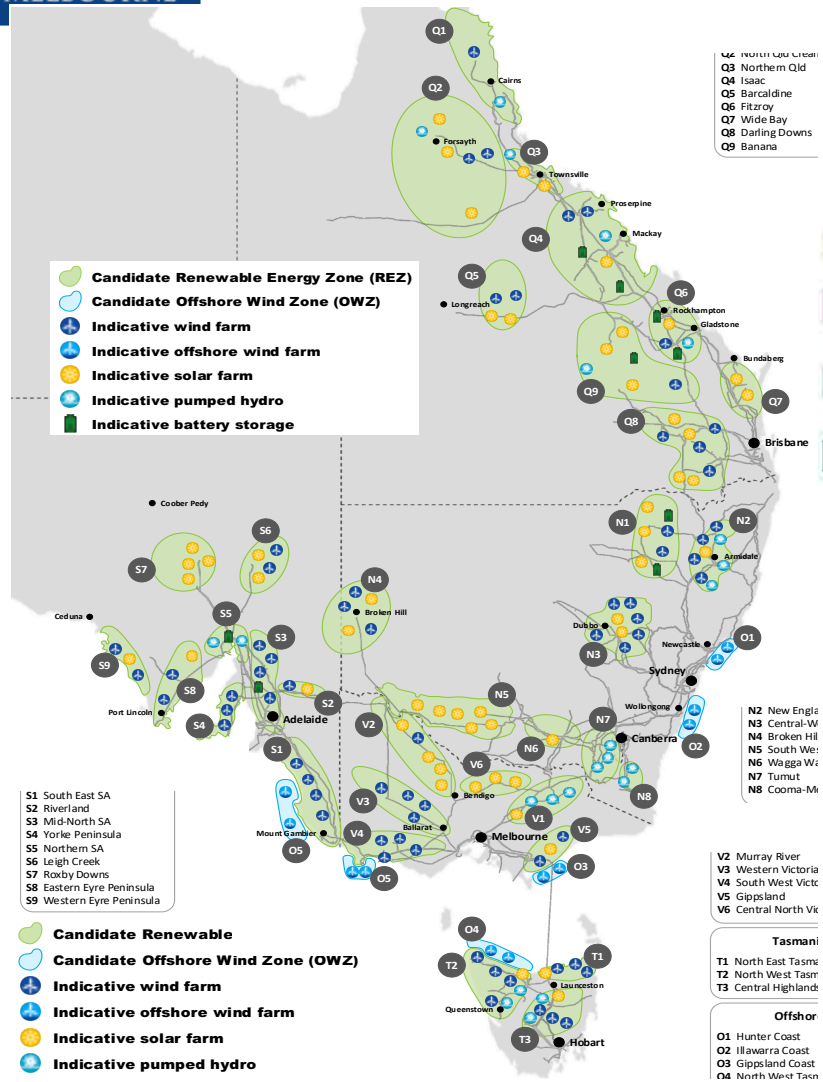
Chair of Electrical Power Systems, The University of Melbourne

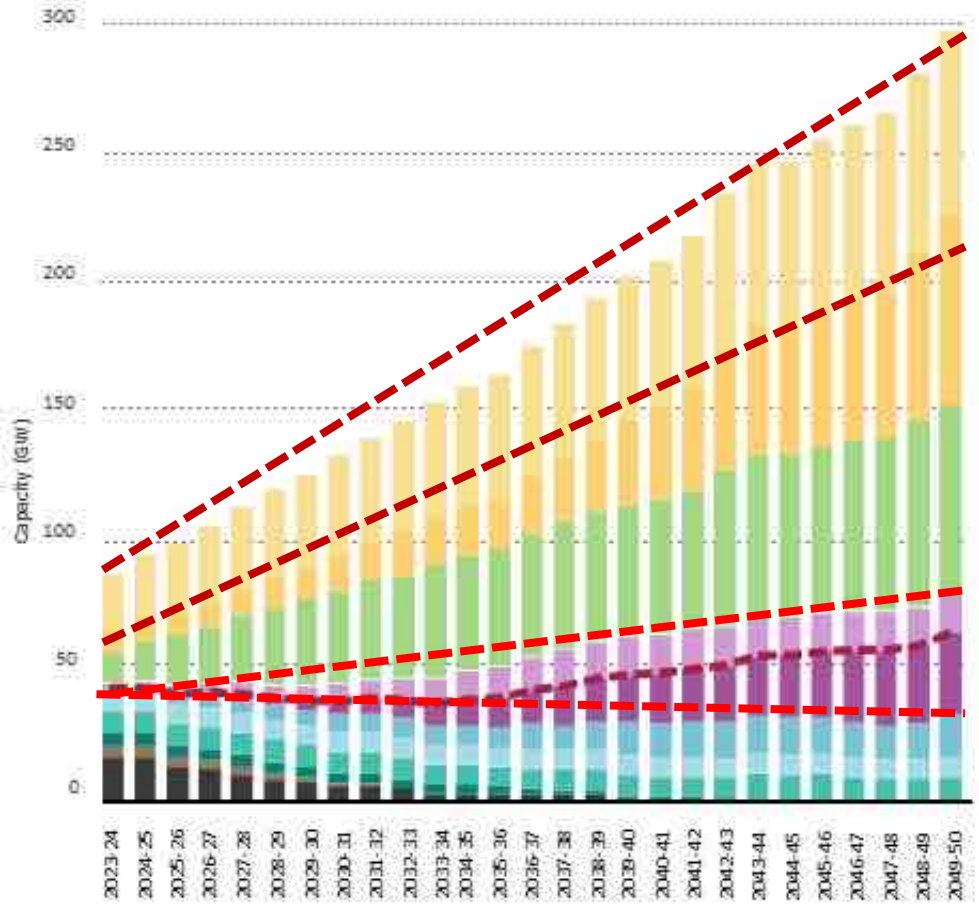
pierluigi.mancarella@unimelb.edu.au

Melbourne, 16th Novembre 2023

Future power system in Australia

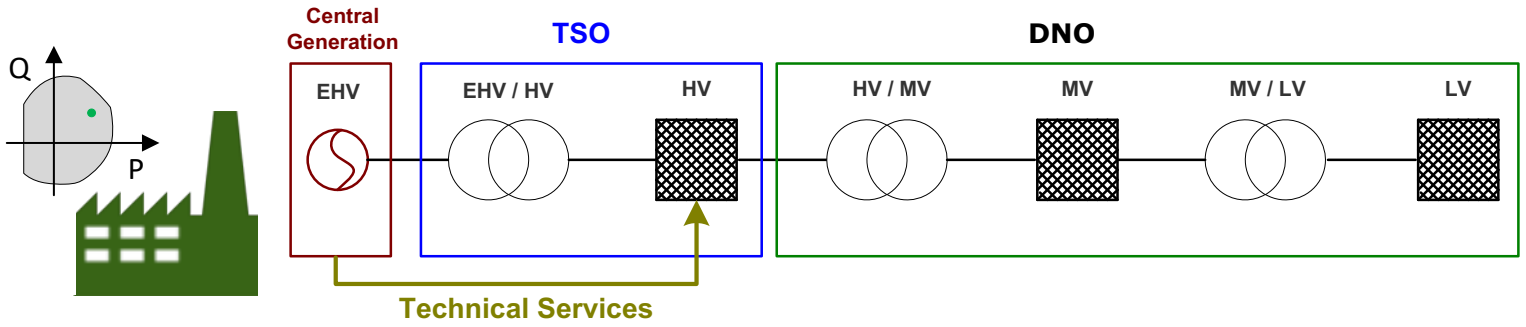


Installed capacity in ISP 2022 "step" scenario



[A] AEMO - 2023 Electricity Statement of Opportunities; [B] AEMO - ISP 2022

Historical provision of energy, and flexibility, security and reliability



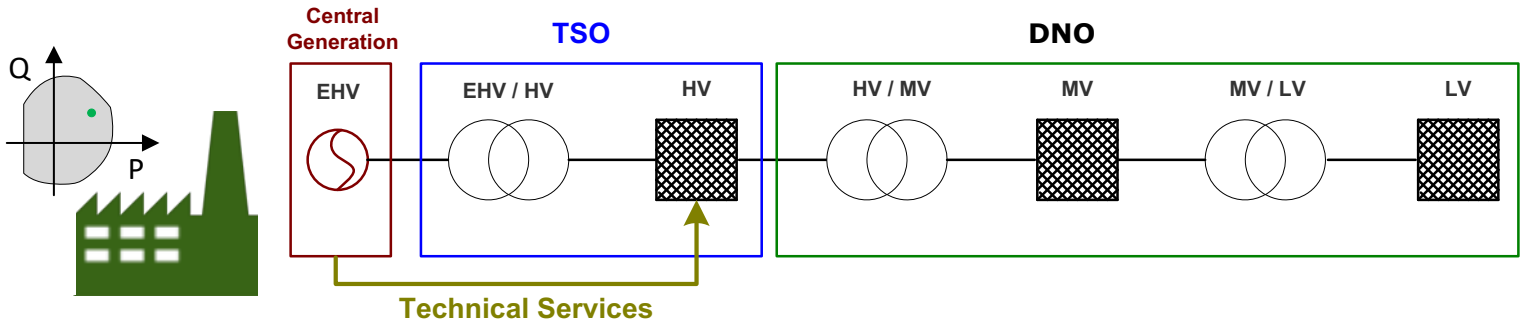
Inflexibility

Flexibility

Source: "More Microgrids" project, 2009

(Images sourced from the internet)

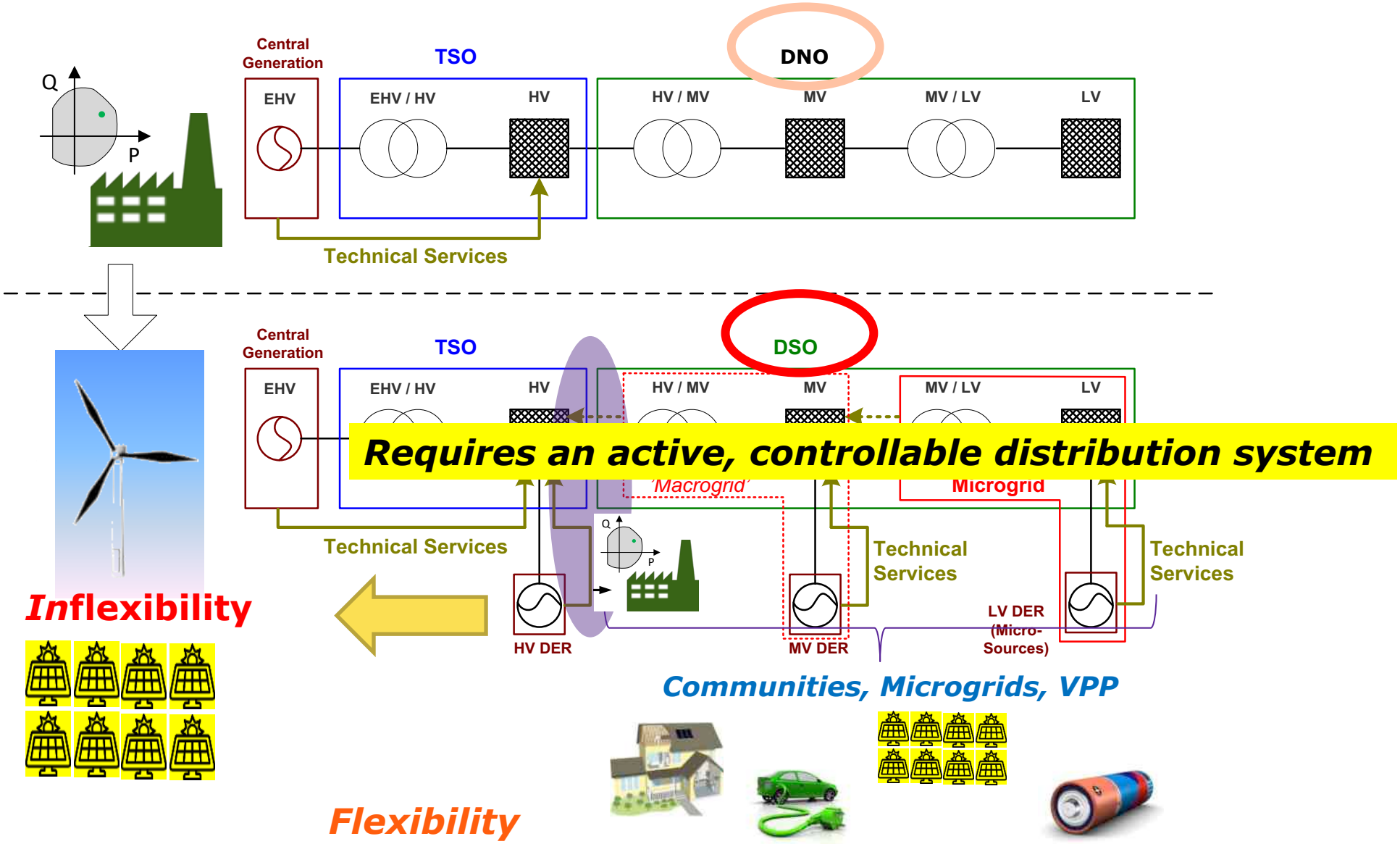
And in the future?



Source: "More Microgrids" project, 2009

(Images sourced from the internet)

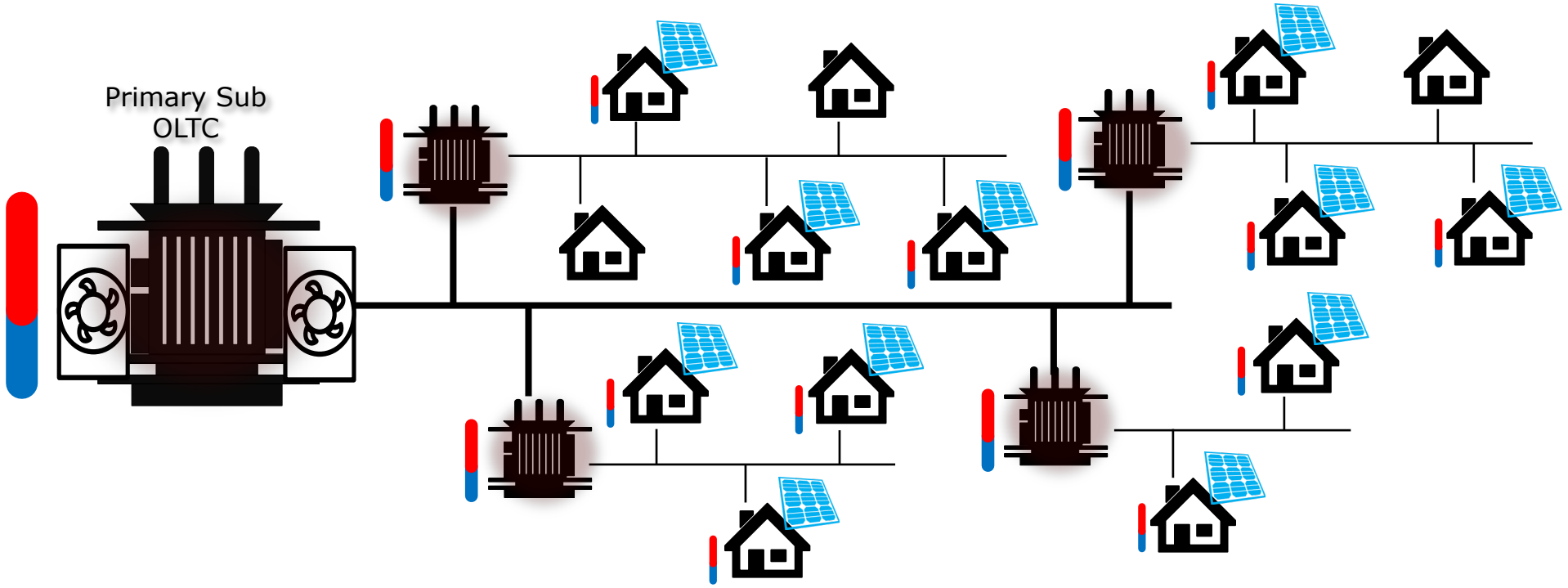
Who will provide energy and flexibility services in the future?



Source: "More Microgrids" project, 2009

(Images sourced from the internet)

Network issues with uncontrolled local generation

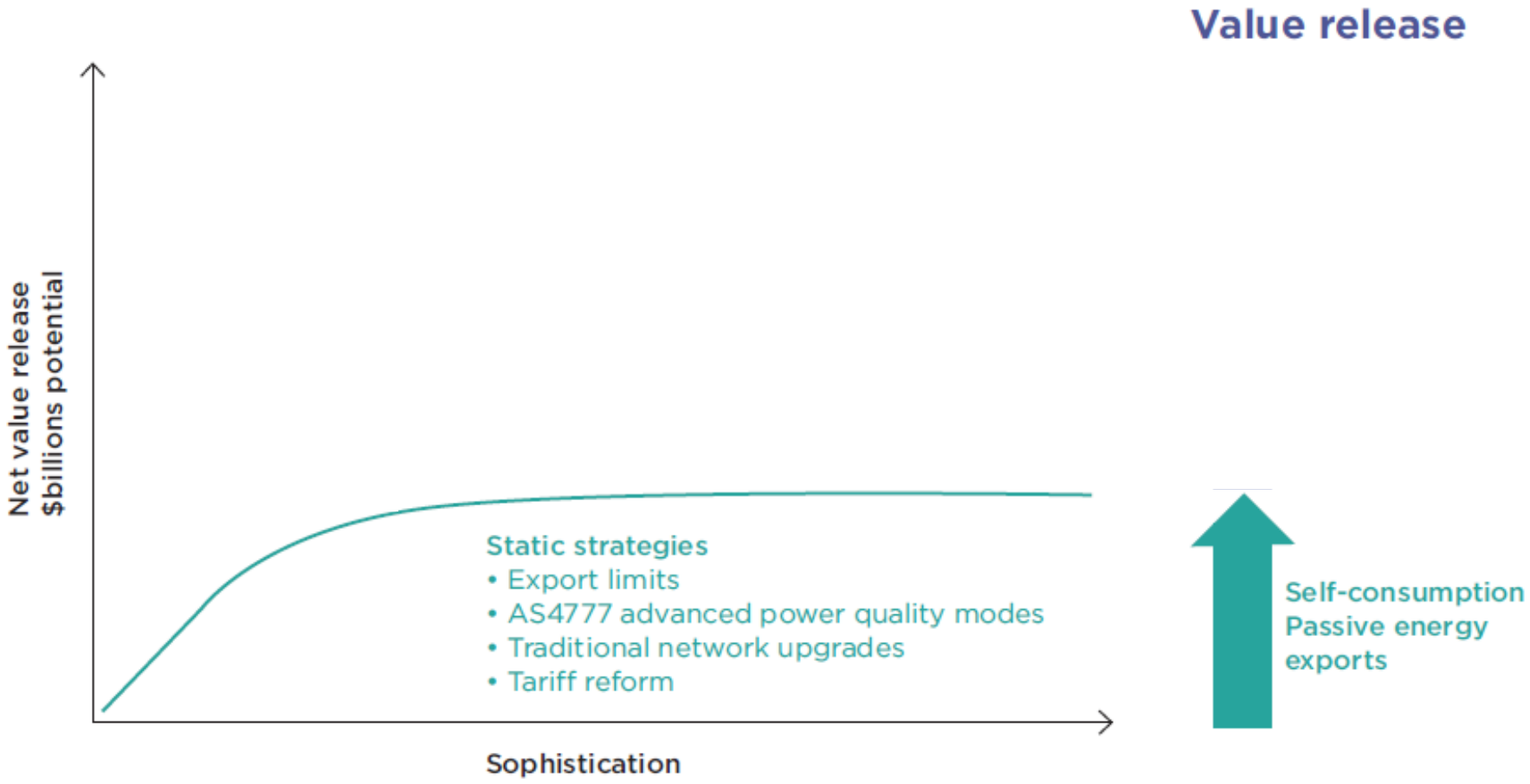


Source: M. Liu *et al.*, “Grid and market services from the edge”, *IEEE Power and Energy Magazine*, July/August 2021

Evolution of DER active management and distributed energy marketplaces

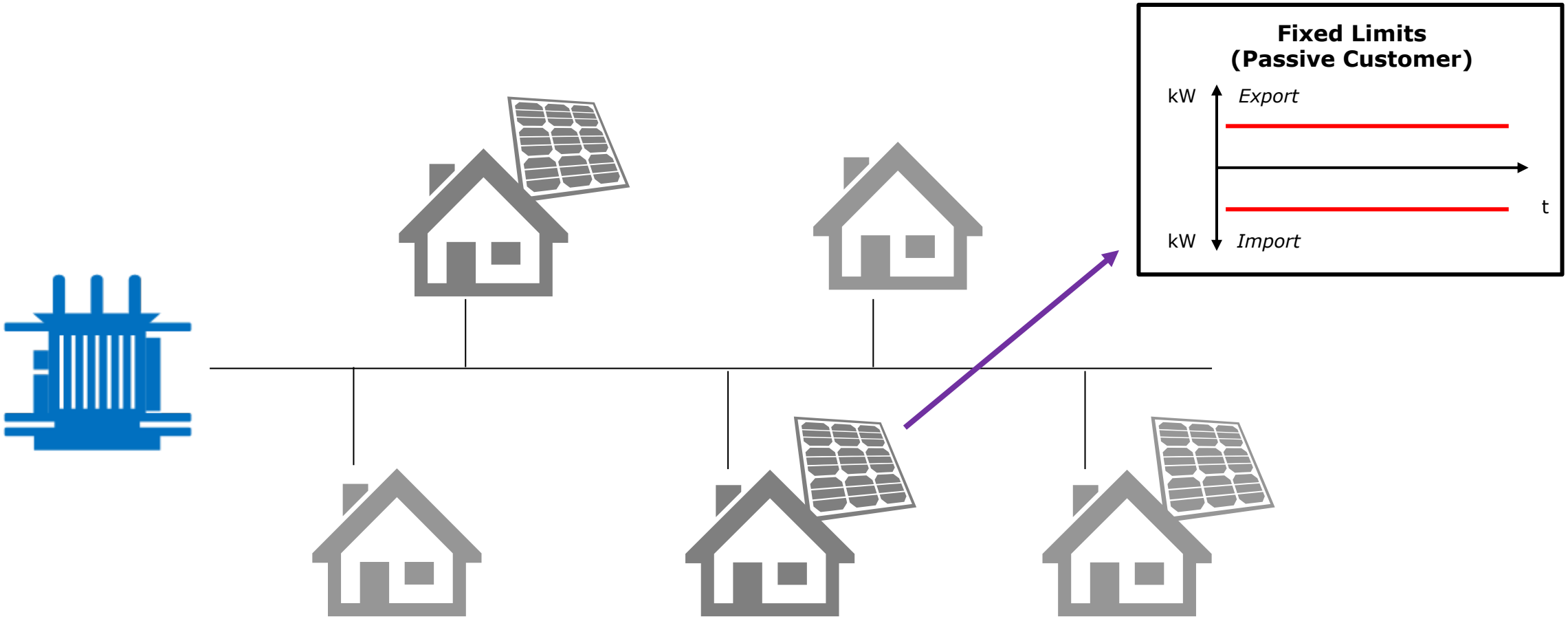
Source: Energy Networks Australia, "Open Energy Networks Project: Position Paper", 2020.

Evolution of DER active management and distributed energy marketplaces

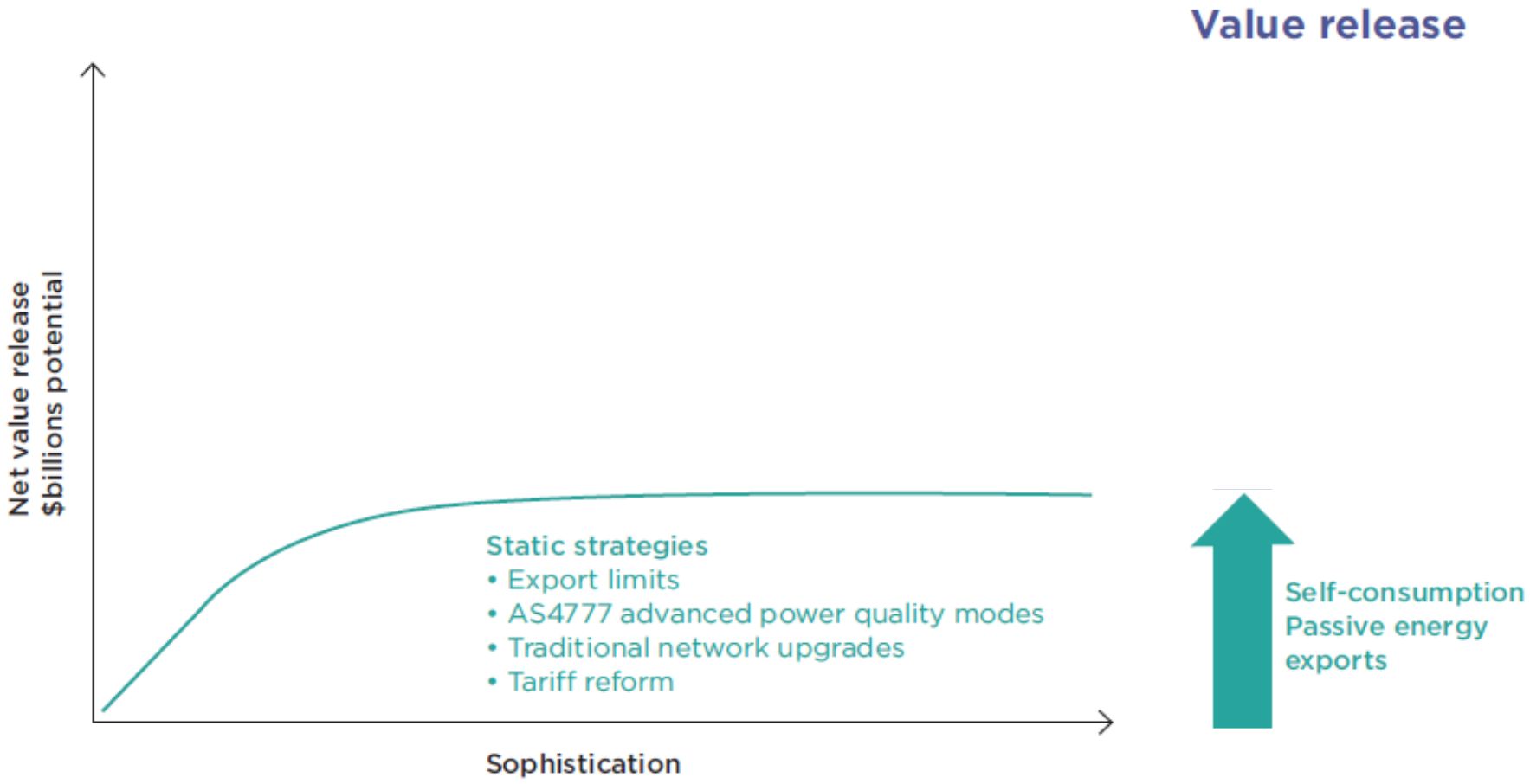


Source: Energy Networks Australia, "Open Energy Networks Project: Position Paper", 2020.

From passive, constrained energy export…



Evolution of DER active management and distributed energy marketplaces



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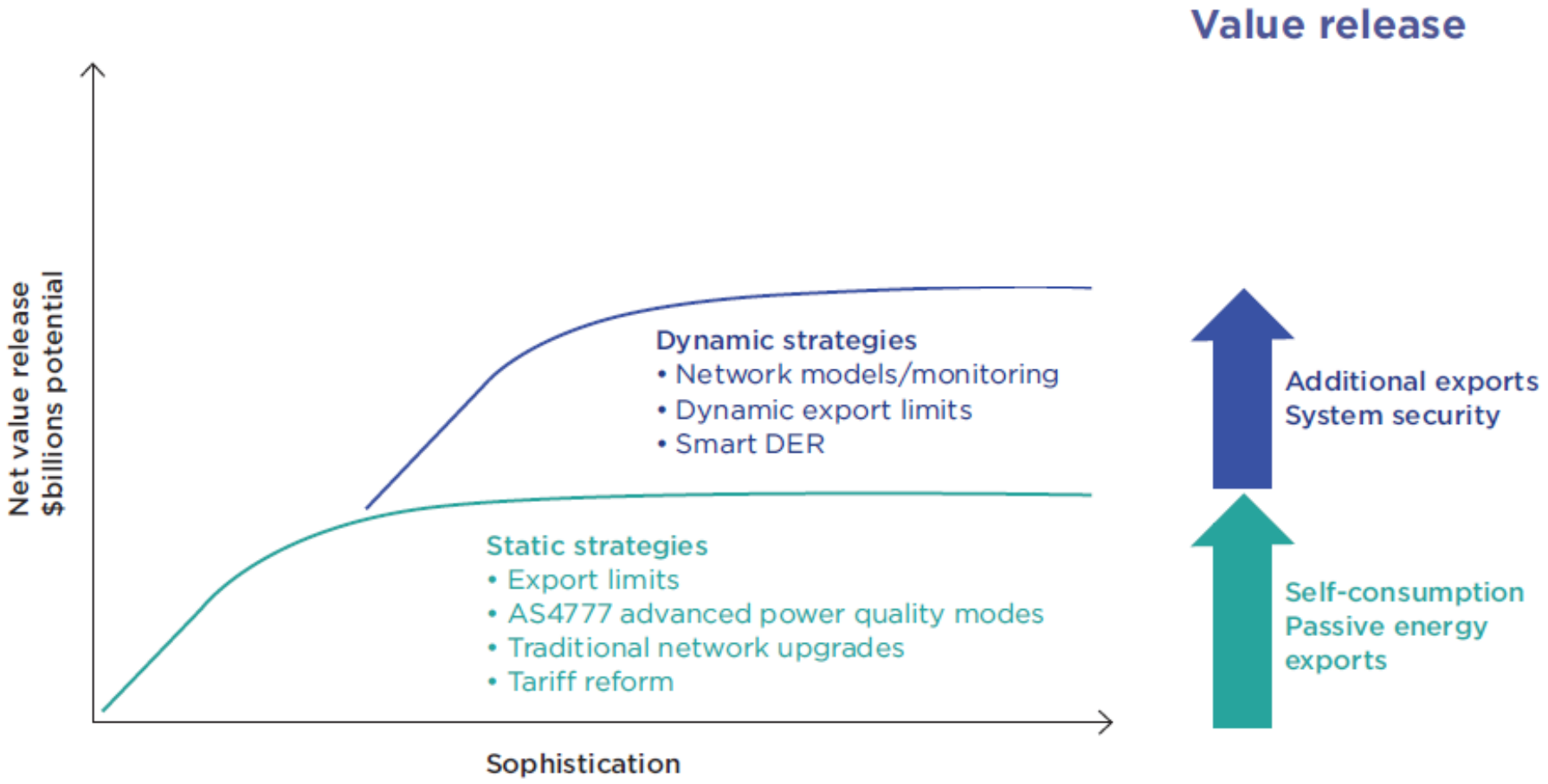
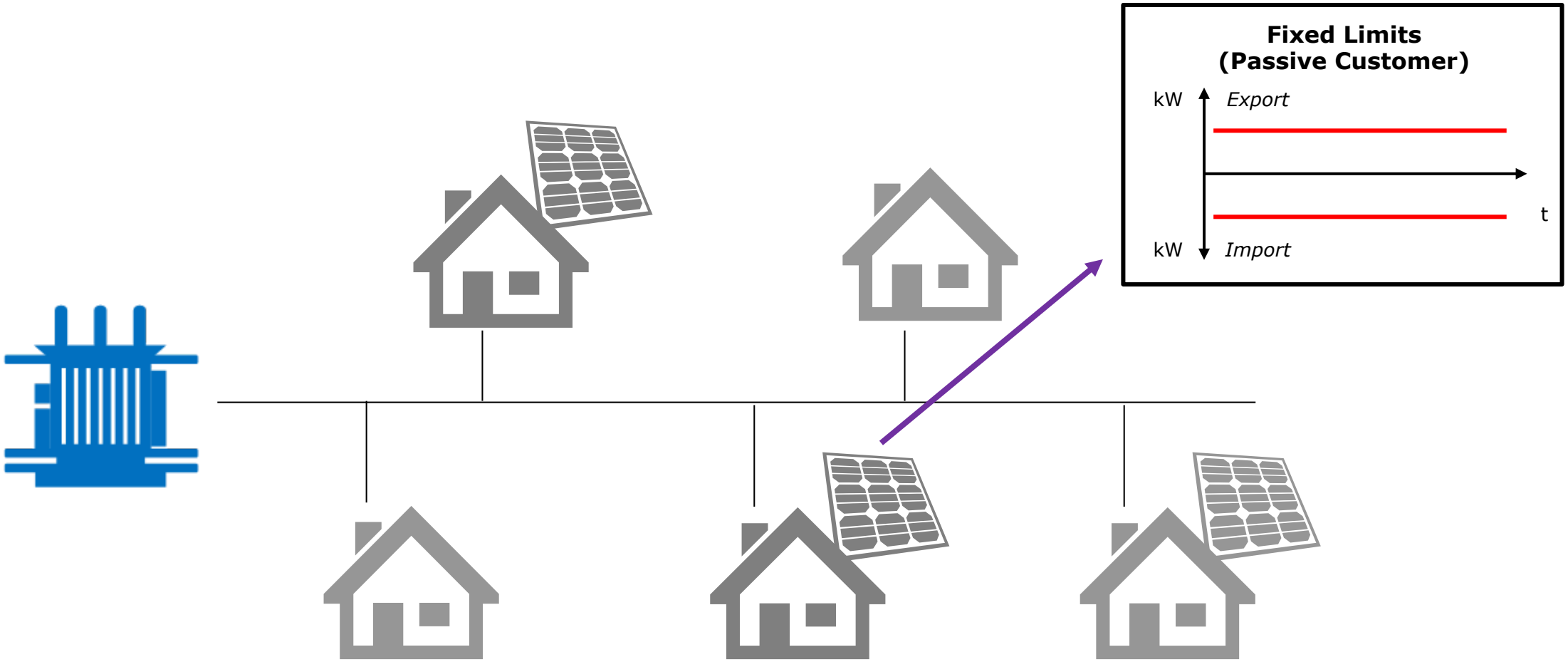
Evolution of DER active management and distributed energy marketplaces



Source: Energy Networks Australia, "Open Energy Networks Project: Position Paper", 2020.

… to "dynamic" operating envelopes (DOEs)



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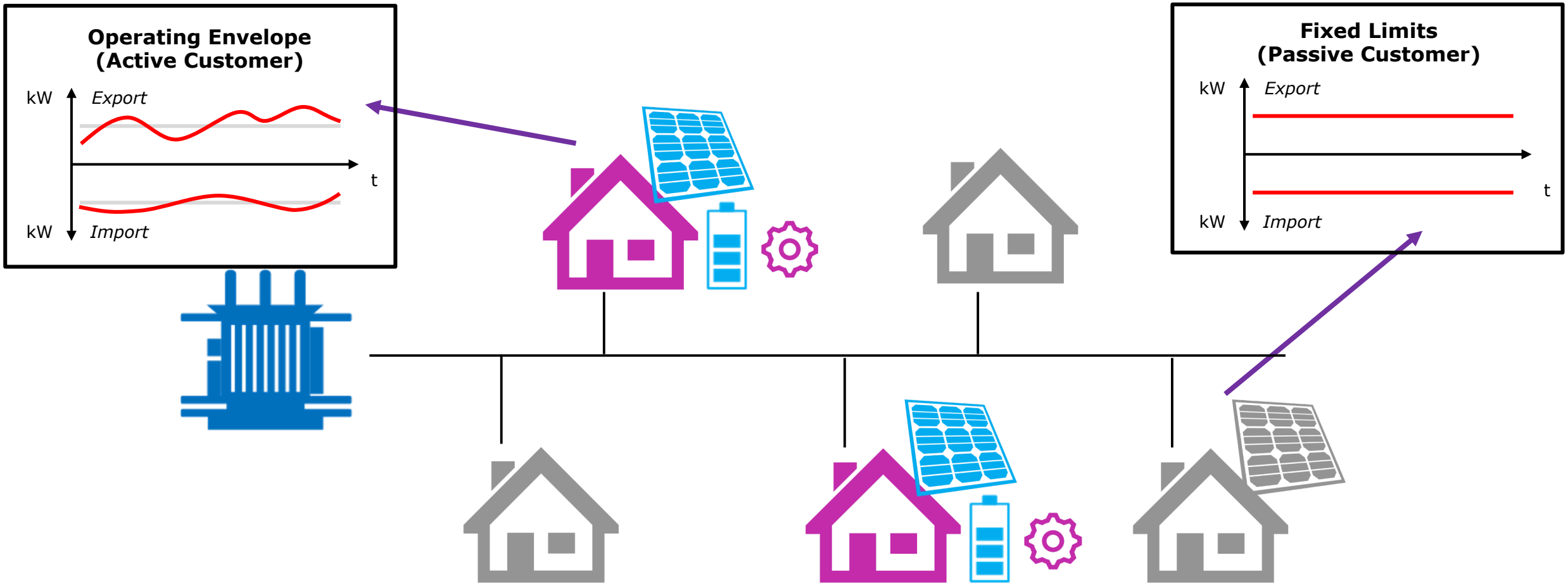
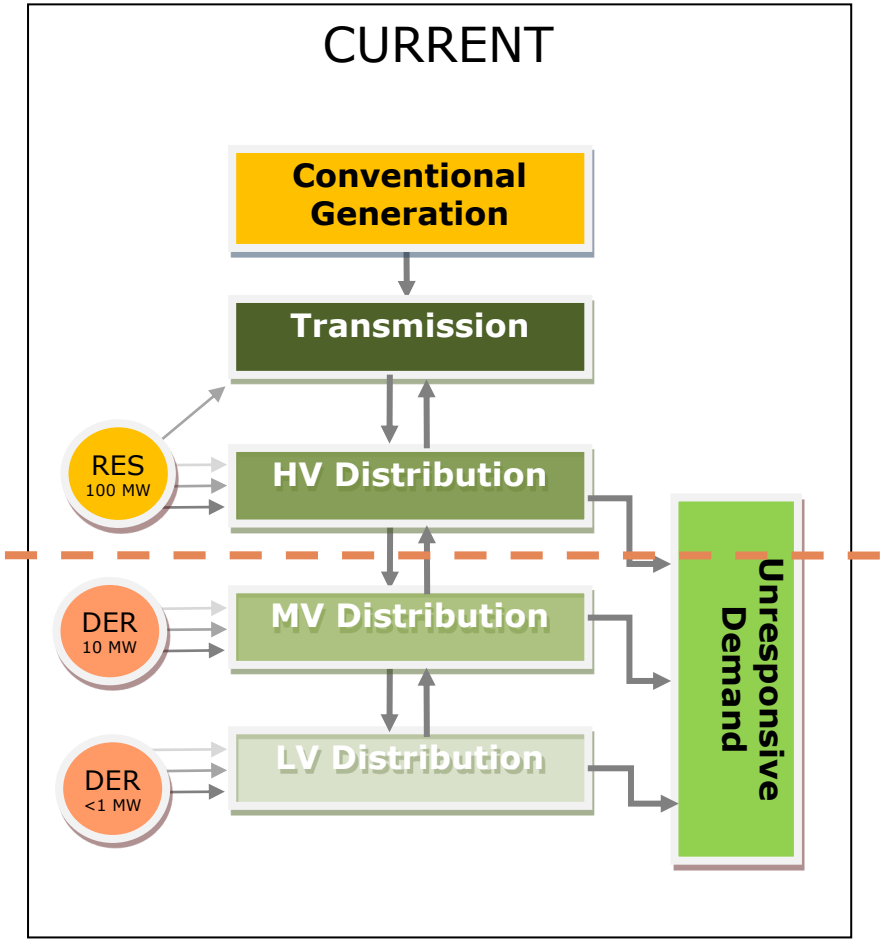


Supporting both network and system security functionalities

System and market issues with a "Fit & Forget" paradigm

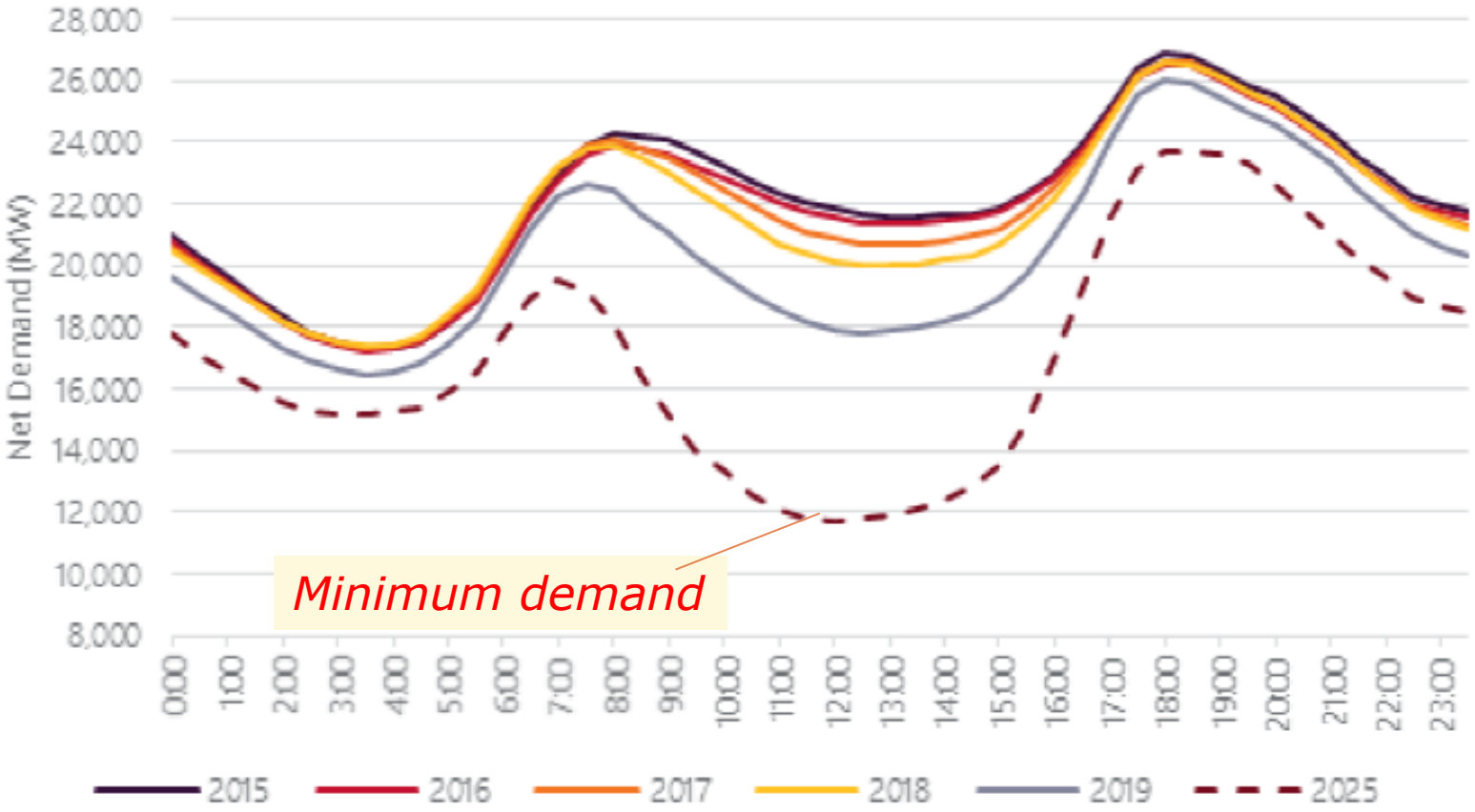
Visible generators = "dispatchable" and "controllable"

Invisible **DER** = "non-dispatchable" and "non-controllable"



Impact of DER on system security

Figure 15 NEM average winter net demand curves



Source: AEMO, "Renewable Integration Study, Stage 1 - Appendix C: Managing Variability and Uncertainty", April 2020

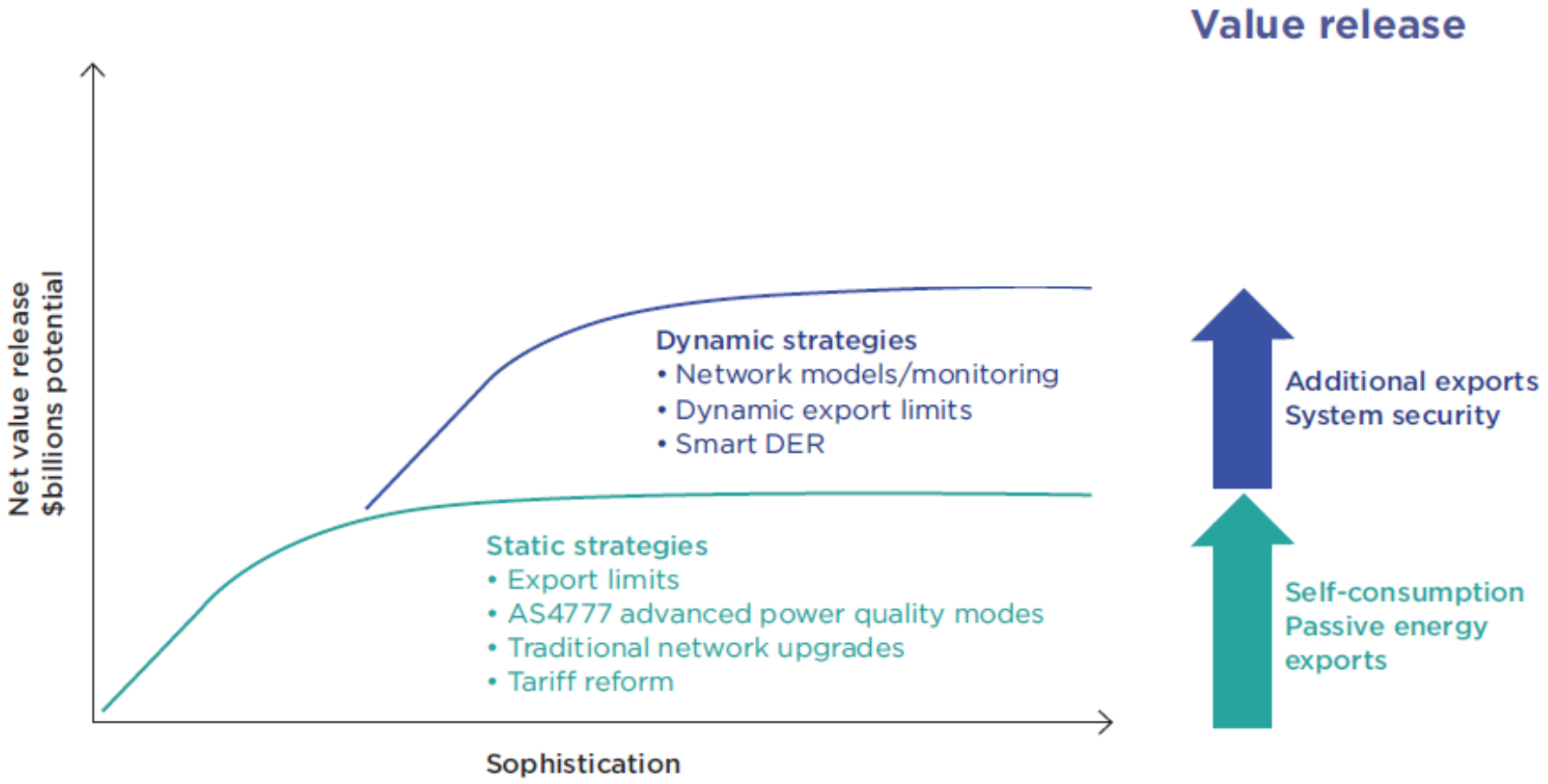
Impact of DER on system security

Electricity provider authorised to switch off rooftop solar in SA in emergencies

This is the consequence of DER not being visible/dispatchable/controllable in a relatively weak grid

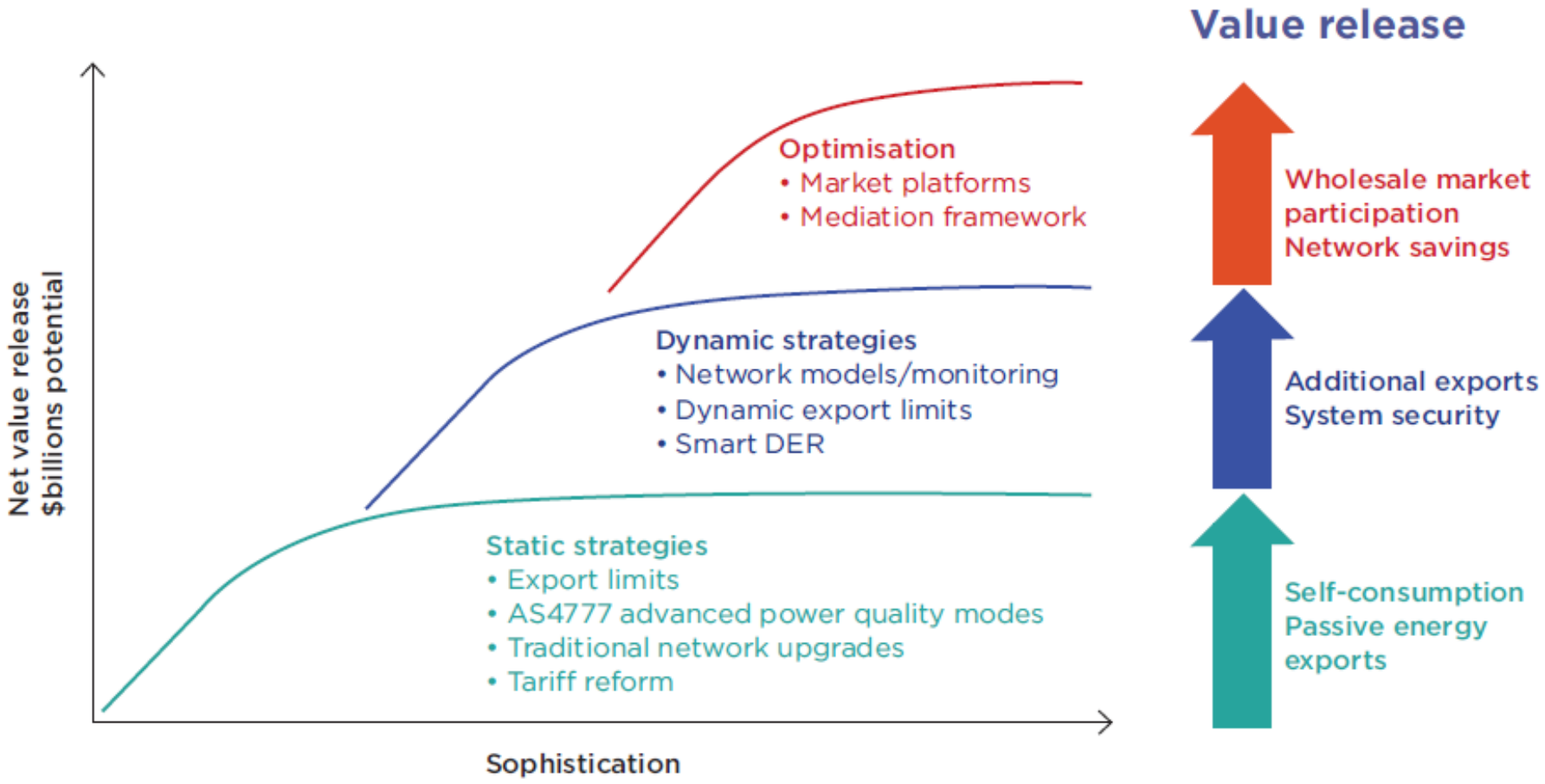
Source: *ABC News*, 27 August 2020

Evolution of DER active management and distributed energy marketplaces



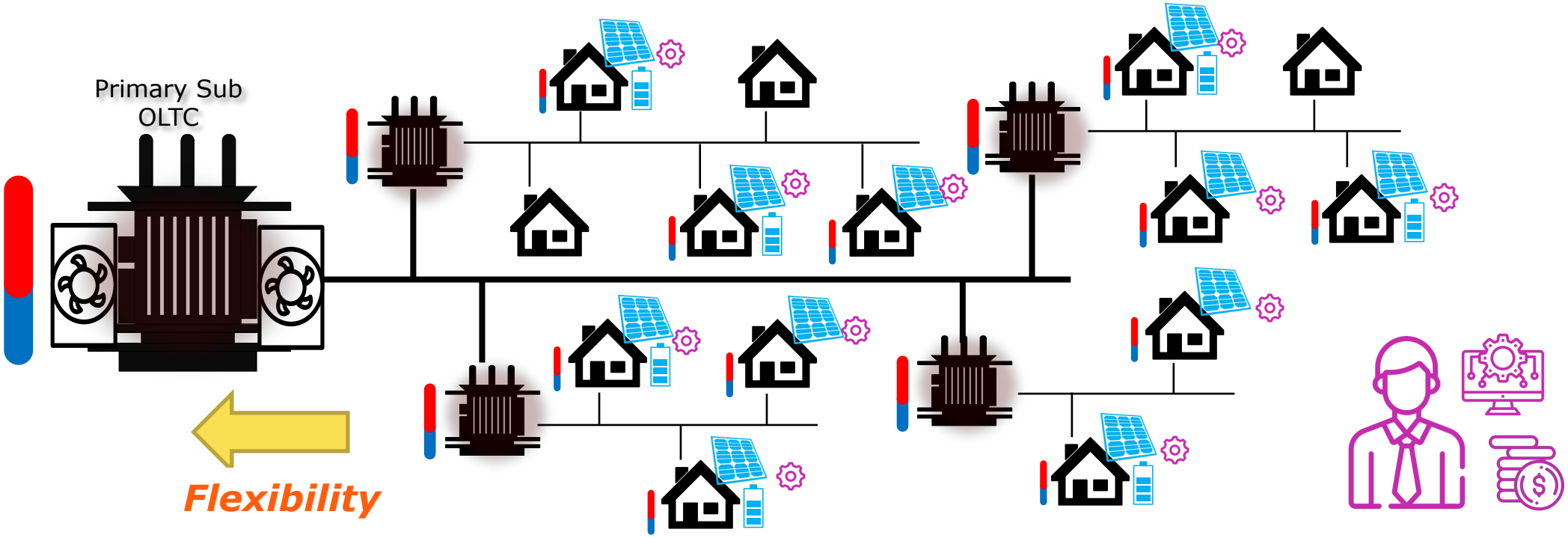
Source: Energy Networks Australia, "Open Energy Networks Project: Position Paper", 2020.

Evolution of DER active management and distributed energy marketplaces



Source: Energy Networks Australia, "Open Energy Networks Project: Position Paper", 2020.

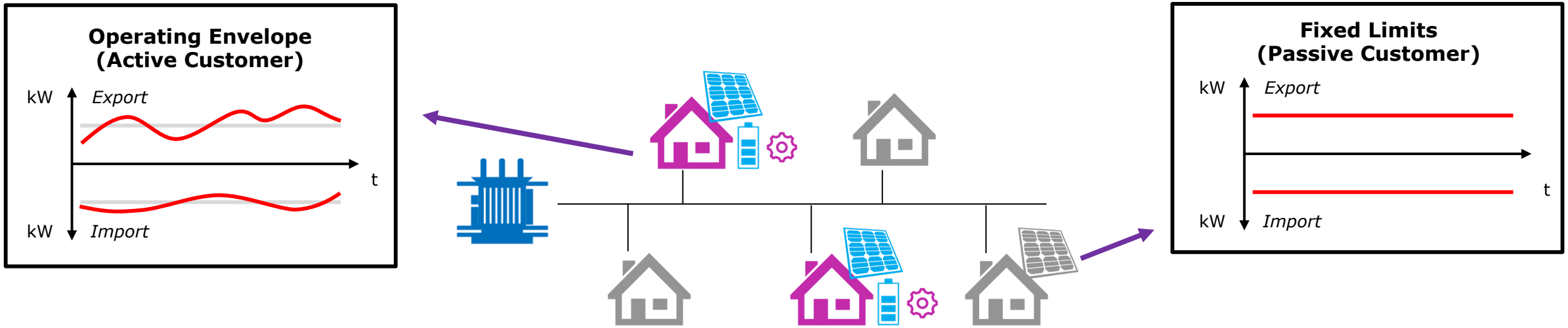
DER bottom-up services and networks impacts



Aggregation of DER → Bottom-Up Services → **Network Problems**

Source: M. Liu *et al.*, "Grid and market services from the edge", *IEEE Power and Energy Magazine*, July/August 2021

But how should I quantify these DOEs?



- How should capacity be allocated to DER?
- Should the allocation methodology be “fair”?
- How does capacity allocation align with the National Energy Objective (NEO)?

Why "fairness", and what is it?

- The NEO talks about "**economic efficiency**", but ***not*** **fairness**
- Recent developments to incorporate **emission reduction objectives**
- However, does capacity allocation among DER customers **need to be fair to maintain social license?**
- **What is "fairness"**?
- Fairness can be considered through the **lens of**:
  - Only those **customers actively participating in the DER marketplace** (and therefore receiving DOEs)
  - **All customers** in the network, including with "passive" DER and without DER
  - **All customers**
- In project EDGE, we looked into assessing **a broad spectrum of possible Dynamic Operating Envelope (DOE) objectives across technical, economic, and fairness metrics**

Allocation of network capacity to DER: Spectrum of DOE "objectives"

Maximise Service (Export to NEM)

- Network efficiency
- No consideration of fairness

Policy-Based, Weighted Allocation

- Each DER has a weighting coefficient assigned by the DSO
- E.g., prioritise renewable DER
- Or some DER may pay for "priority access"

Proportional Asset Allocation

- Each DER is allocated *X*% of its rated capacity, where *X* is constant across all participating DER
- The value of *X* is determined by DOE optimisation

Equal Unallocated DER Capacity (Individual Conservation)

- Each DER has *Y* kW of its rated capacity left **unallocated**
- The value of *Y* is determined by DOE optimisation

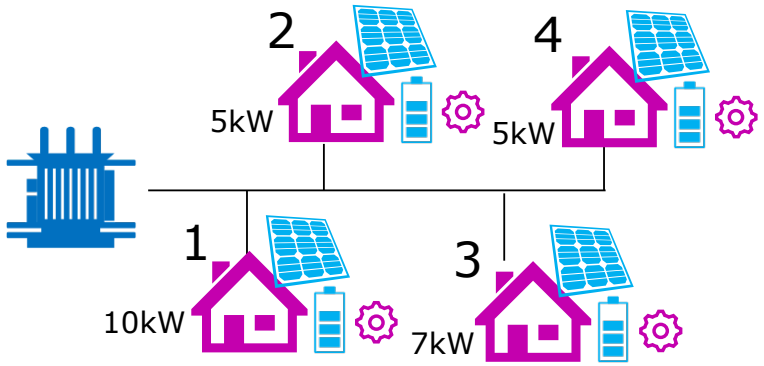
Shared Equal Individual Allocation ("Equity")

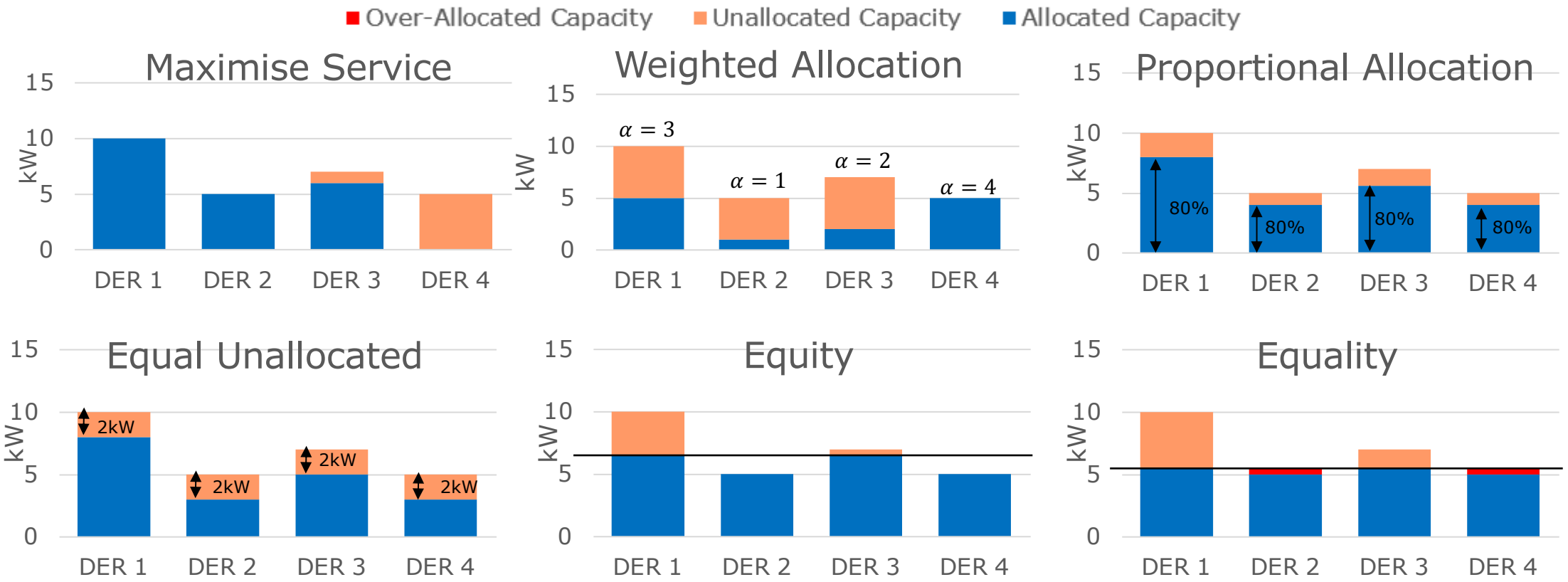
- Each participating DER is assigned the smaller of:
  - *Y* kW
  - DER rated capacity
- The value of *Y* is determined by DOE optimisation

Absolute Equal Individual Allocation ("Equality")

- Each participating DER is assigned *Y* kW
- DER may be assigned capacity greater than their rated capacity
- The value of *Y* is determined by DOE optimis

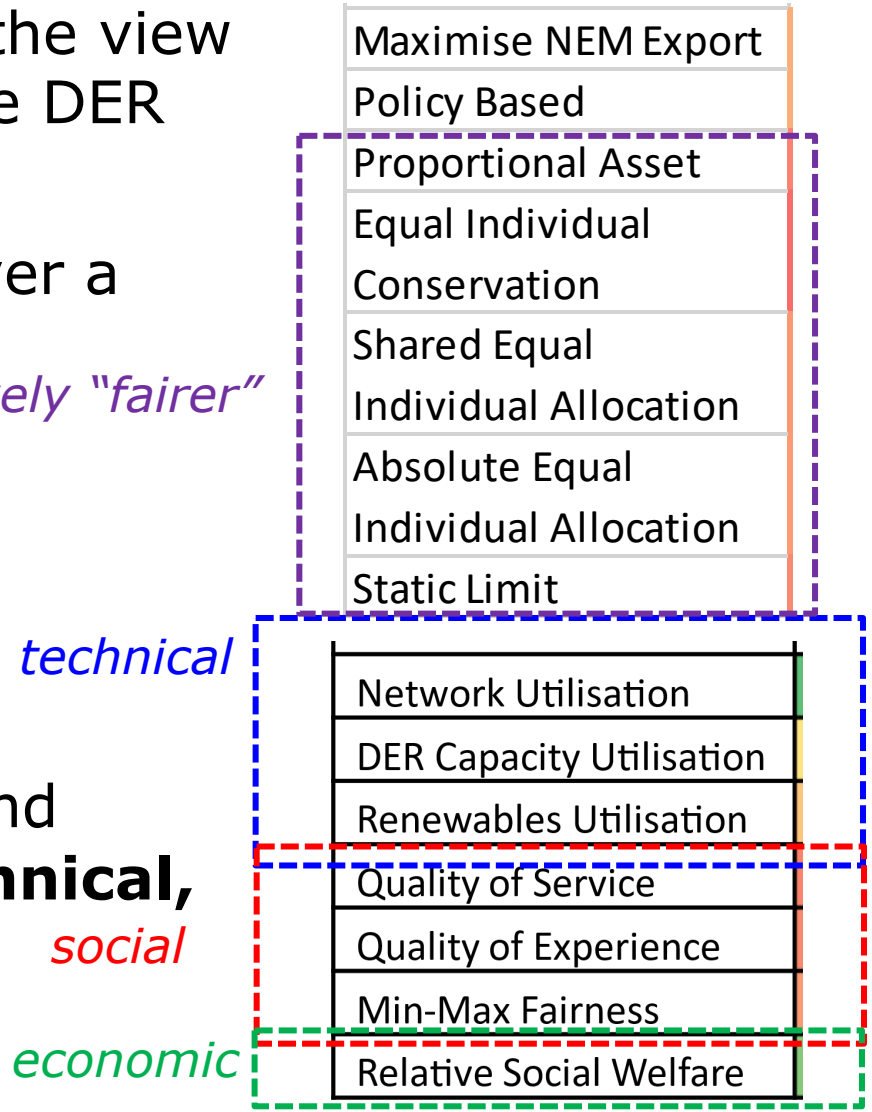
DOE Objectives - Illustrative Examples





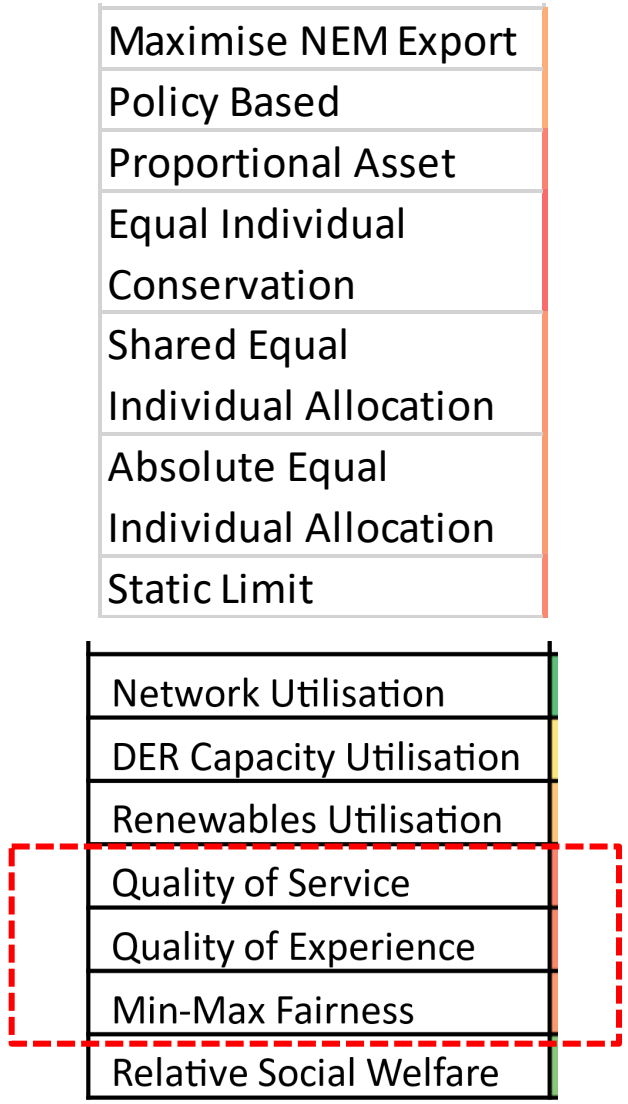
EDGE socio-techno-economic scope of work

- Fairness was predominately assessed from the view of **customers actively participating** in the DER marketplace
- We applied **different DOE "objectives"** over a range of:
  - representative networks
  - DER penetration levels
  - levels of DER participating in the DER marketplace
- We assessed all the different DOE models and scenarios through **a suite of different technical, economic and fairness metrics**



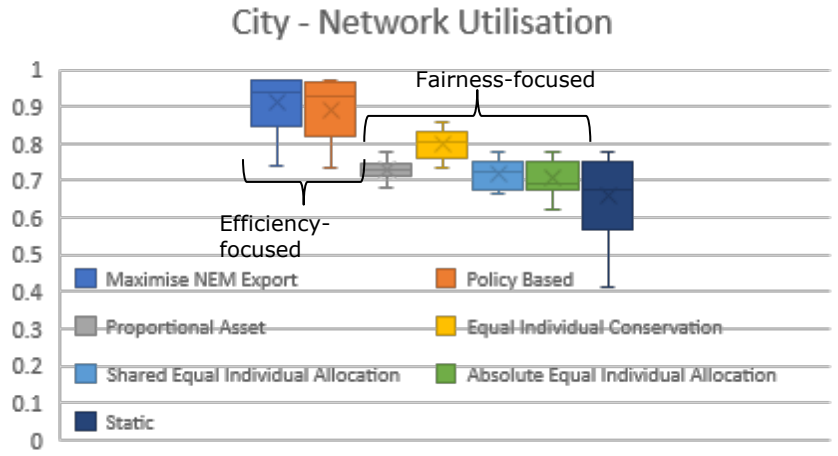
Social metrics for fairness

- ***Quality of service***: "Everyone is entitled to have capacity allocated. To be fair, I should get similar capacity allocated as my neighbours. In addition, the more capacity that we are assigned collectively, the fairer the system is."
- ***Quality of experience***: "As long as everyone is impacted similarly to me then the system is fair, even if we are getting heavily curtailed."
- ***Min-max fairness***: "The difference between the 'winners' and the 'losers' in the system should be as small as possible."

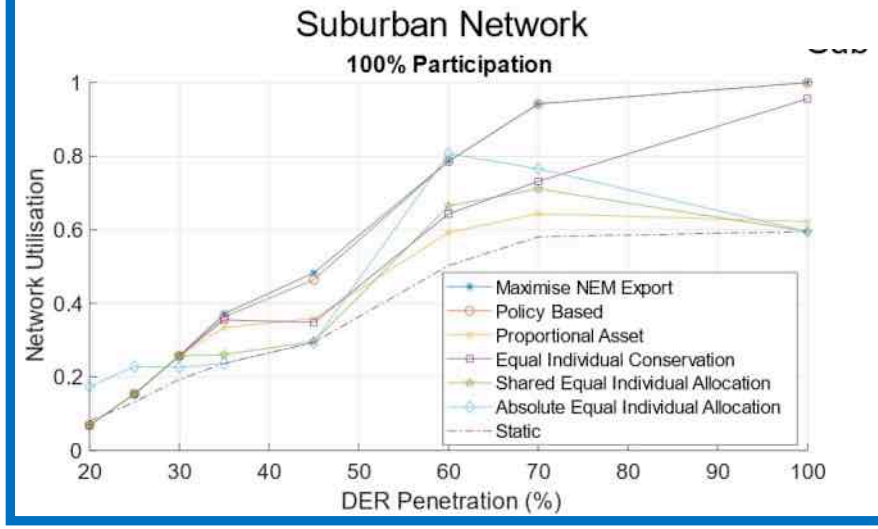


Key Results

Calculating DOEs using intuitive concepts of fairness in relation to participating customers may reduce the technical and economic benefits that the wider community can obtain



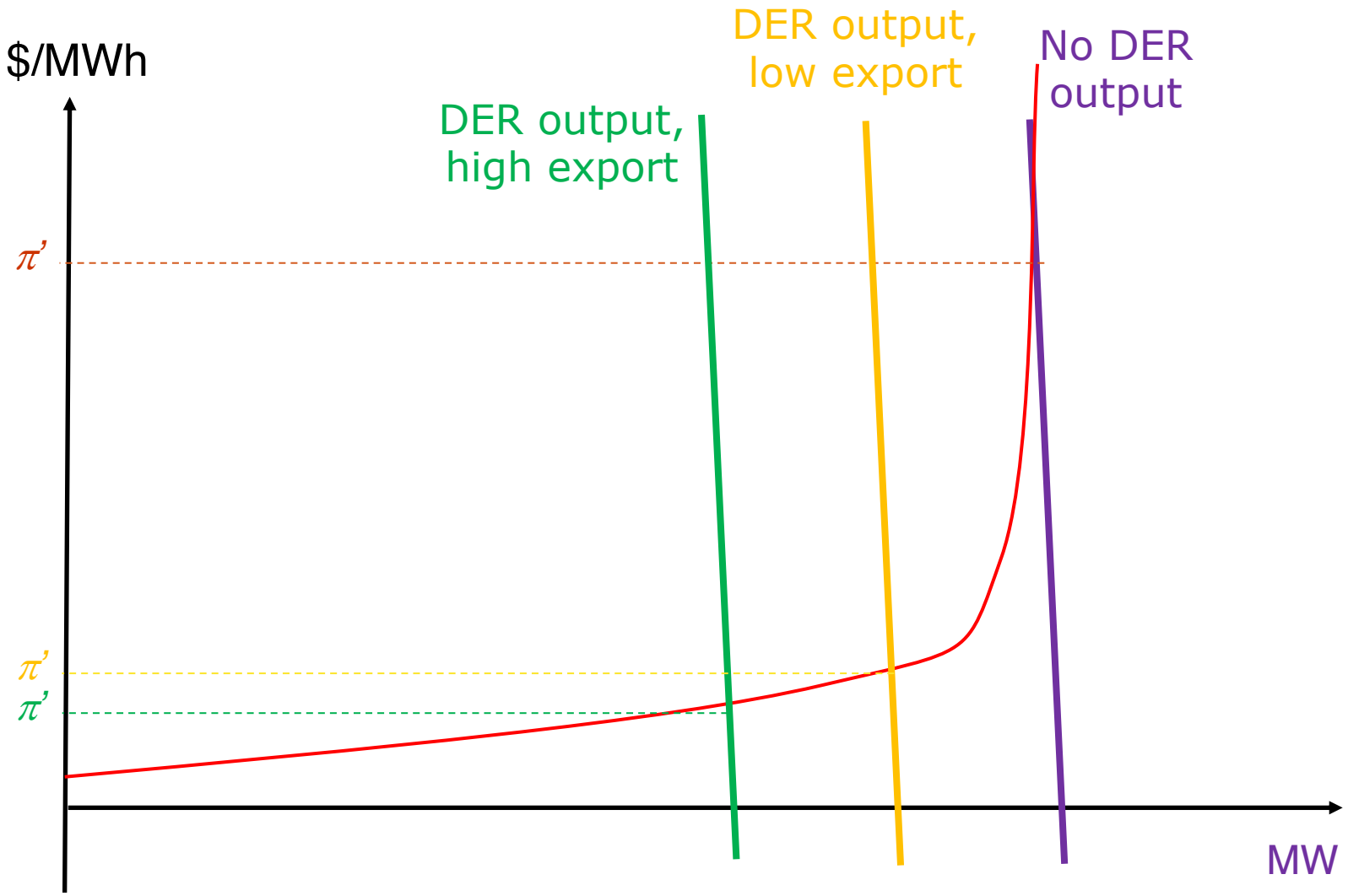
This **loss of community benefits** can become **worse with deeper DER penetration** as networks become more constrained, which is exactly when DOEs are most needed!



Additional DER participating in DOEs can also **reduce community benefits** if DNSPs are attempting to **allocate capacity** among participating customers in **an intuitively fair way,** without other considerations

By trying to be **fair to a subset of customers** (those with DER and actively participating in the marketplace), **benefits and fairness to the wider pool of customers and community might also reduce**

What does it mean for the whole system?



Food for thought

- There is, in general, **negative correlation** between the fairness metrics and the technical (and then economic) metrics
- This is because increasing "fairness" may directly **reduce capacity** that can be allocated to DER, and so the social welfare of the network and the system
  - Artificial reduction of the network hosting capacity
- Intuitive concepts of fairness and equality may thus lead to system-level, **socially "unfair" outcomes**
- Fairness allocation objectives may be in **opposition to NEO** efficiency (and emission reduction) principles
- **Increasing system efficiency** will likely lead to better outcomes/be **fairer for all customers** in general
- *Overall, a **new social contract** is required to make sense of all of this!*

What comes next?

- How will we include ALL customers' perspectives and more general socio-economic principles?
- How to balance the expectations of DER customers against those of all customers?
- How can all customers clearly benefits from DER and its efficient management?
- How will we need with dynamic "import" limits?
- Can dynamic network pricing do the job, or will we need distributed markets?
- How can we develop dynamic network pricing that reconciles:
  - DER "rights and responsibilities"
  - Dynamic network limit framework for network and system security
  - "Spot value" for local network and whole system operation
  - Asset cost recovery

Acknowledgment

- The incredible work of the team (Dr James Naughton, Dr Shariq Riaz, Ms Carmen Bas Domenech, Mr Lucas Quiertant, Dr Sleiman Mhanna)
- The continuous support and feedback from the Ausnet and AEMO teams during Project EDGE

Socio-techno-economic aspects of DER: Results and considerations from project EDGE

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Melbourne, 16th Novembre 2023

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