

Operational Experiences from a 100% Solar Network

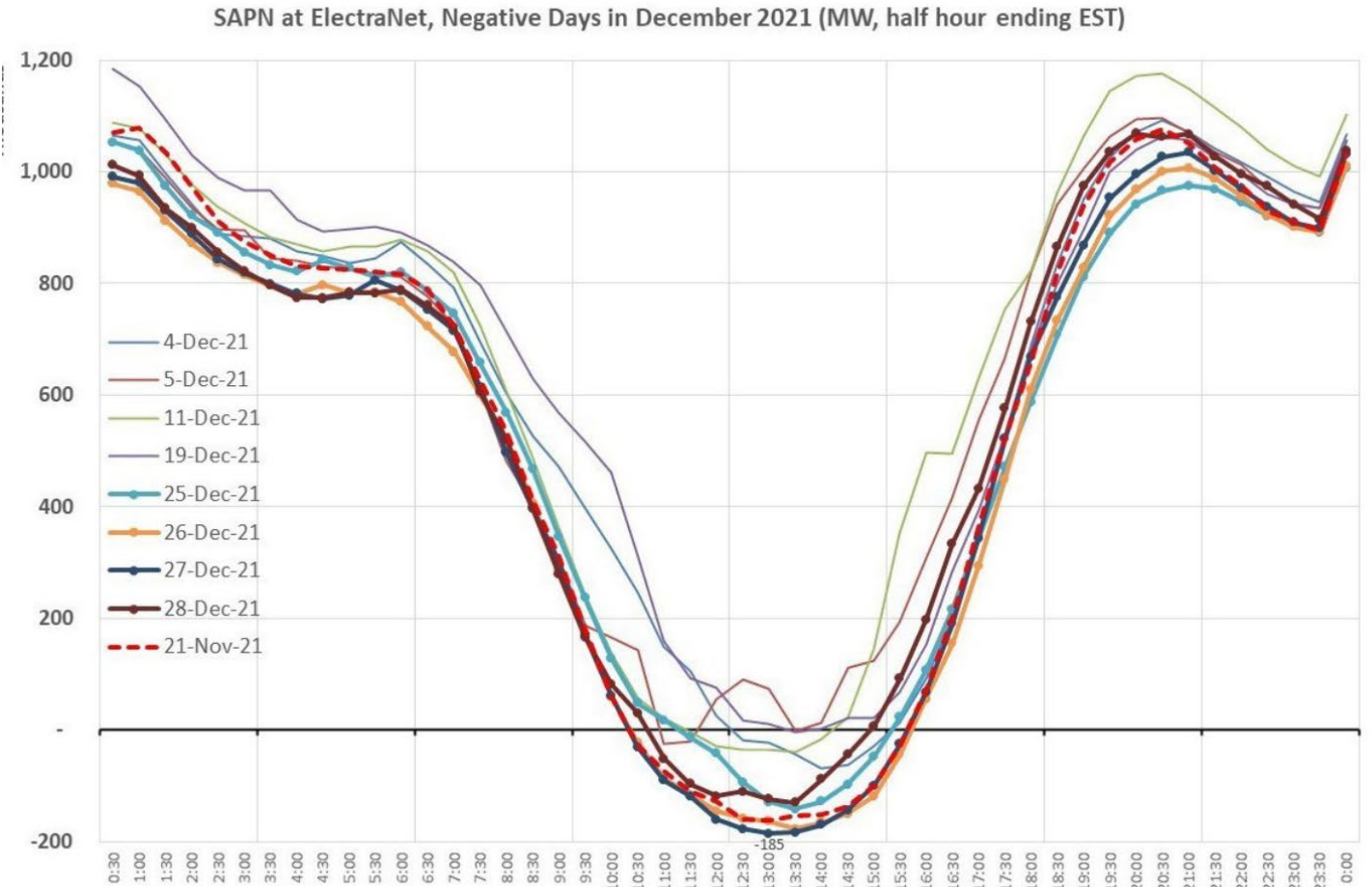
ReliabilityFirst – May 2023



Empowering South Australia

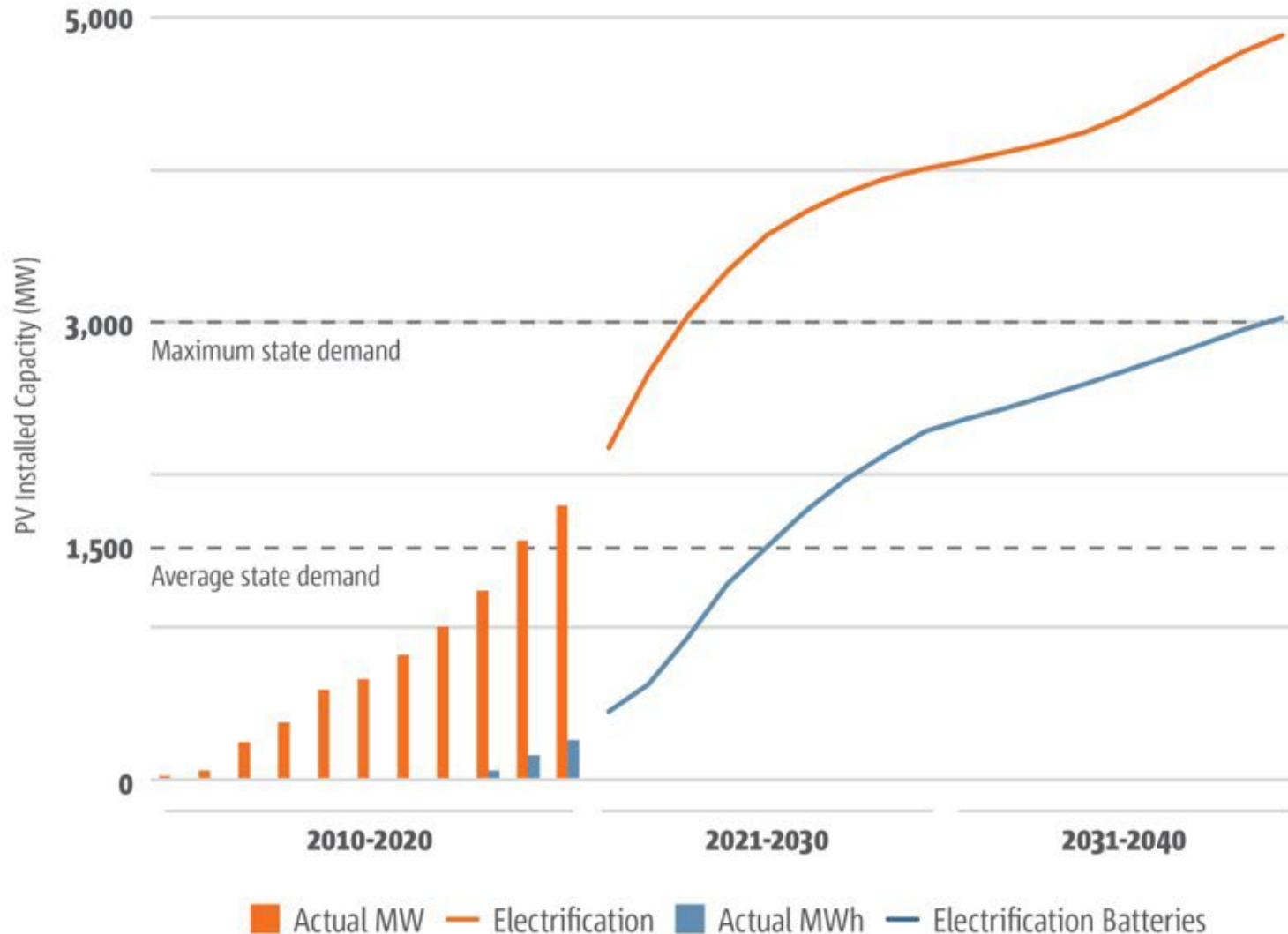
The distribution network: SA's newest power station

- On 2 October 2021, the distribution network in SA exported to the transmission network for the first time
- During Spring, this occurs for up to 4-5 hours per day on most mild, sunny weekend days, and occasional mild, sunny workdays



Could we run on 200% solar, or 100% batteries, by 2030?

SA Forecasts AEMO ESOO 2021



~300,000 rooftop solar systems

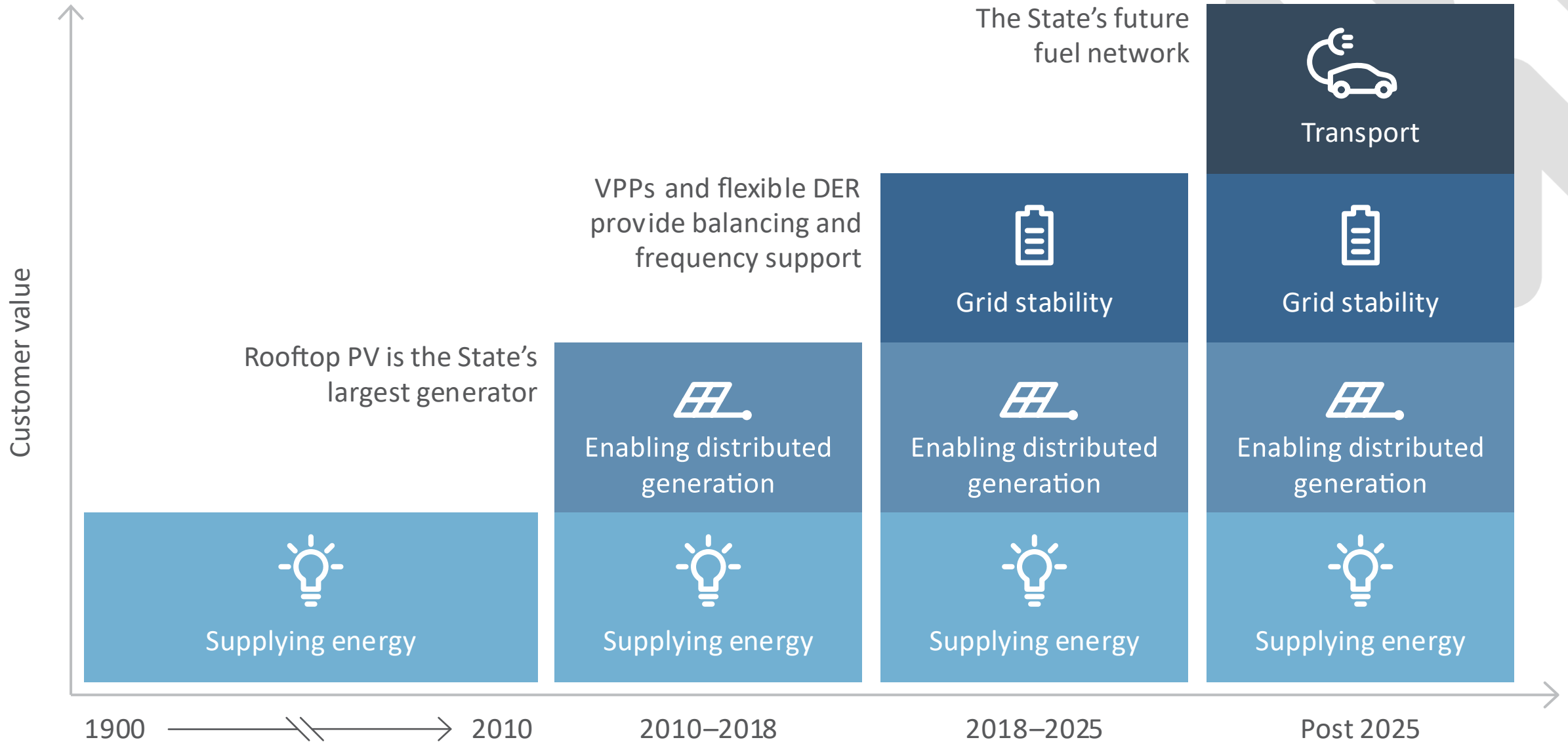
>1 in 3 customers – world’s highest
State’s largest generator
Record growth continues



~30,000 home batteries

9 active VPPs in the State

We can adapt the network to release significant value



The opportunity of a 100%+ solar network

Low cost

Clean

Abundant

Local



The challenges

Going outside of
existing engineering
experience base

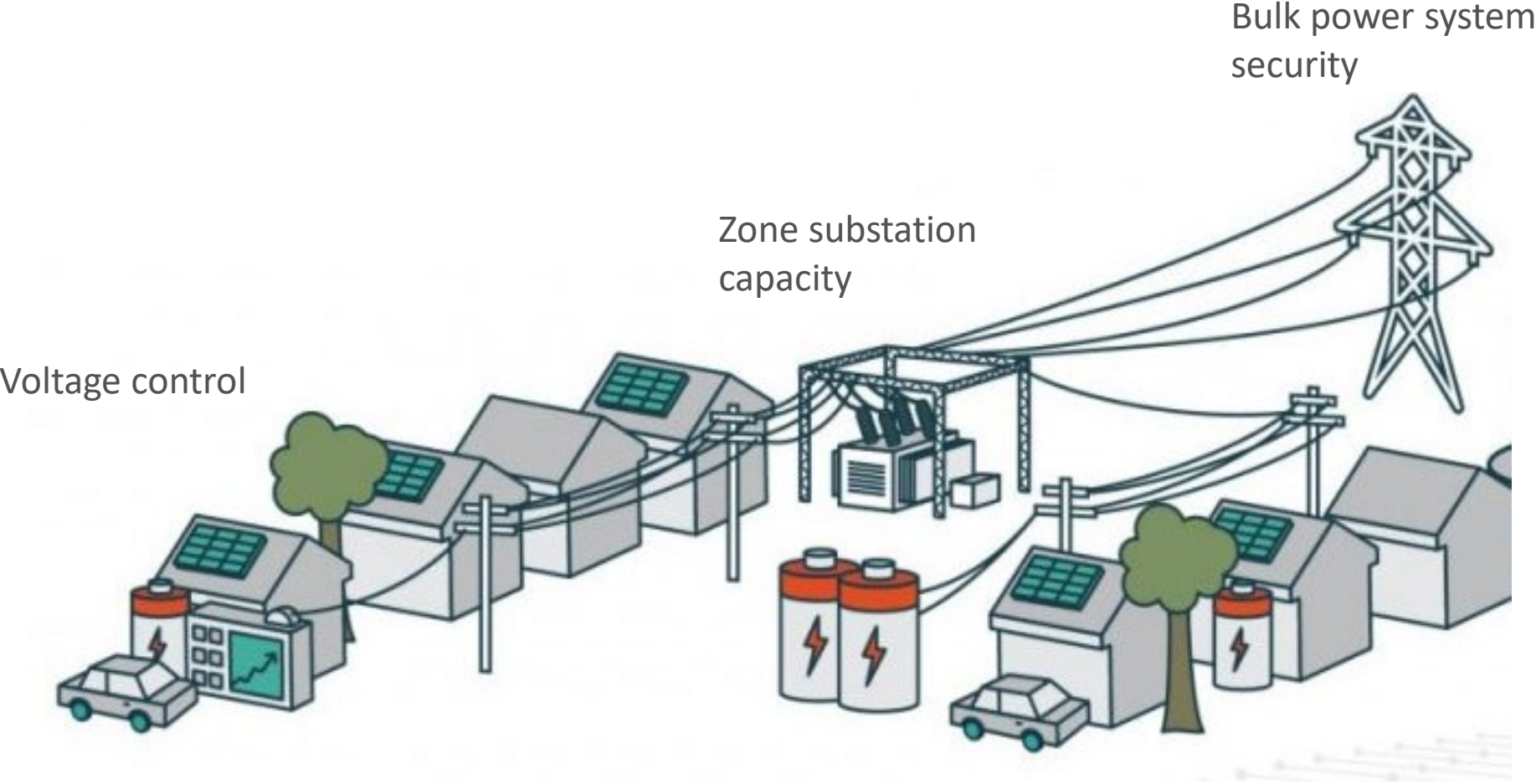
Achieving
“symmetrical network
capacity” for both
load and generation

Ensuring it still works
when things go wrong

Ensuring costs and
benefits are allocated
fairly



Where are the pressure points?

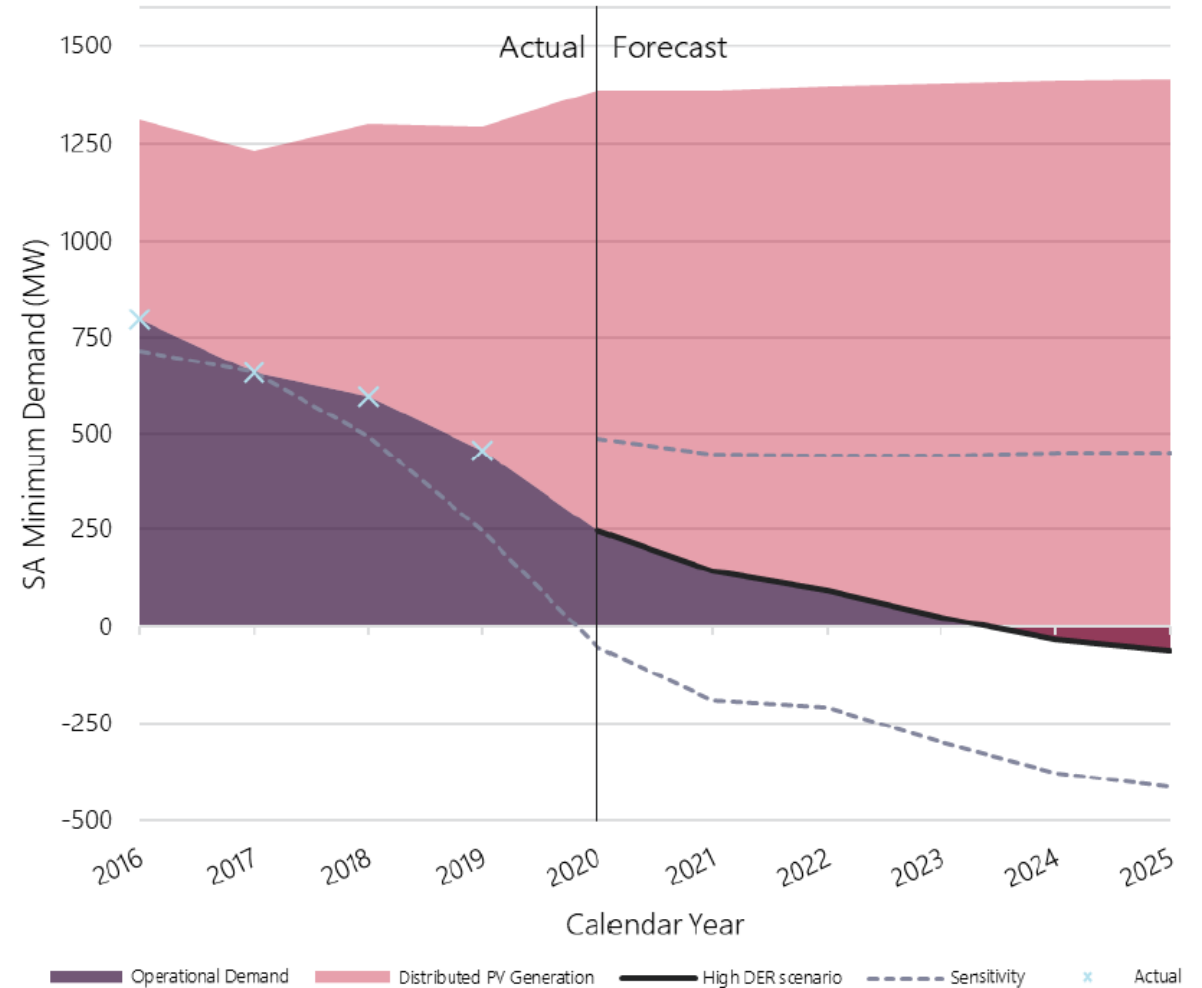


<http://www.energynetworks.com.au/news/energy-insider/building-our-energy-future-through-open-stakeholder-engagement/>

Bulk power system security challenges

Three impacts of high solar PV generation on bulk power system security:

- Inability to operate **minimum amount of synchronous generation** to maintain system strength and voltage control
- Large **reductions in rooftop PV generation** in response to a major transmission fault in the metro area
- **Under Frequency Load Shedding (UFLS)** can destabilise the system during disturbances



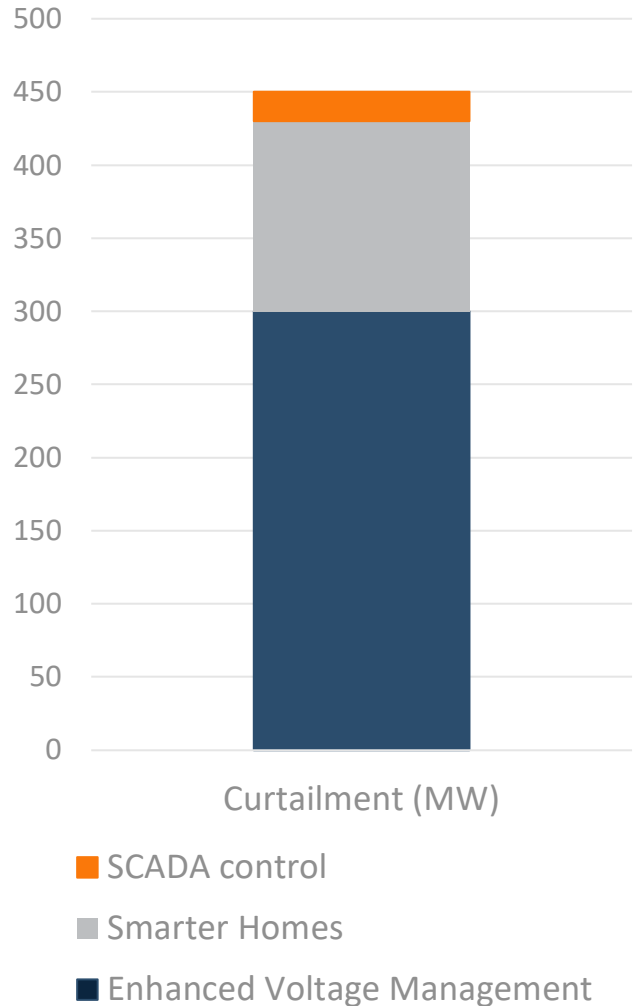
Source: Minimum operational demand thresholds in South Australia, AEMO 2020

November 2022 storms



- 4:15PM Tuesday 12 November 2022 front hit
- Gust of **106 km/h** at Adelaide Airport
- **163k customers** were impacted over the event – this is nearly 20% of our customer base
 - Including over **500 wires down**
- Needed to curtail rooftop solar between 13 and 19 November for system security

Generation Curtailment Methods & Capability



Three main generation curtailment methods totalling **~450MW** minimum, ordered by stages used:

1. SCADA-controlled Generation - **~20MW** from large generators where SCADA control is a requirement
2. Smarter Homes - **~130MW** via remote disconnection under Smarter Homes
3. Enhanced Voltage Management (EVM) - **~300MW** curtailed by increasing substation voltage to trip PV systems

Additional / Future Method: Flexible Exports (in trial phase)

Event achievements

- Successfully managed one of the most challenging islanding events that could occur using available generation curtailment methods
- Successfully achieved a world record 91% instantaneous wind and solar penetration during the islanding event

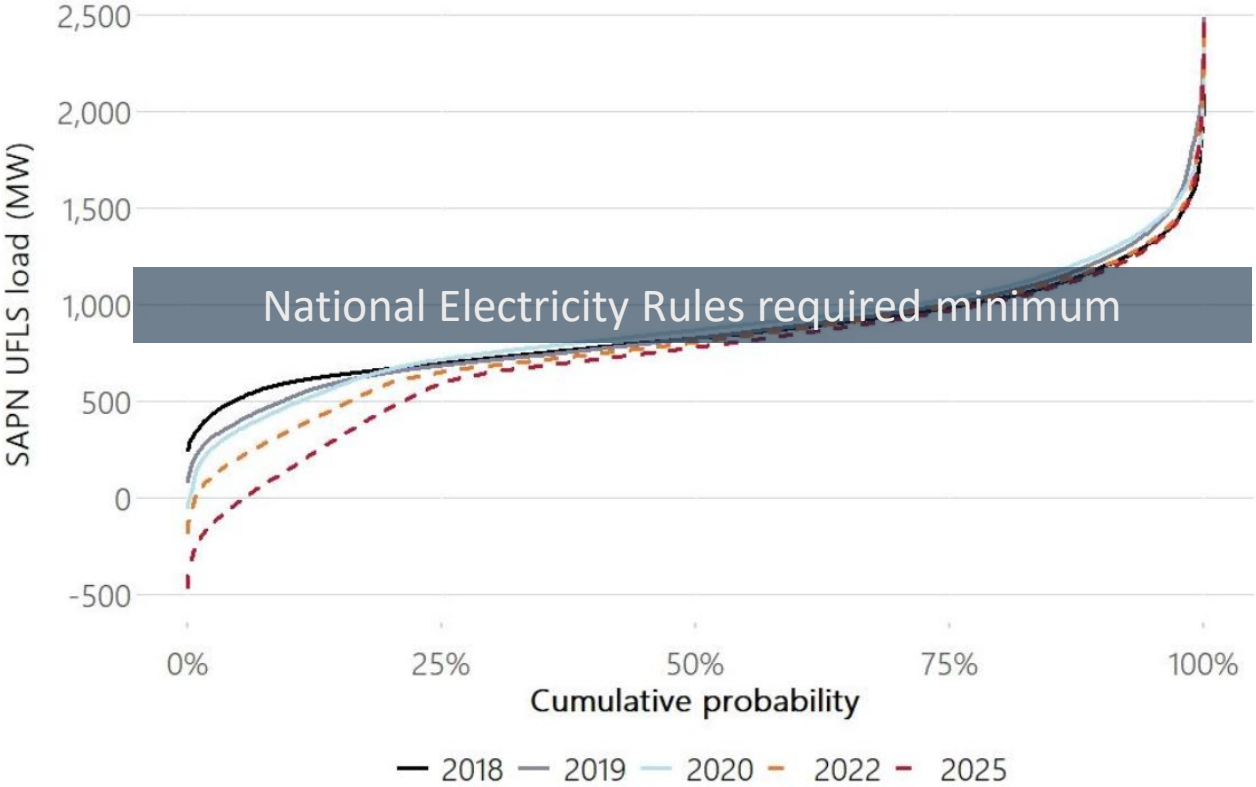
Insights from the event

- Ensuring rooftop solar meets grid connection standards in the field is critical and challenging – both for fault ride through and remote management capability
- Storms and distribution network outages impacted on multiple telecommunications paths (both smart meter and customer internet), highlighting need for robust local fallbacks
- In future, generation curtailment will need to be carefully coordinated with frequency control provision from within the distribution network
- Managing these challenges may go beyond traditional roles and responsibilities of industry participants



Under-frequency load shedding

Figure 2 Total net SAPN load on UFLS

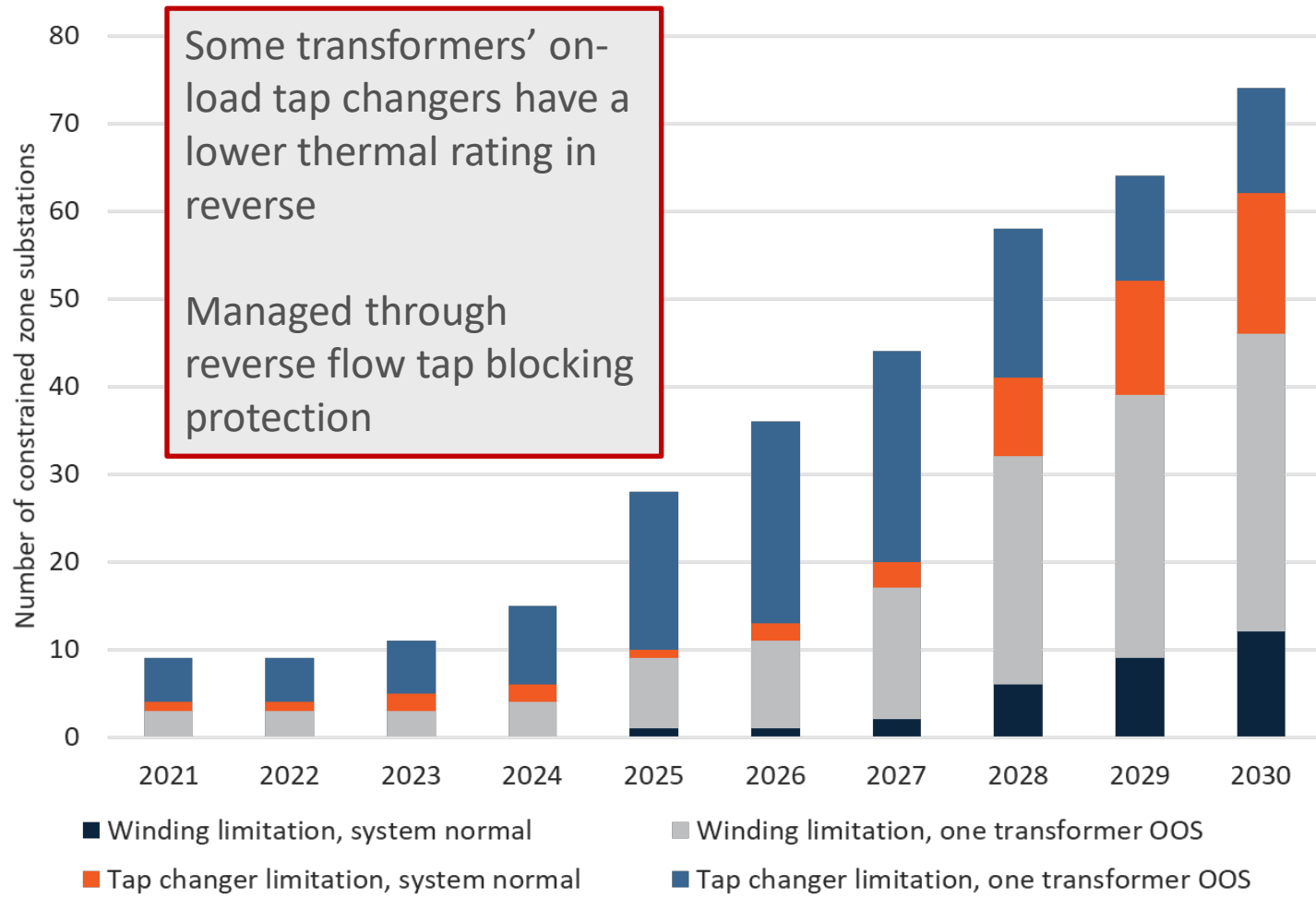


Total UFLS load in SA reached - **110 MW** (-152 MW on distribution network) on 21 November 2021

UFLS load should be ~800 to 1,200 MW



Zone substation thermal limits are emerging



Some transformers' on-load tap changers have a lower thermal rating in reverse

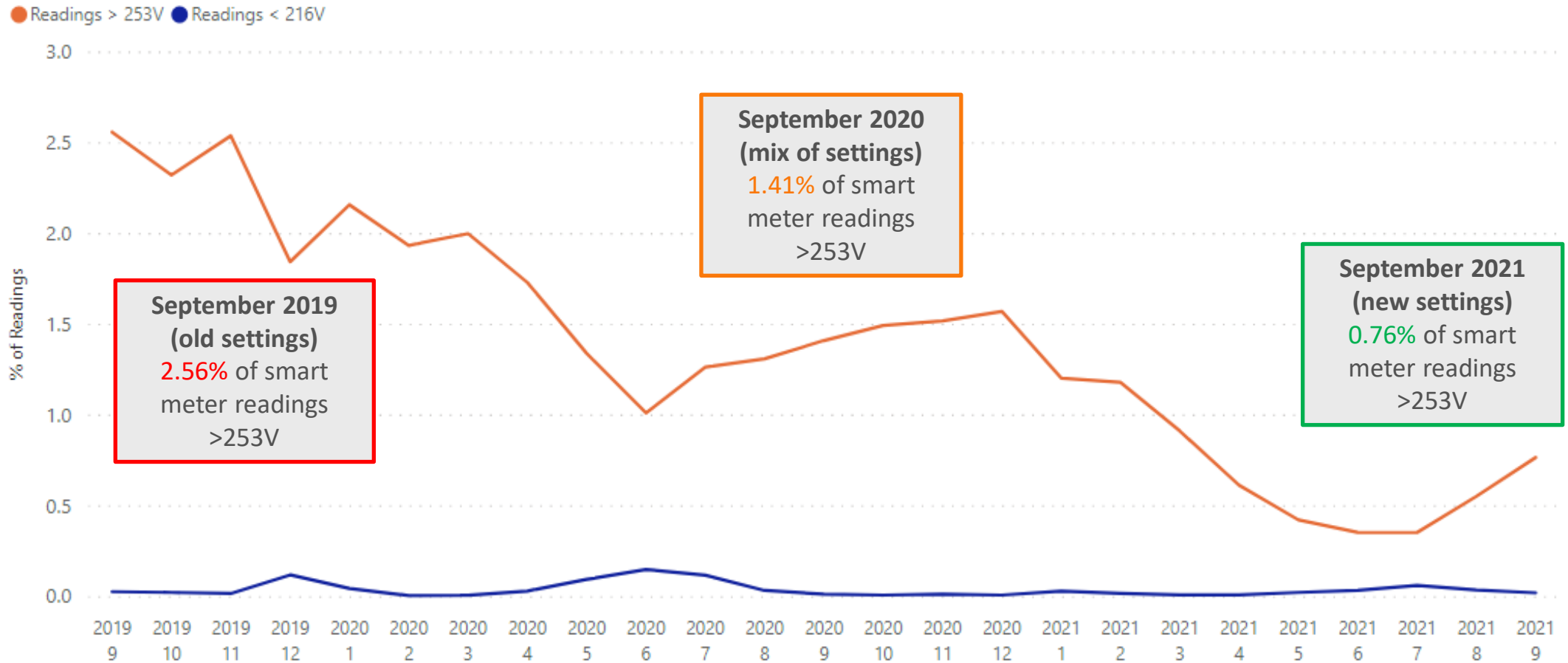
Managed through reverse flow tap blocking protection

Large solar farms and/or high PV uptake can lead to peak export exceeding peak load at some substations

Manage by encouraging local use of power, then use dynamic operating envelopes (via Flexible Exports or SCADA) when limits exceeded

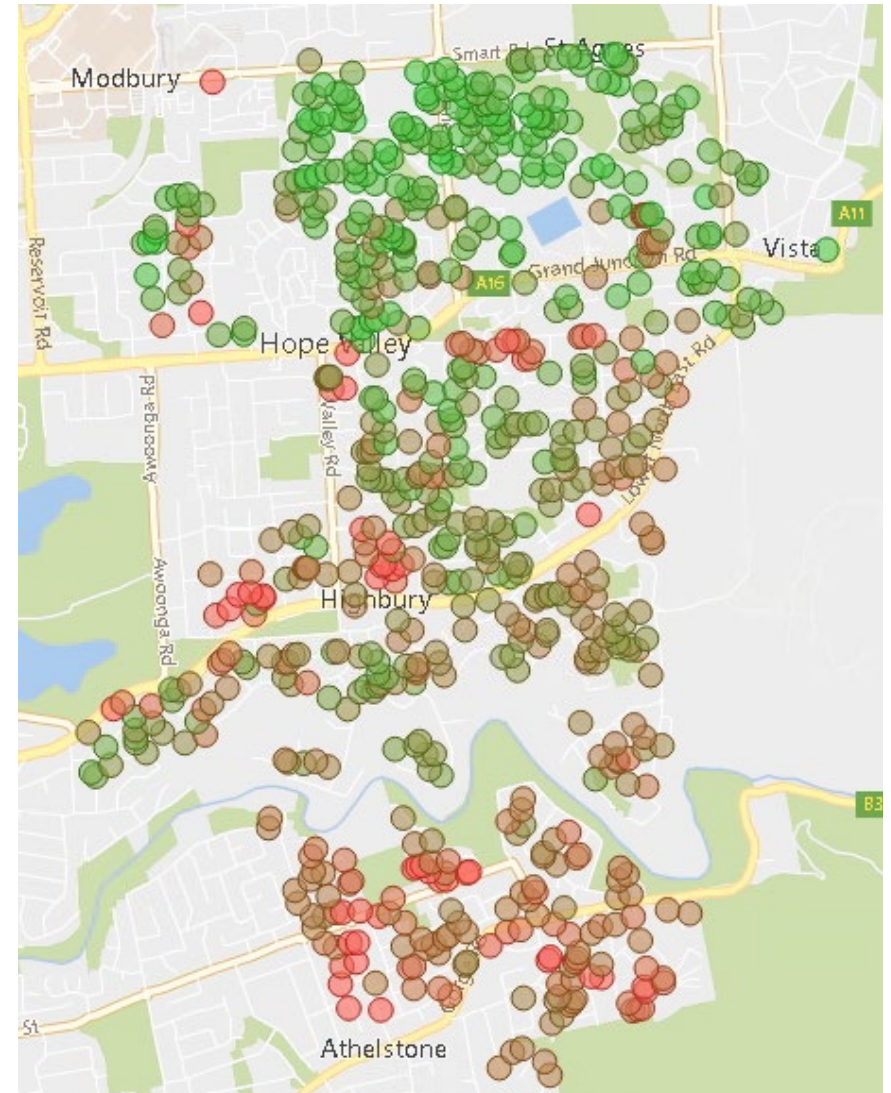
When curtailment becomes too frequent, consider storage and/or augmentation

Network voltages have improved due to voltage settings upgrades

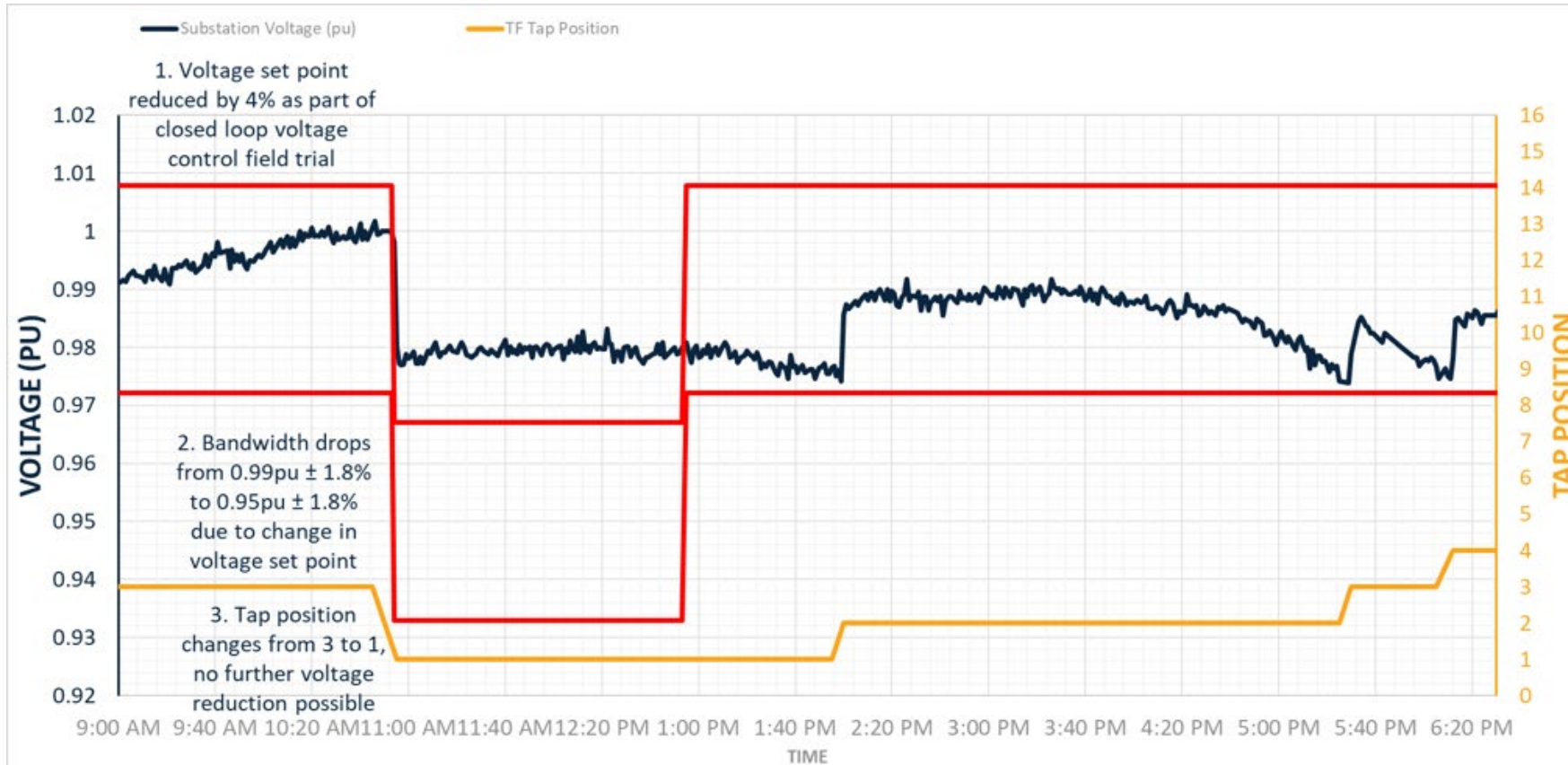


Closed loop voltage control

- Can we adjust substation voltages in direct response to feedback from customer voltages?
- Trialled at Hope Valley substation using a diverse set of data sources
- In most of Australia, customer voltage data must be procured from third parties – this means **significant integration challenges**

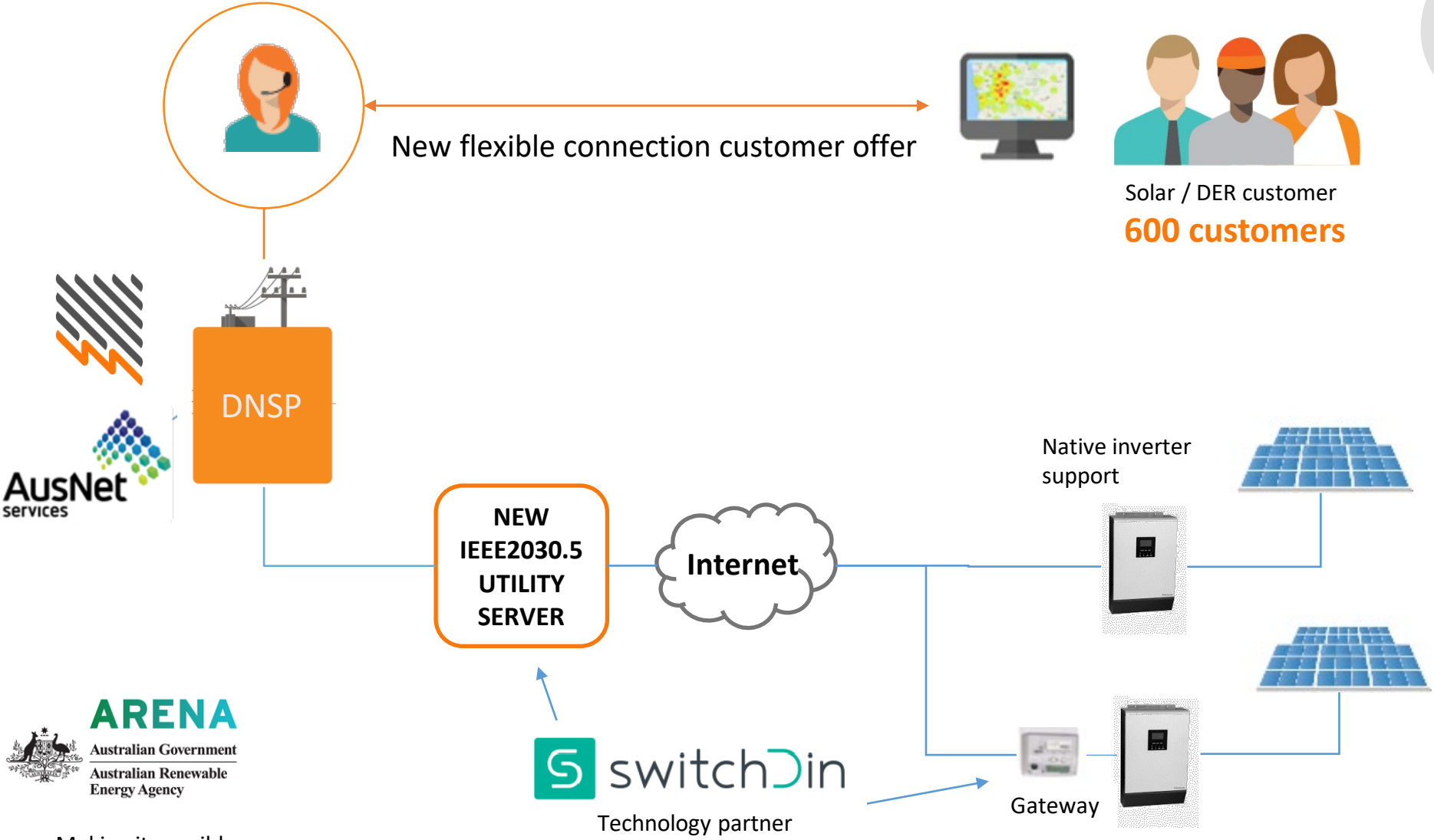


Reaching the physical limits of substation voltage regulation



- Closed loop voltage control needs adequate substation tapping range to work
- Influenced by transmission voltages, which are difficult to manage under high-PV conditions
- Current topic for joint planning between SA Power Networks and ElectraNet (transmission network)

Flexible Exports for Solar PV



New flexible connection customer offer



Solar / DER customer
600 customers

Successful trial conducted 2022

To be launched progressively across South Australia in 2023/24



Inverter integration

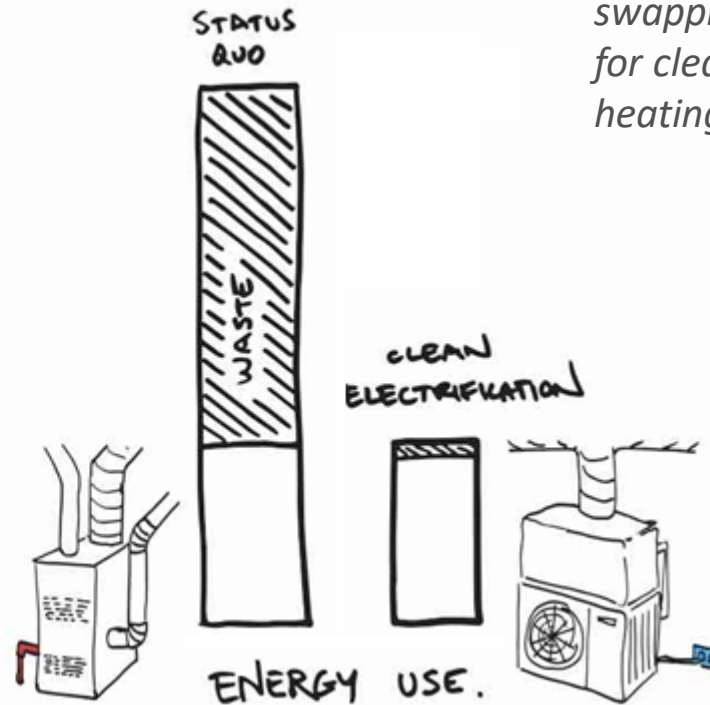
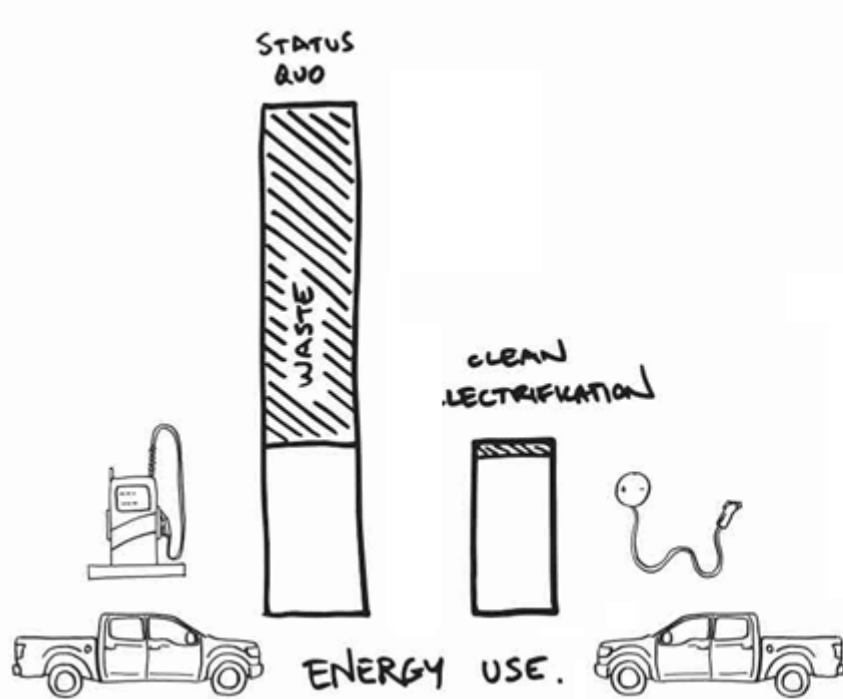


Advisory

Making it possible

“Using it locally” through electrification

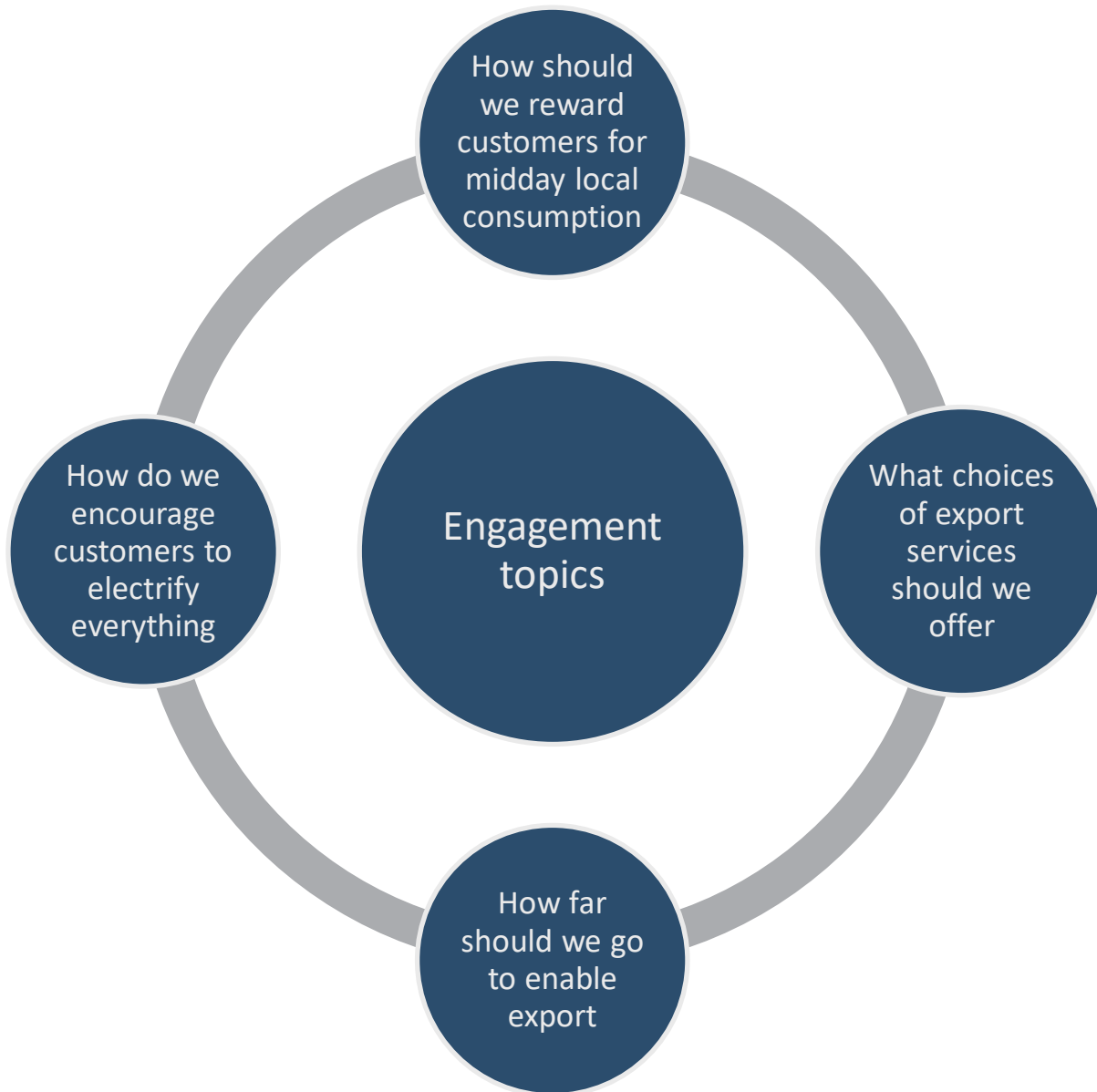
“Electrification” is the process of swapping fossil fuel burning machines for clean and efficient electric ones e.g. heating, hot water, cooktops & vehicles



- For most applications, electricity has significant advantages
- Solar PV allows energy to be generated very cheaply, close to where it will be consumed

An electric future will save customers money and support economic growth and prosperity

Towards 200% solar (or more!) by 2030?



- With the right smarts, the distribution network **can be run as a power station**, accommodating >100% solar using existing assets
- In 2025+, we want to go further, by **expanding and optimising** the space we have for solar on our network, and **increasing local use** of energy through EVs, storage and other flexible loads
- This will require **extensive community engagement** to design our >200% solar network



Empowering South Australia