“Emerging approaches in distribution network optimization”
30 Jan 2026 Newcastle

EPICS Tutorial

Workshop

- Hands-on session to give exposure to modeling challenges and solutions in the distribution network space
- Showcase the opportunities to build on collaborative open-source toolboxes for distribution network simulation and optimization
- Showcase workflows using *git* to accomplish effective collaboration
- We will take an approach building on the *JuMP* toolbox in the *Julia* programming language, using off-the-shelf algorithms for simulation and optimization, with a focus on domain-specific applications through *PowerModelsDistribution* and *OpenDSSDirect*

Agenda

- Overall timing 9am - 3pm
  - Part 1: 9am-noon (with coffee break)
    - talks with slides, provide installation guidelines just before lunch
  - lunch noon-1pm
    - You can install VSCode, Julia, git
  - Part 2: 1pm-3pm
    - installfest, mostly guided but self-study, no general presentation

Audience

- We assumed
  - Electrical engineering or computer science background
  - Familiarity with linear algebra and complex numbers
  - Anyone interested in these topics
    - Ph.D. candidates, postdocs, early career researchers, vacation students
- BYOD – Bring your own device (laptop)

Goals

- Help you understand what is happening in Australian distribution networks
- Help you see the opportunities of moving from simulation to optimization thinking
- Generate excitement on scientific collaboration on open-source toolboxes for power systems research
- Give you the confidence to experiment with
  - Distribution network data sets for Australia
  - Modeling capabilities of OpenDSS(direct) and PowerModelsDistribution
  - Optimisation problem statements such as *distribution state estimation and dynamic operating envelope* quantification
- Share slides, background materials and contact details

Talks Content

- Introduction to power sector in Australia
- Challenges in distribution networks
- Modeling challenges
- From simulation to optimization modeling
  - What is mathematical optimisation
  - Multiconductor & multiperiod OPF, SE, DOEs
- Installfest: OpenDSSDirect and PowerModelsDistribution
- Get some examples running? E.g. GPST DOE code or something similar (https://github.com/frederikgeth/GPSTTopic82024/)

Who am I?

- Prof. Fred(erik) Geth
- Bachelor of Science EE/CS, Master of Science & PhD EE-power systems, all at KU Leuven (Belgium)
- PhD 2014 “Battery storage integration in distribution networks”
- Developed an EV integration optimization software tool at Tractebel 2014-2015
- Research lab EnergyVille 2016-2018
- Moved to Newcastle Australia and worked with national lab (CSIRO) 2018-2022
- Startup GridQube in Brisbane 2022 – mid 2025
- Love cycling (bikepacking) and skiing

Who am I?

- Julio Braslavsky
- Electronics Engineer 1989 National University of Rosario, Argentina
- PhD 1996 Electrical Engineering (Control Systems) University of Newcastle, Australia
- Postdoc: Université Catholique de Louvain-la-Neuve 1996 Belgium, University of California Santa Barbara 1997
- Senior Research Scientist CSIRO 2010. Senior Principal Research Scientist 2024
- Love cooking, camping, dancing (tango)

Who am I?

- James Foster
- Mathematics and Science, University of Newcastle, Australia
- PhD 2014 Mathematical Optimisation with Power Flow Applications
- Postdoc: University of Wisconsin-Madison
- Research Scientist CSIRO 2019, Senior Research Scientist CSIRO 2025.
- Love reading, hiking, games with my kids

Who am I?

- Gregor Verbic
- BSc and MSc in Electrical Engineering, University of Ljubljana, Slovenia
- PhD (2003) on voltage stability, University of Ljubljana, Slovenia
- Postdoc: University of Waterloo (2005)
- Moved to Australia in 2010
- Professor of Electrical Engineering at the University of Sydney
- Love everything outdoors

Landscape of electricity networks in Australia

Australian Energy Market Operator (AEMO)

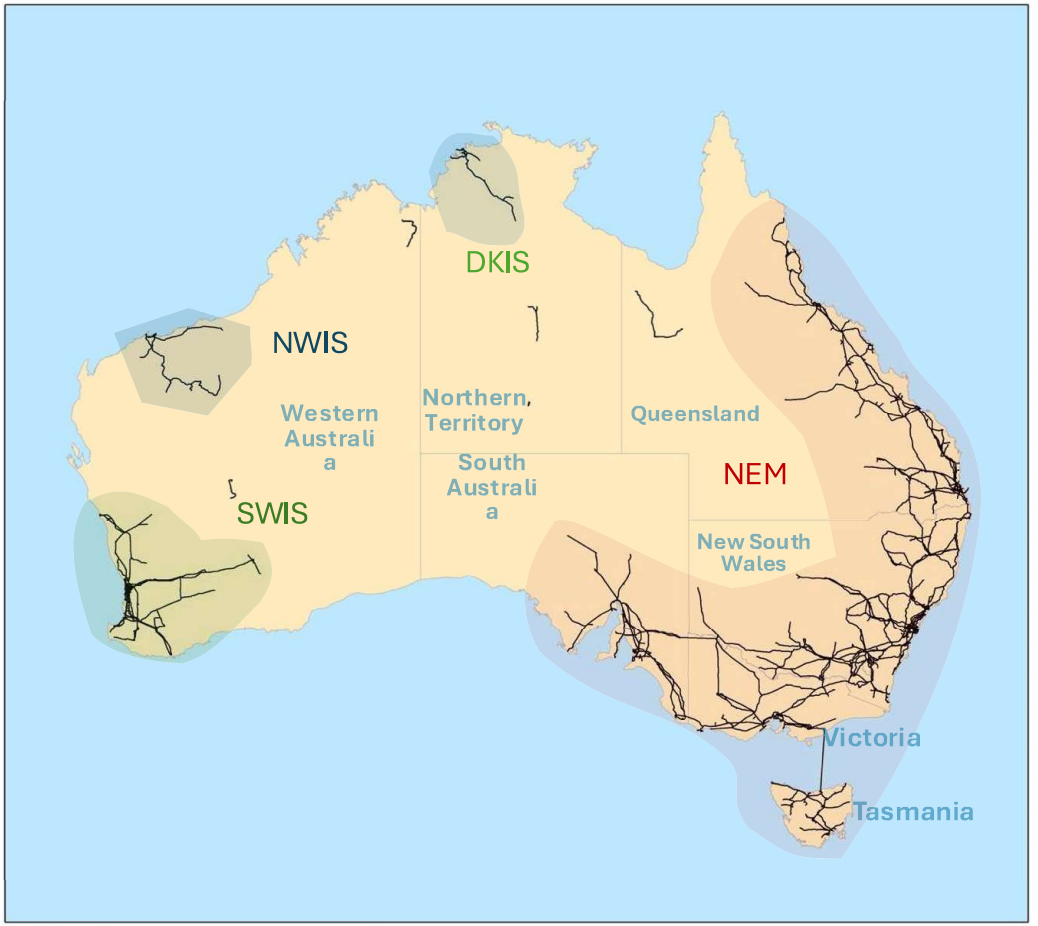
NEM (National Energy Market)
80 GW generation capacity
15 - 35 GW demand
5-minute dispatch energy market
Security constrained economic dispatch with co-optimised ancillary services

AEMO

SWIS (South-West Interconnected System)
5.8 GW generation capacity
Wholesale electricity trading and a capacity market

NWIS (North-West Interconnected System)

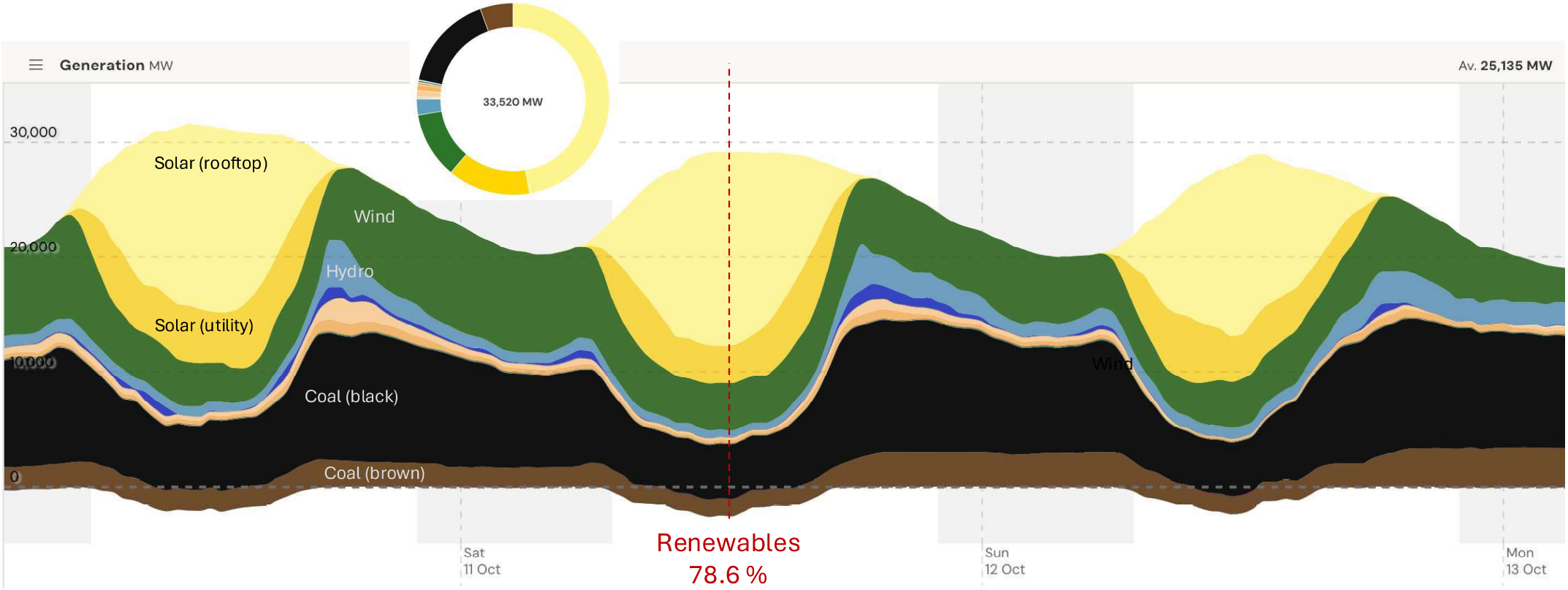
DKIS (Darwin-Katherine Interconnected System)
Numerous smaller systems



Renewables are rapidly displacing coal and gas generation

About 40% of Australian homes today have rooftop PV – capable of meeting 50 % underlying energy demand across the NEM in a sunny day

Current national record highest renewables generation over a day on Saturday 11 Oct 2025

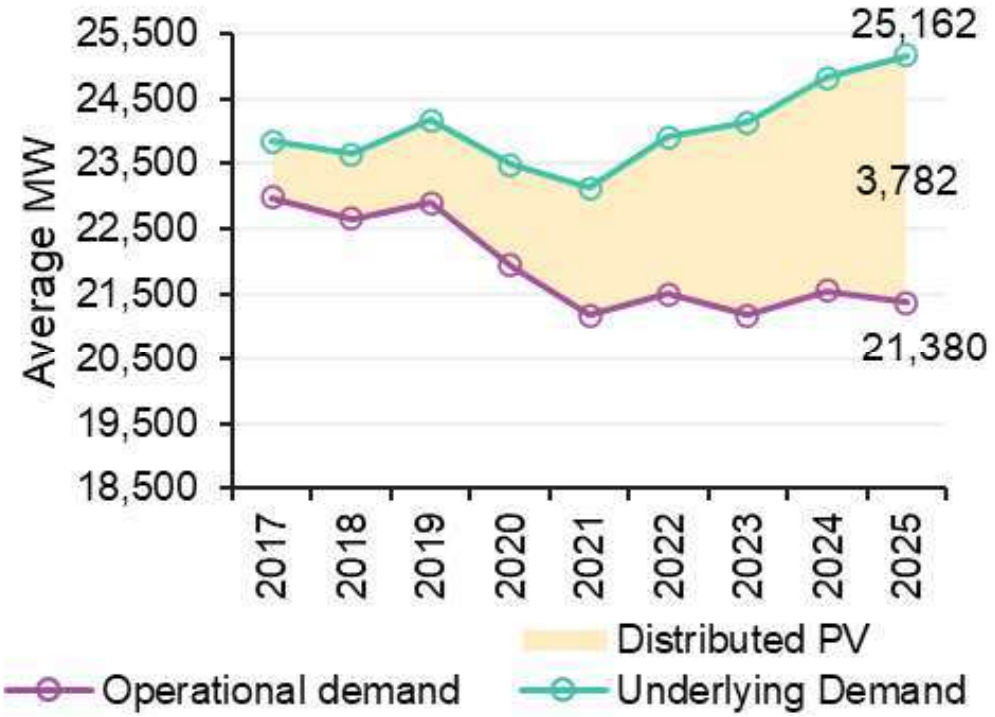


System operational challenges from high-level distributed PV

The growth of distributed PV has been reducing **operational demand** – needed to maintain minimum levels of dispatchable synchronous generation online

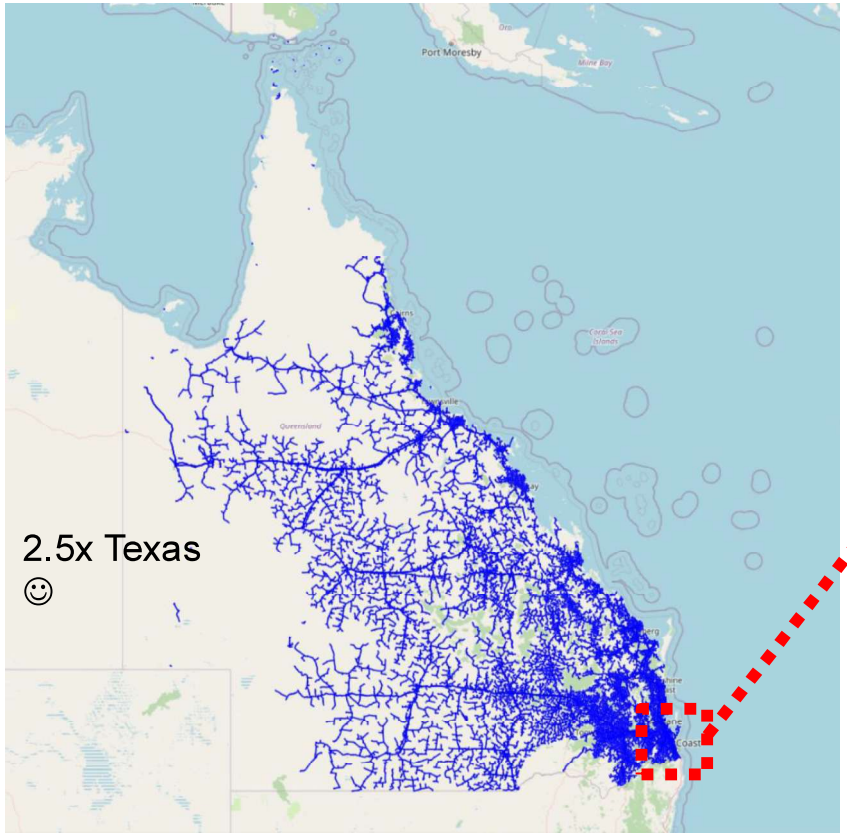
Today less than 5 % of (more than 4 million) rooftop PV inverters in Australia are controllable (standard AS/NZS 4777.2-

Without mitigating actions, high-PV generation at low-demand times pose risks to voltage and frequency controllability

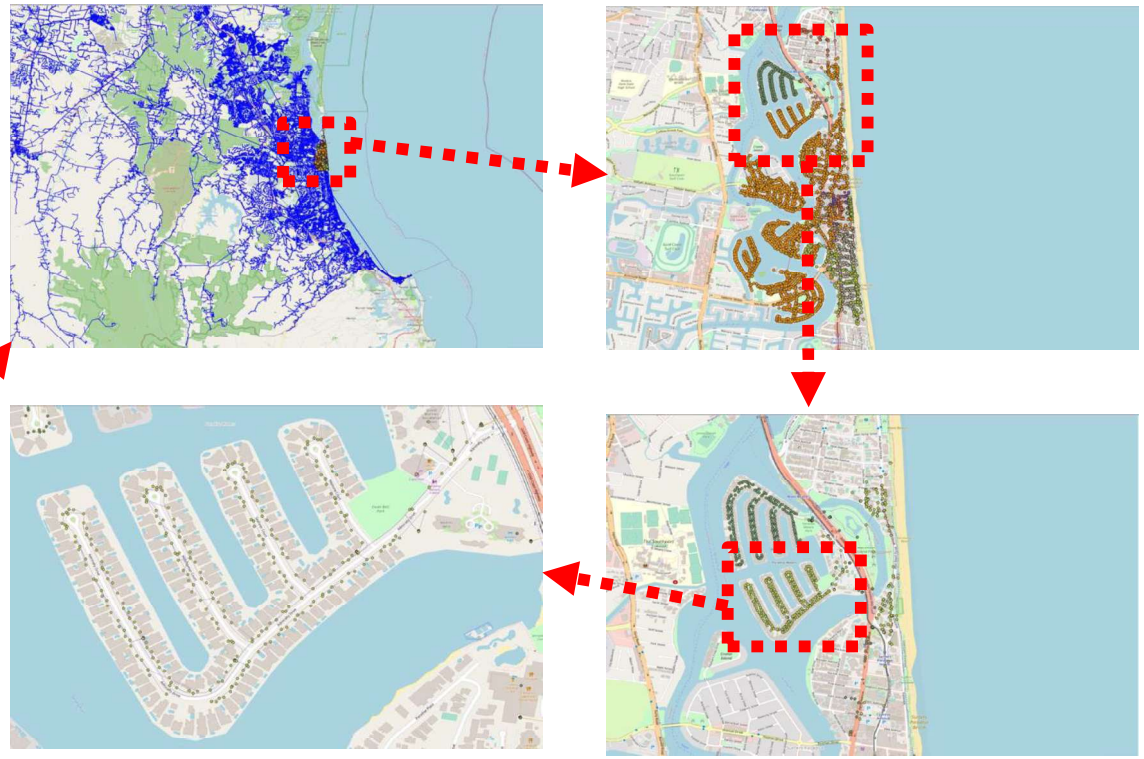


AEMO Quarterly Energy Dynamics (Q1 2025)

Distribution systems (& data sets) are huge



~14.5 million objects - ~30 million electrical nodes



Consequences for networks **not** ready for fast growth of DER

Countries Ranked by Watt per person

Rank (by W/person)	Country	Installed Solar (MW, 2024)	Annual Growth (2023–24)	W per person
1	Australia	38,472	15.6%	1,426
2	Netherlands	24,048	13.0%	1,336

https://ourworldindata.org/grapher/solar-electricity-per-capita 071

"Use as little electricity as possible between four and nine"

Dutch government TV campaign "Flip the switch"

"8,000 companies are currently waiting to be able to feed in electricity, while 12,000 others are waiting for permission to use more power."

Tennet, the government-owned agency that runs the Netherlands' national grid

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Netherlands' renewables drive putting pressure on its power grid

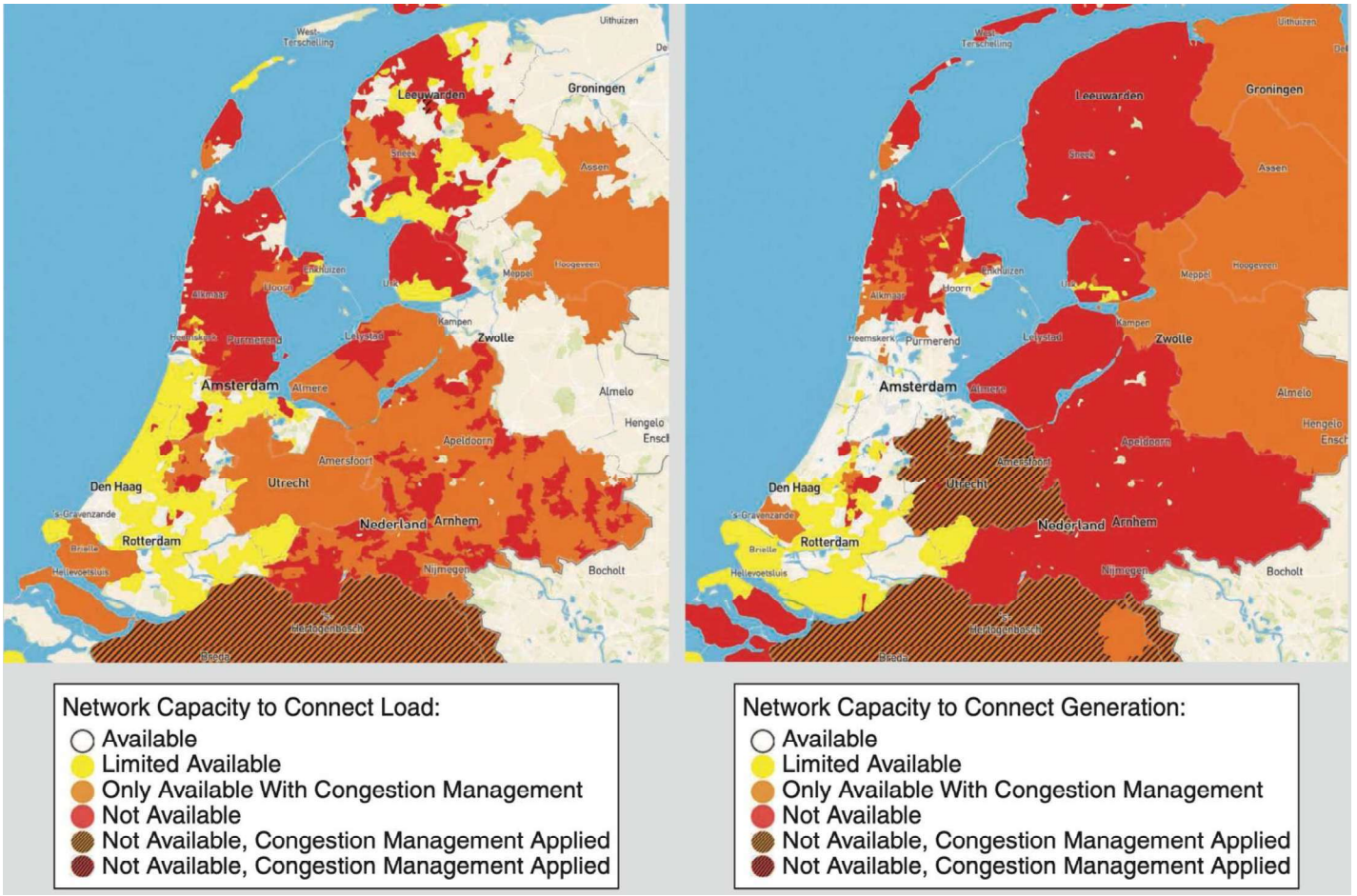
16 October 2025 Share Save

John Laurenson
Business reporter, Rotterdam

AFP via Getty Images

The Netherlands has raced to switch to wind and solar power

Distribution network congestion is reality



https://capaciteitskaart.netbeheernederland.nl/

Why focus on distribution systems?

In countries like Australia, **this is where the action is**

A transformation driven by consumers adoption of DER (Distributed Energy Resources)

DER bring opportunities and challenges

Seizing the opportunities and resolving the challenges requires investment and new ways to plan and operate the network

Dynamic operating envelopes (DOEs)

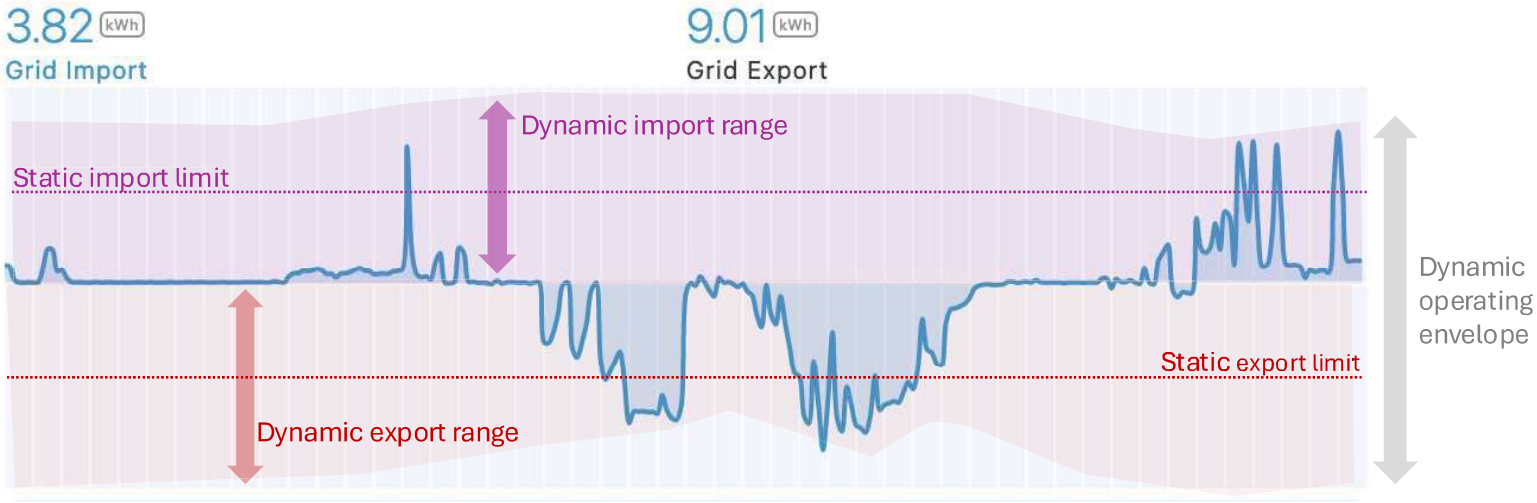
Allow DER to play a greater role in energy markets and the grid

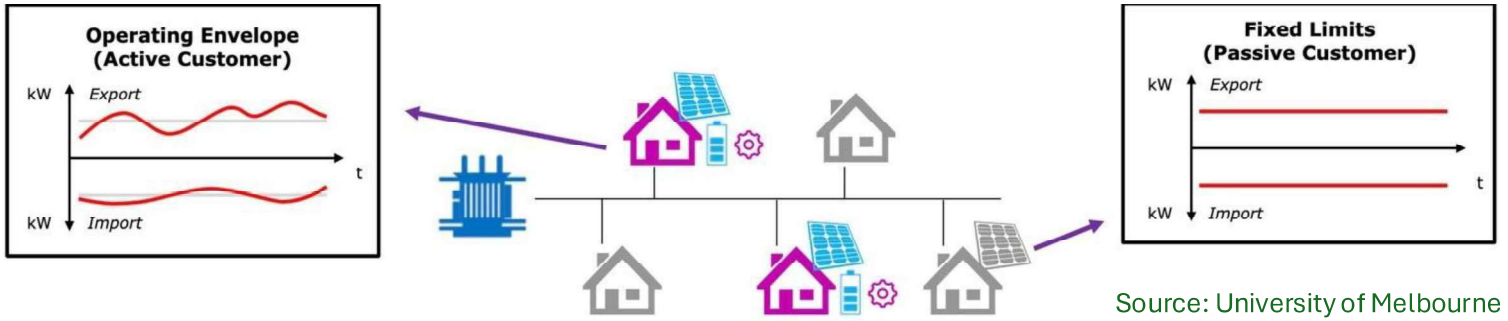
Set dynamically:

1-5-minute intervals,

24 hours in advance

Define time-varying, locational limits to the power that a consumer can import / export to the grid at a given moment





Source: University of Melbourne

DOEs are essential to realise the value of DER at scale

What about Australian networks?

MV is typically three-wire three-phase or single-wire earth return (SWER)

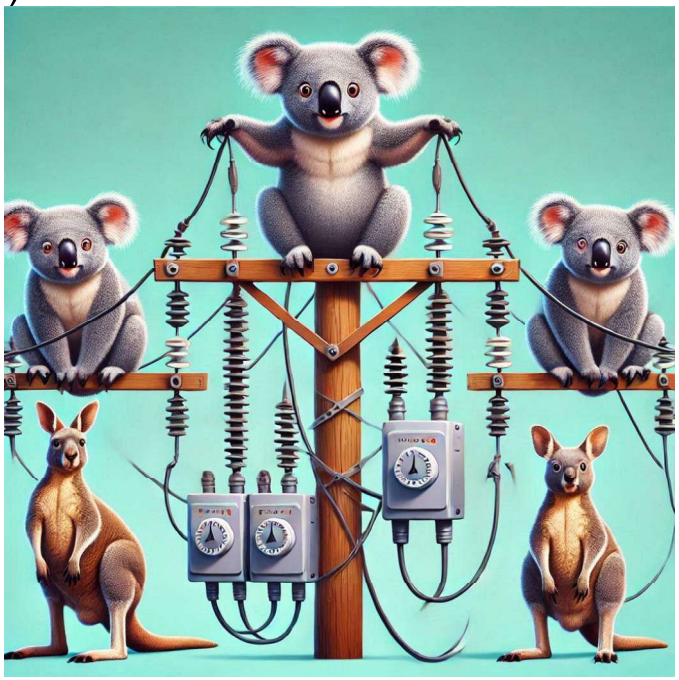
- Overhead lines and underground cables
- No transposition of lines

LV feeder (backbone) is typically three-phase four-wire OH/UG

- Laterals to customers single or three-phase
- Split-phase 2x230V when downstream of SWER

Multi-earthed neutral grounding philosophy

- <1 Ohm at sub, <10 Ohm at customer connection



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Batteries

Home batteries
and large scale well underway

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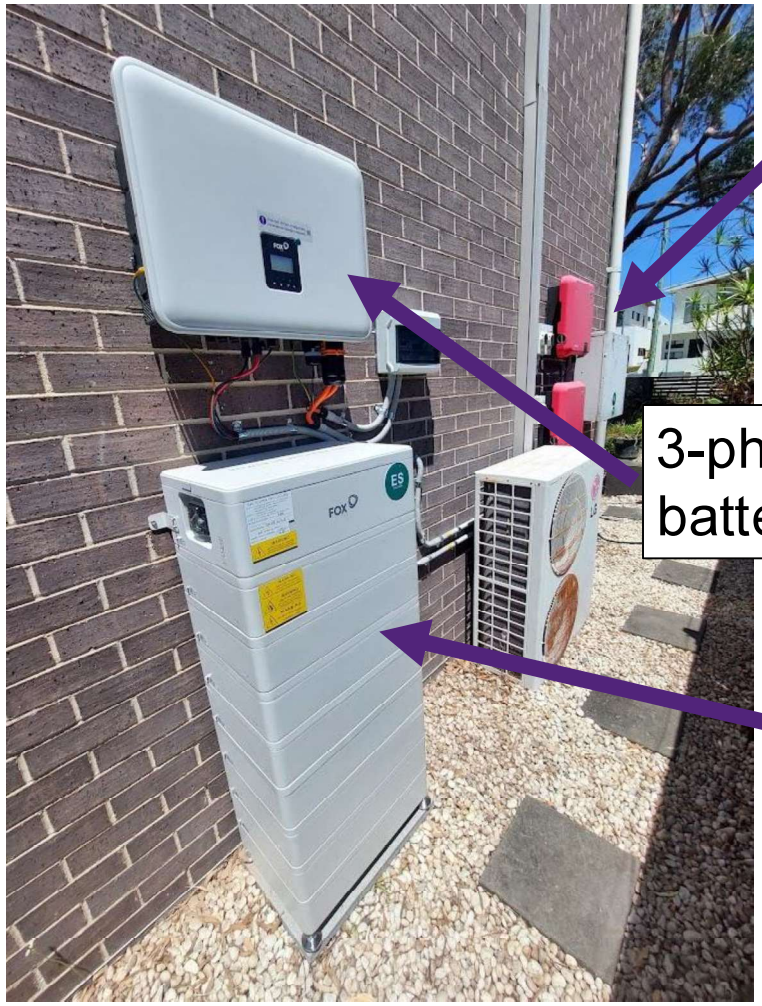
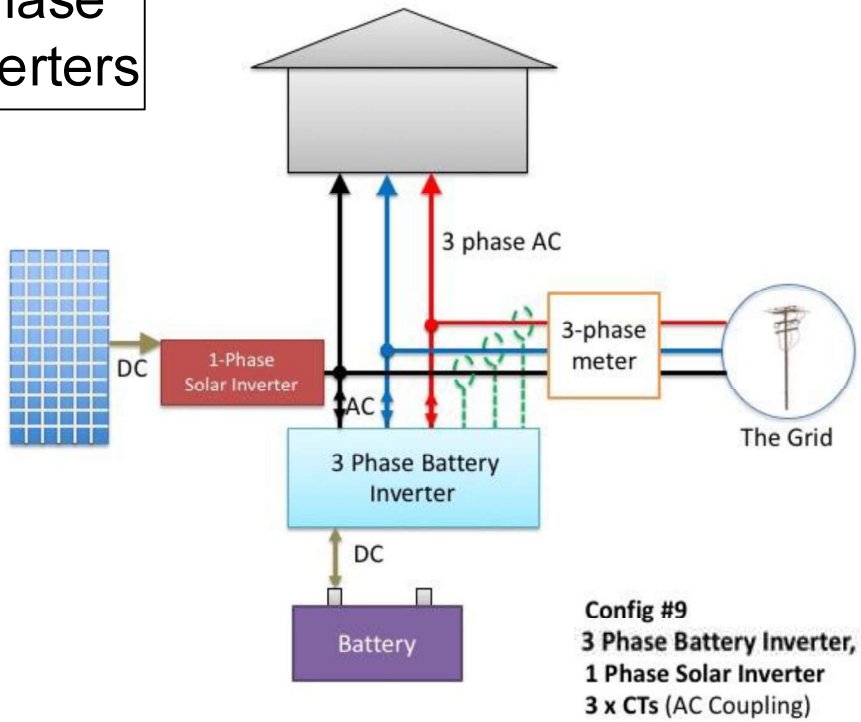
Home battery installations will match the scale of Snowy Hydro scheme – in a single year

Three-phase battery inverter with a single-phase solar inverter





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