Australian National University

Battery Storage and Grid Integration Program

An initiative of The Australian National University

Watt's in store for the energy system?

+ discussion with Prof Ian Lowe

Dr Bjorn Sturmberg

Senior Research Fellow, Battery Storage and Grid Integration Program

The Australian National University

Outline

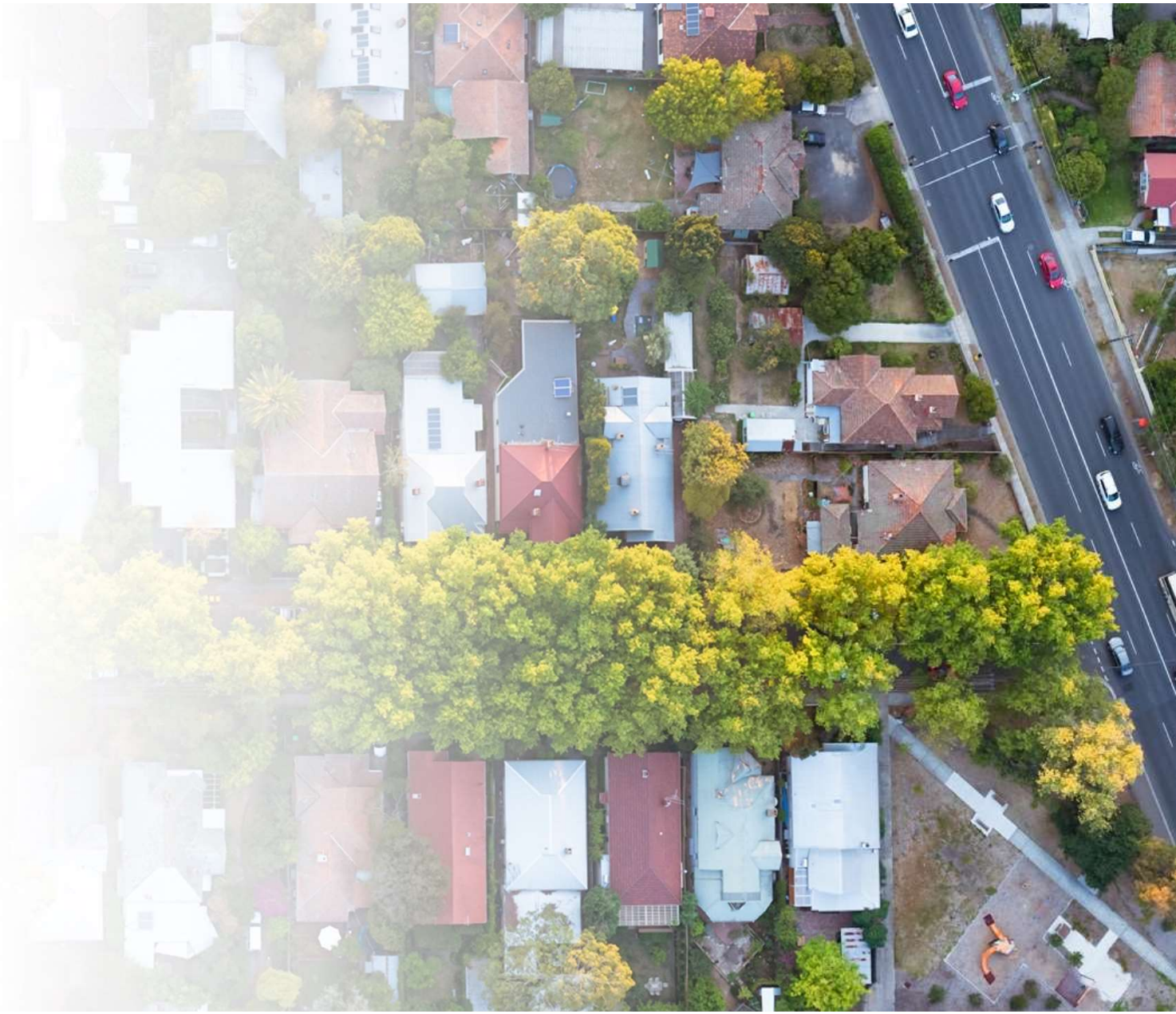
- **Key messages**
  Choices & power are in your hands
  Transition needs to be Fast & Fair

- Power **supply**

- Power **demand**

- Socio-political **sentiment**

- Discussion with **Prof Ian Lowe AO**



Kids book about clean energy

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SCHEDULES

Amy's Balancing Act

Join the author and discover how a young girl and her animals collide with the science of renewable energy.

Fri, Dec 30 | 8:45AM – 9:45AM | Puppet Joint

Available in the Festival Store

Chris Bowen MP, Federal Minister for Climate Change and Energy

Choices & power in your hands

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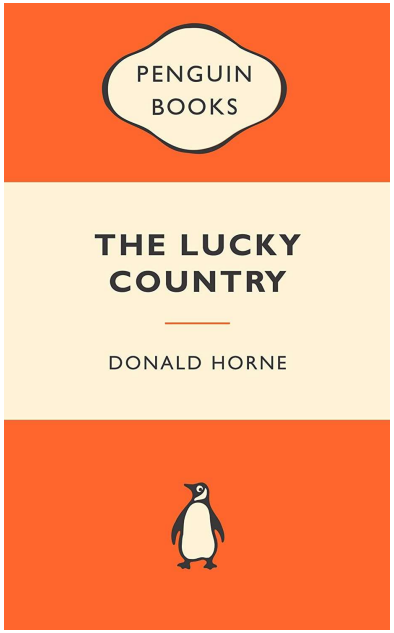

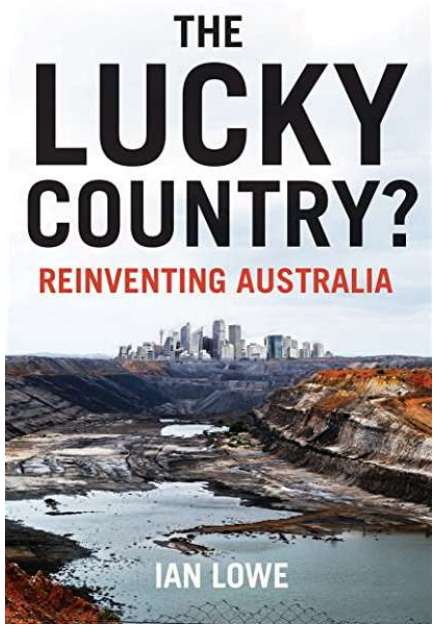

Lucky country with **abundance** of solar, wind, minerals, IP…

Choices & power in your hands

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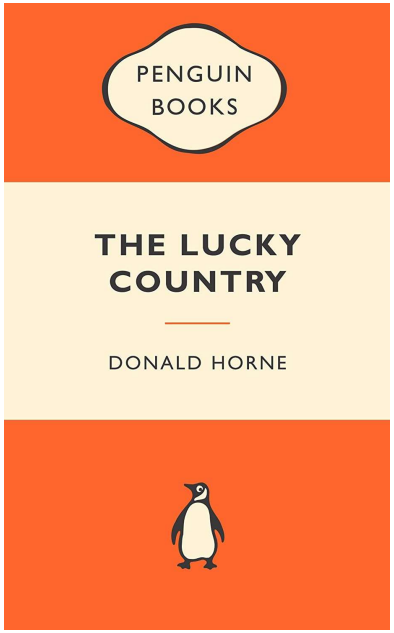

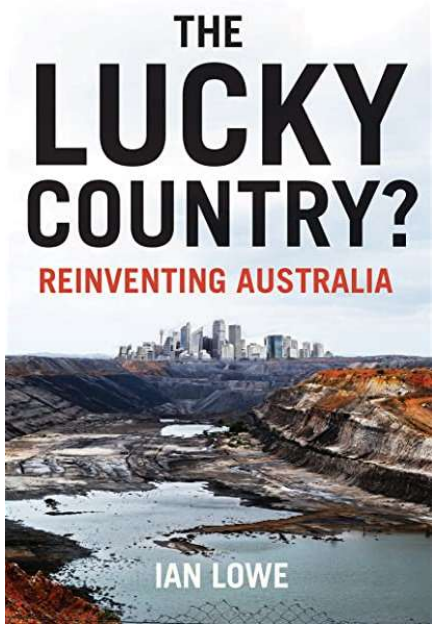

Lucky country with **abundance** of solar, wind, minerals, IP…

and **choices**

Transition principles

Fast

Transition principles

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Fast

Fair

Transition principles

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Fast

Fair

Fast to be Fair

Transition principles

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Fast

Fair

Fast to be Fair

Fair to be Fast

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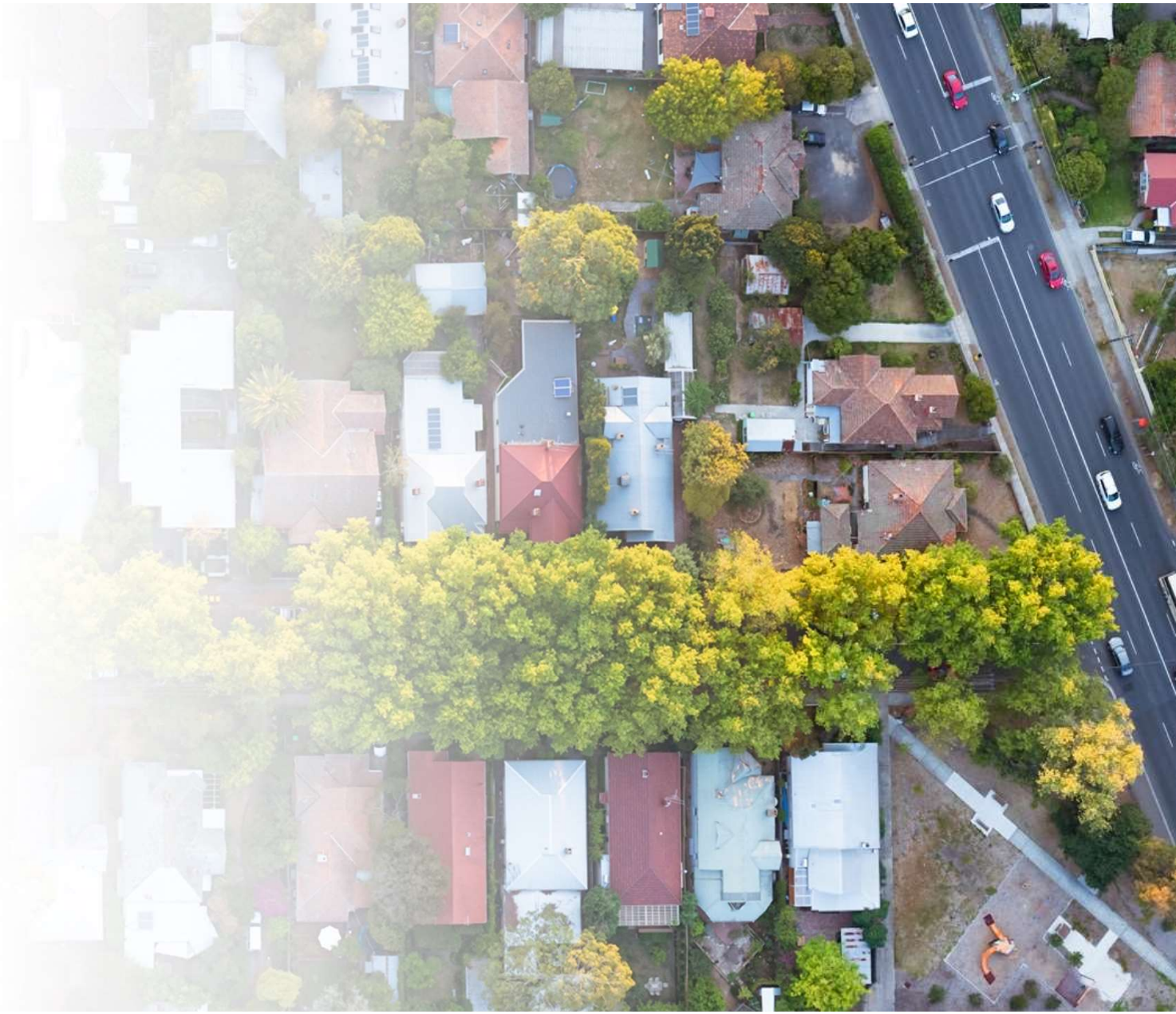

This is the NEM

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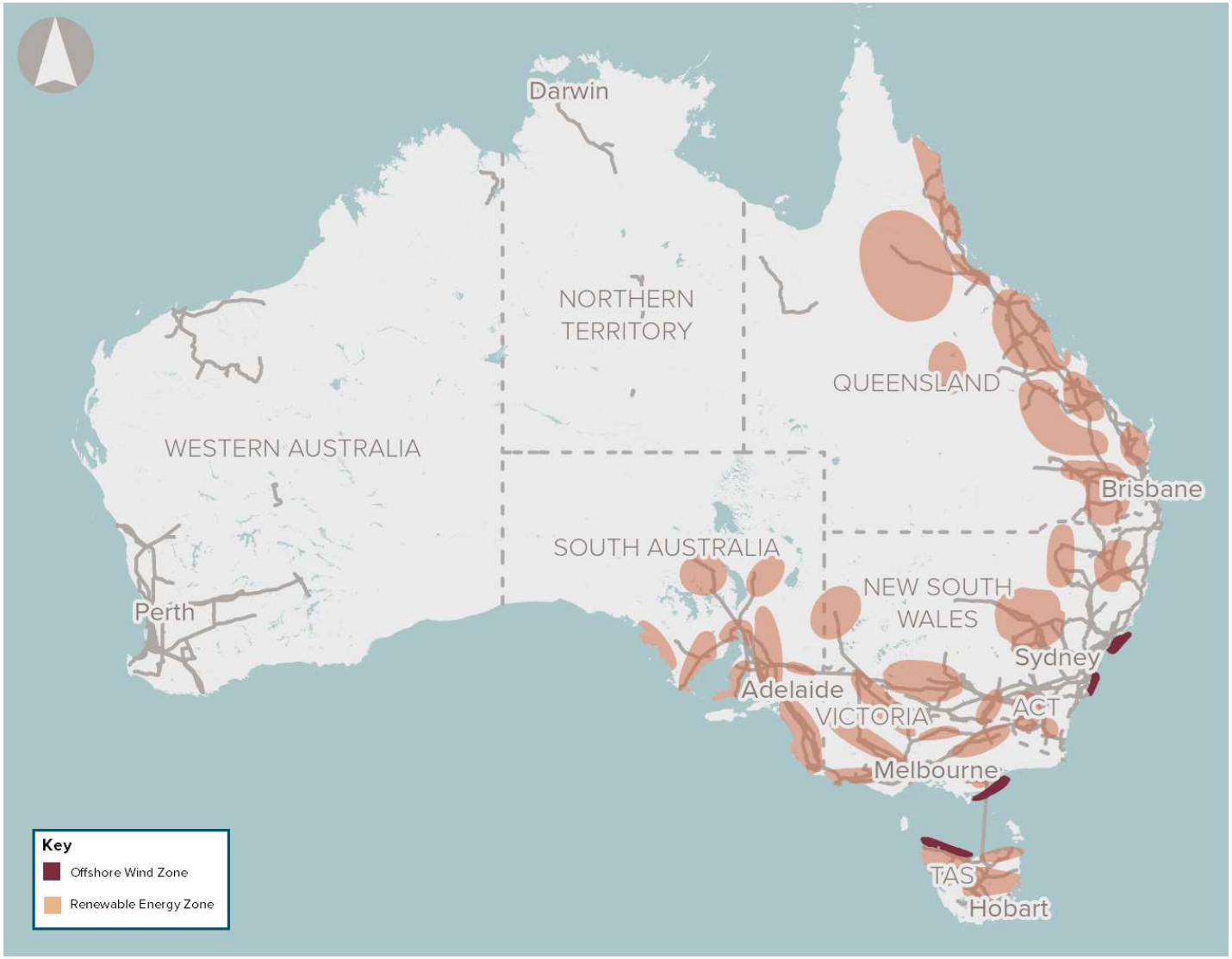

NEM generation mix

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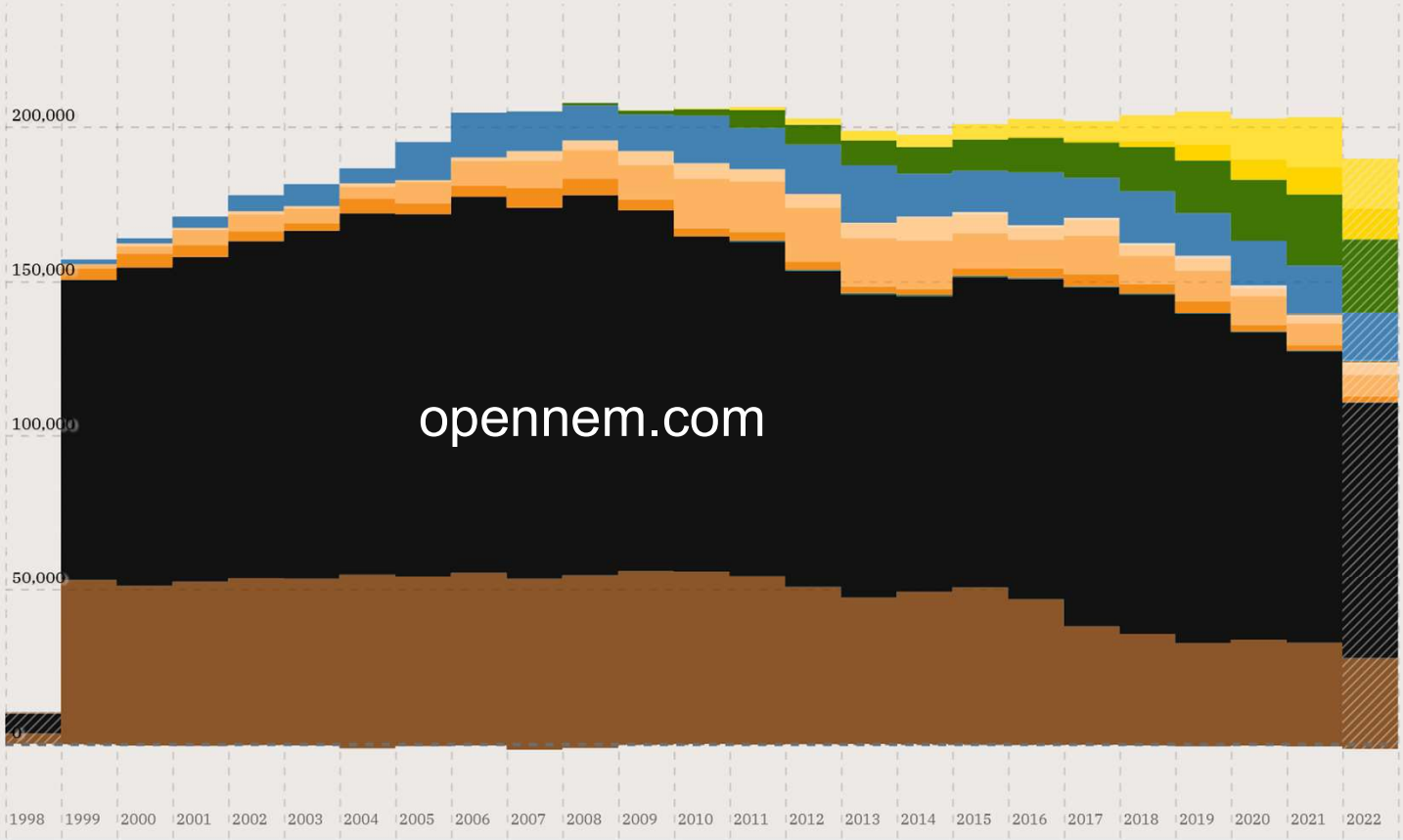
Energy NEM

Consumption Generation Export

1D 3D 7D 30D 1Y ALL Month Season Quarter Half Year Fin Year Year

Energy GWh/year

Av. 187,333 GWh/year

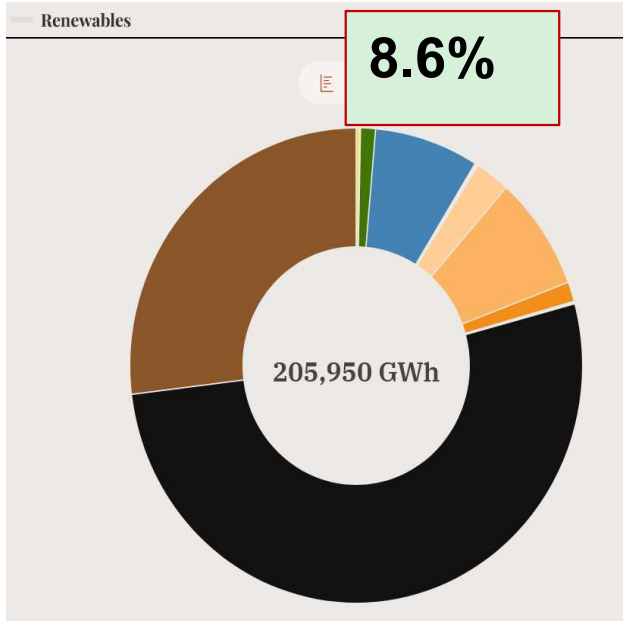


1998 – 2022

Default	Energy GWh	Contribution to demand	Av.Value $/MWh
Sources	**4,698,625**		**$63.45**
Solar (Rooftop)	91,631	2.0%	$52.58
Solar (Utility)	33,725	0.7%	$74.39
Wind	163,038	3.5%	$67.38
Hydro	283,119	6.0%	$70.28
Battery (Discharging)	594	0.01%	$182.48
Gas (Waste Coal Mine)	761	0.02%	$172.97
Gas (Reciprocating)	6,157	0.1%	$86.20
Gas (OCGT)	73,086	1.6%	$107.78
Gas (CCGT)	224,283	4.8%	$64.28
Gas (Steam)	77,917	1.7%	$75.09
Distillate	1,267	0.03%	$327.66
Bioenergy (Biomass)	3,446	0.07%	$61.99
Coal (Black)	2,575,789	54.8%	$54.74
Coal (Brown)	1,163,813	24.8%	$46.50
Loads	**-15,306**		
Pumps	-14,549	-0.3%	$62.17
Battery (Charging)	-757	-0.02%	$83.76
Net	**4,683,319**		
Renewables	**574,959**	**12.2%**	

NEM generation mix

2010 – 12 years ago
“new decade resolution”



NEM generation mix

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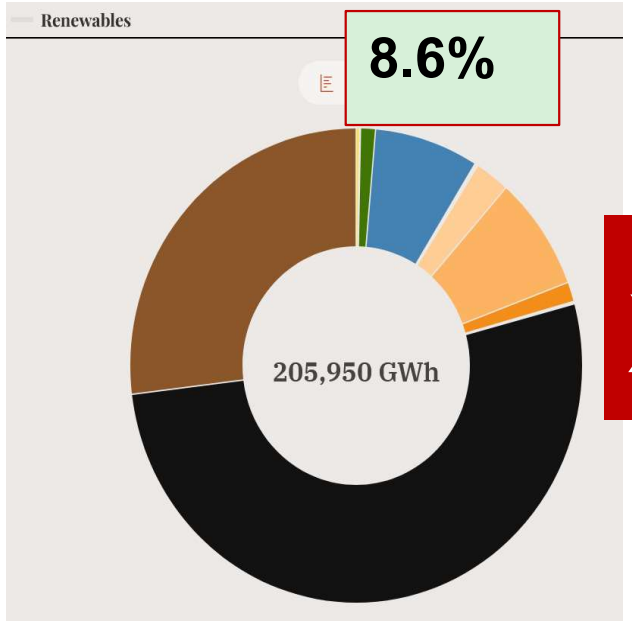
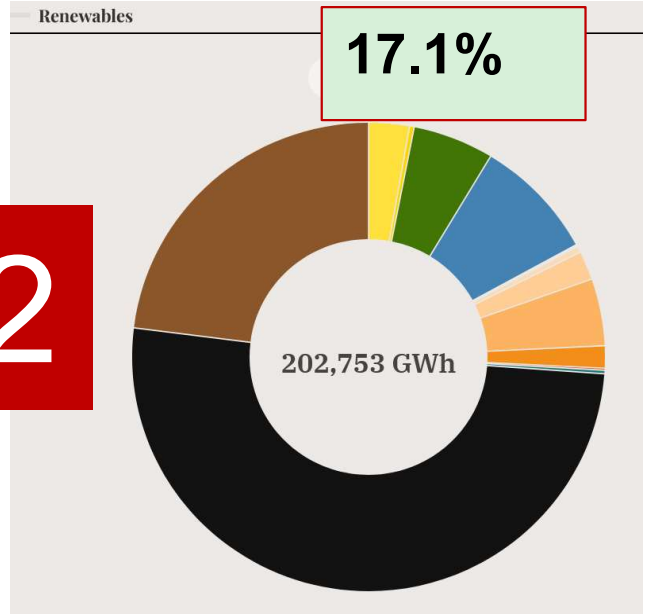
2010 – 12 years ago
"new decade resolution"

2016 - 7 years ago



x2



NEM generation mix

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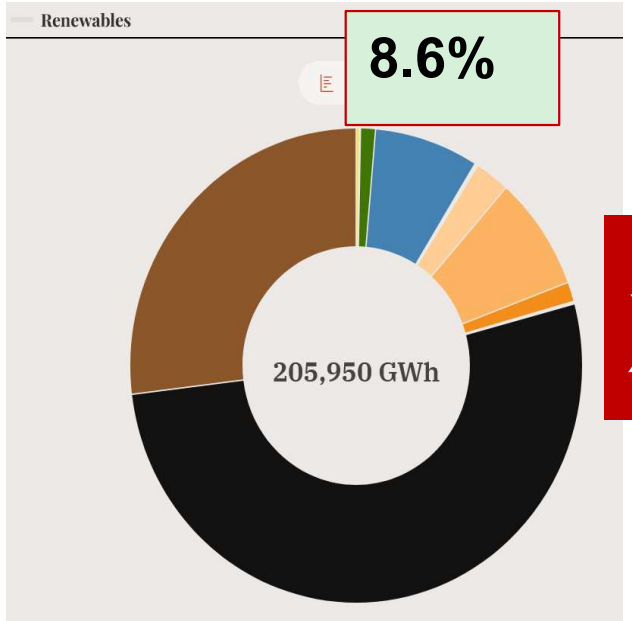
2010 – 12 years ago
"new decade resolution"

2016 - 7 years ago

2022 - 7 years to 2030



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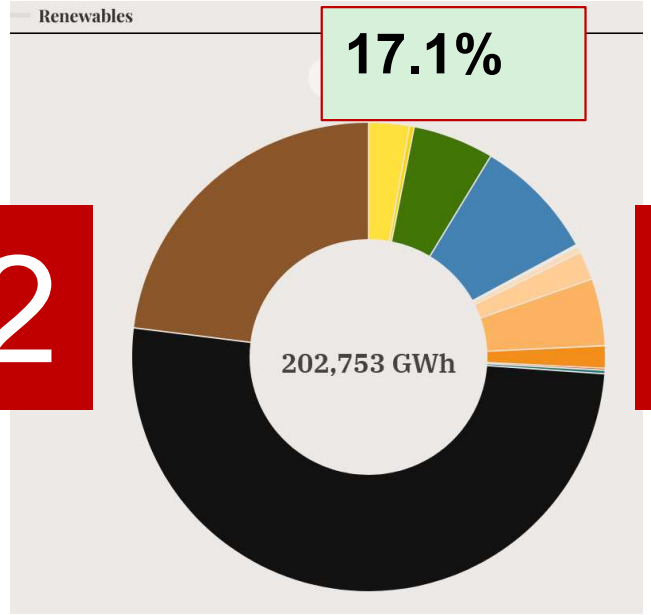

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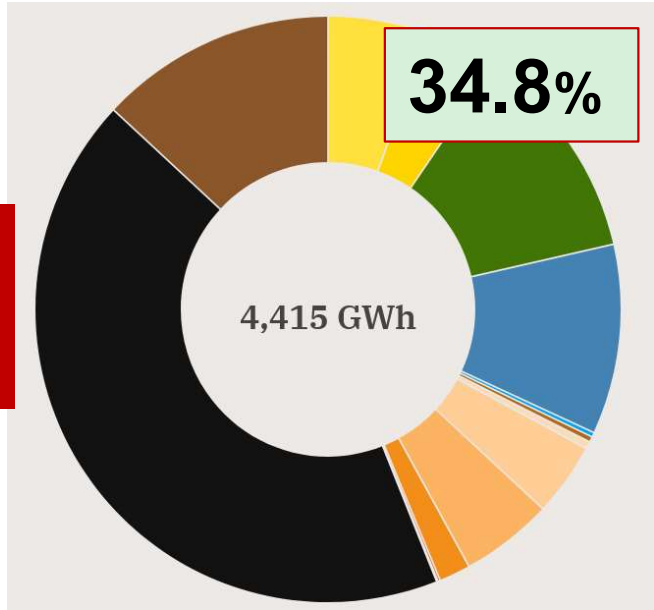

Renewables %	28.4%	45.5%
	27 – 3 Jul 2022	12 – 18 Dec 2022

SA renewables records

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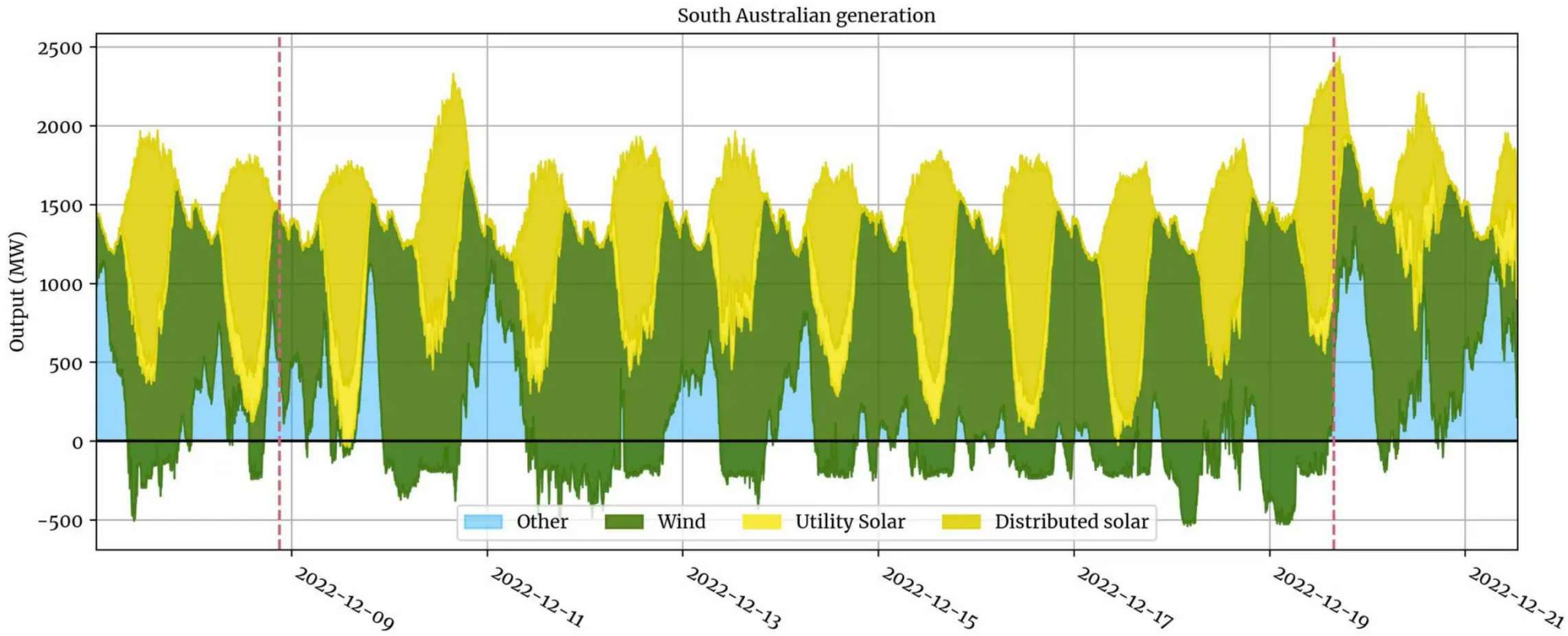
100% renewables for 10 days



Energy vs Power

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Energy

Watt-hours (Wh)

Power

Watt (W) *ie Watt-hours per hour*

Energy vs Power

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Energy
Watt-hours (Wh)

↔

Power
Watt (W) *ie Watt-hours per hour*

Distance
Meter (m)

↔

Speed
Meters per hour (*eg km per hour)*

WA (SWIS)

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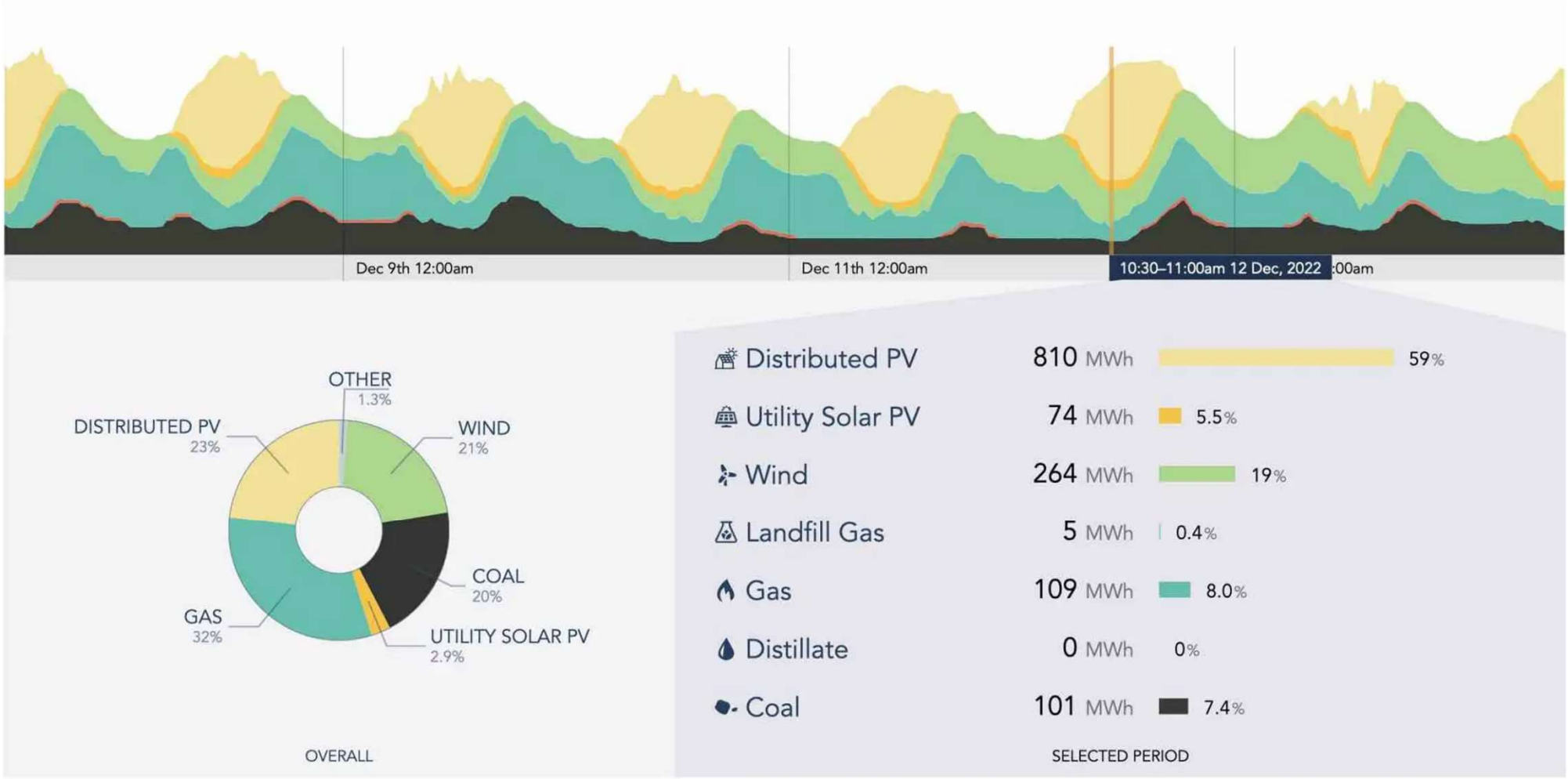
84% renewables for 30 min



Onslow 100% renewables (WA)

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850 people, 1400 km north of Perth

80 minutes 100% powered by

700kW Rooftop solar
600kW Solar farm
1MW (? MWh) Battery

NEM generation mix

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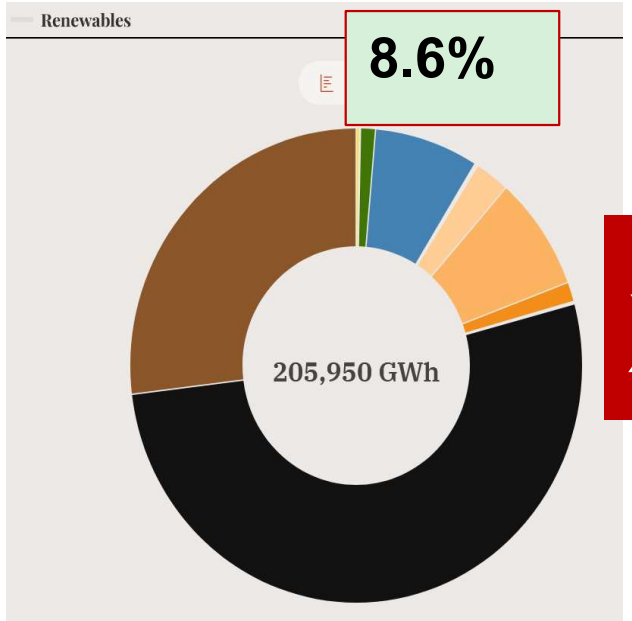
2010 – 12 years ago
"new decade resolution"

2016 - 7 years ago

2022 - 7 years to 2030



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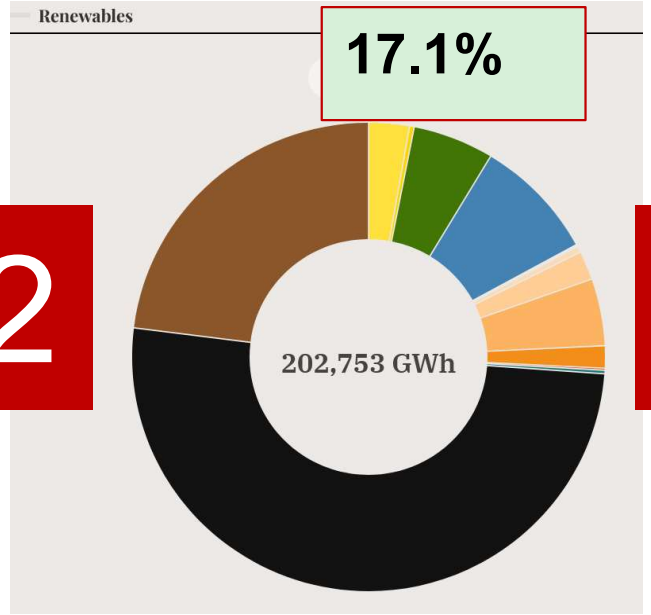

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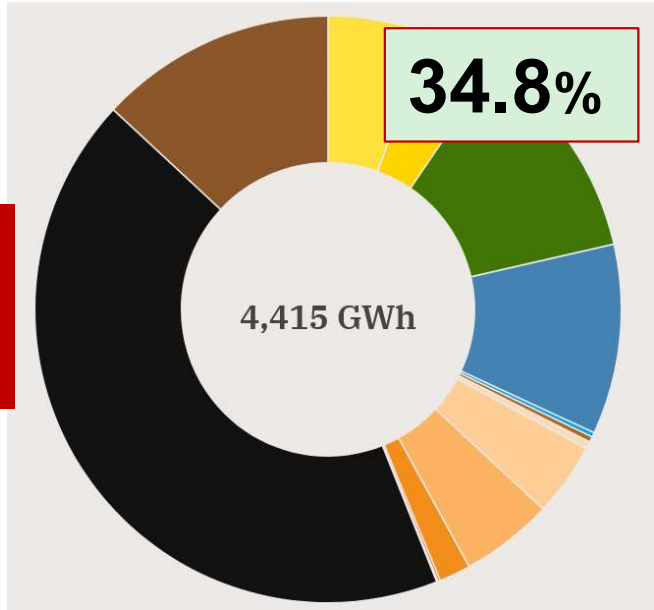

Renewables %	28.4%	45.5%
	27 – 3 Jul 2022	12 – 18 Dec 2022

The next 84 months

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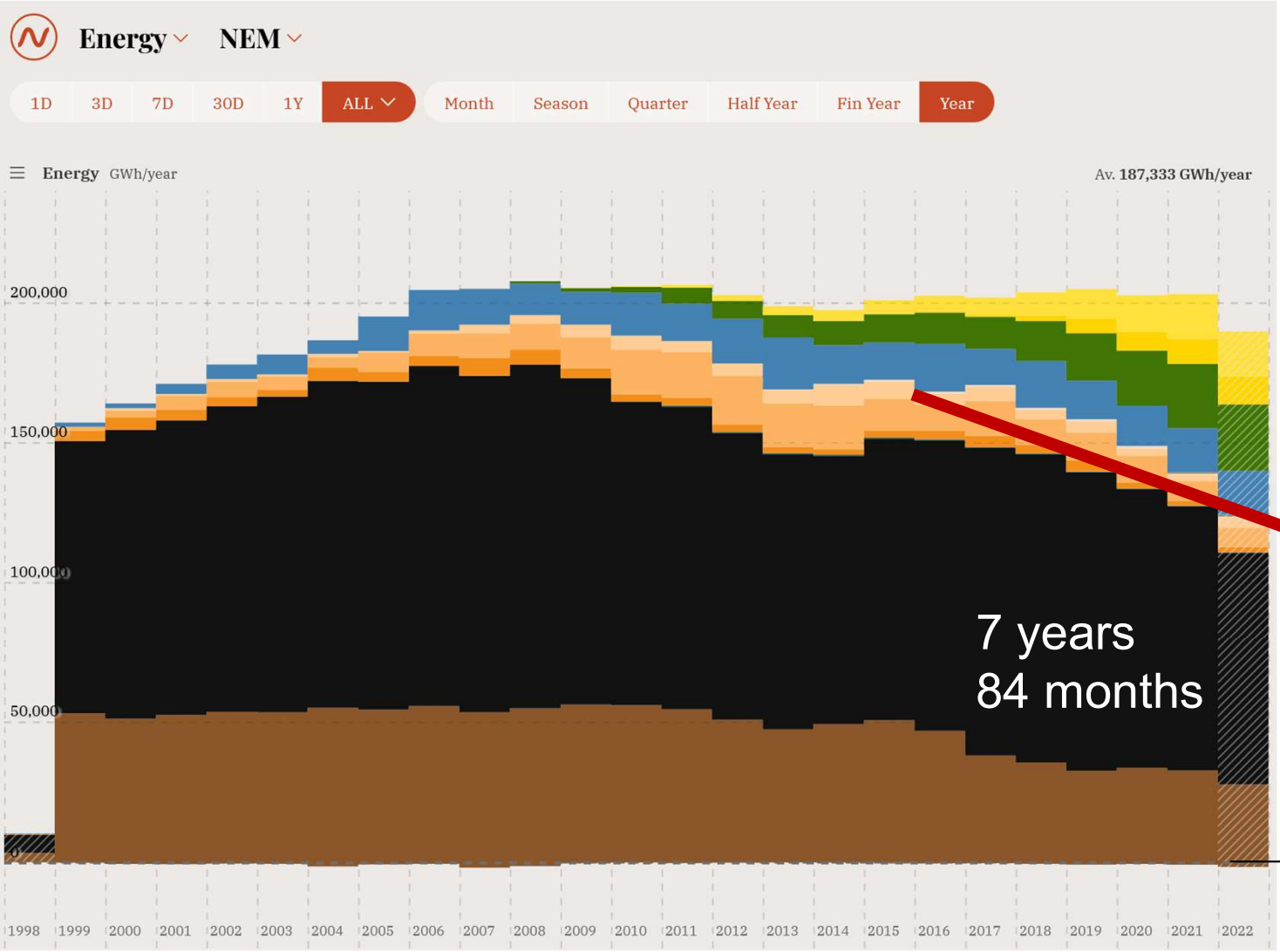

7 years
84 months

- **82% aim**

2030

The plan for reaching 82% RE

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AEMO

2022 Integrated System Plan

Expected energy transition to 2050

('Step Change' scenario)

The plan for reaching 82% RE

Australian National University

Battery Storage and Grid Integration Program
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AEMO

2022 Integrated System Plan

Expected energy transition to 2050

('Step Change' scenario)

Coal closures

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How coal closure dates have changed in the last two years

GRATTAN Institute

Coal power station capacity in the National Electricity Market (gigawatts)

Australian coal power stations

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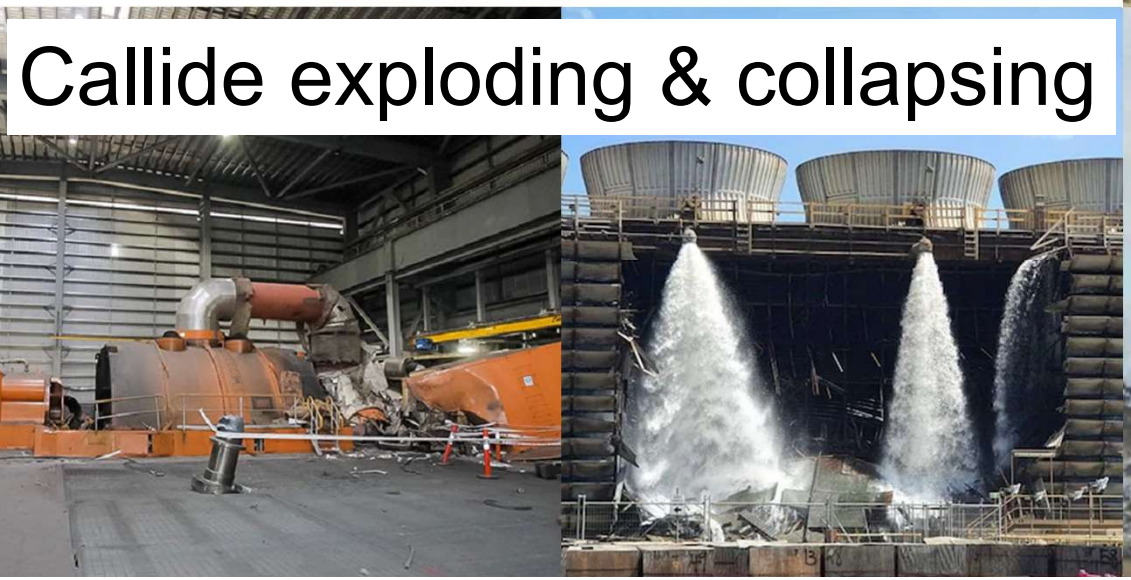
Old - compared to design life
Old - compared internationally

Inefficient - Hazelwood least carbon efficient power station in the OECD



The plan for reaching 82% RE

Australian National University

Battery Storage and Grid Integration Program
An initiative of The Australian National University

AEMO

2022 Integrated System Plan

Expected energy transition to 2050

('Step Change' scenario)

Coal generation

to be withdrawn

Capacity to be retired by:

2030	2043
60%	100%

Gas-fired peaking plants

to increase

While current mid-merit plants will all retire within that period.

NOW	2050
7 GW	10 GW

The plan for reaching 82% RE

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AEMO

2022 Integrated System Plan

Expected energy transition to 2050

('Step Change' scenario)

Grid-scale wind and solar

to increase 9-fold

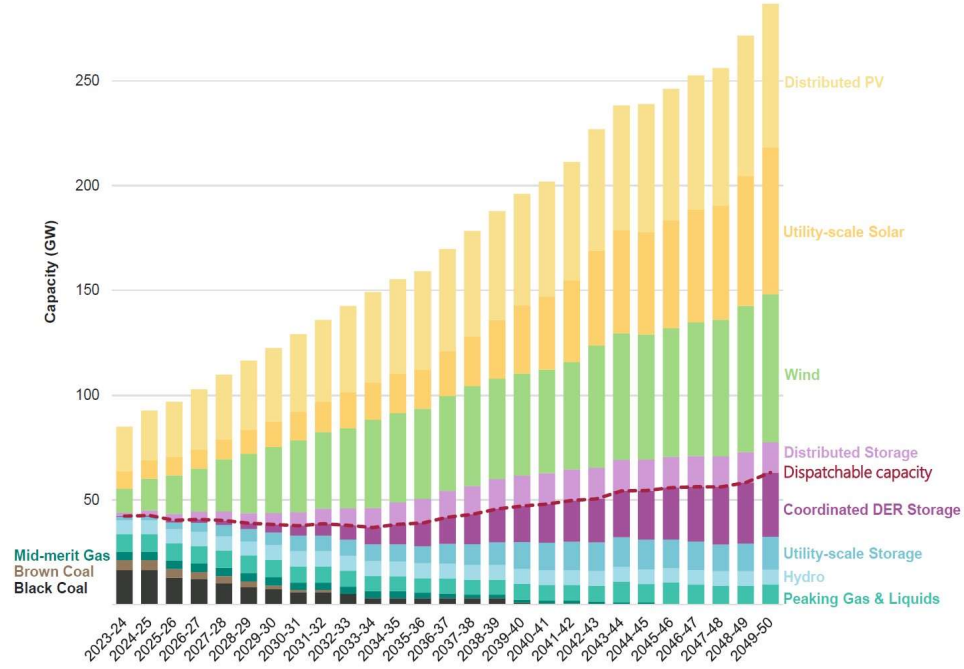
NOW	2030	2050
16 GW	44 GW	141 GW

Distributed solar PV

to increase 5-fold

NOW	2030	2050
15 GW	35 GW	69 GW

Figure 1 Forecast NEM capacity to 2050, *Step Change* scenario



Variable power over space-time

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Variable power supply = Variable power demand
every ms, s, hr, day, season, year

Energy vs Power

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100% renewable **power** 2025

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Engineering Roadmap to 100% Renewables

December 2022

An Engineering Framework report on the steps required to operate the National Electricity Market at 100% instantaneous penetrations of renewables

Variable power over space-time

Australian National University

Battery Storage and Grid Integration Program
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Variable power supply = Variable power demand
every ms, s, hr, day, season, year

Time
=
Storage

Space
=
Transmission

Variable power over space-time

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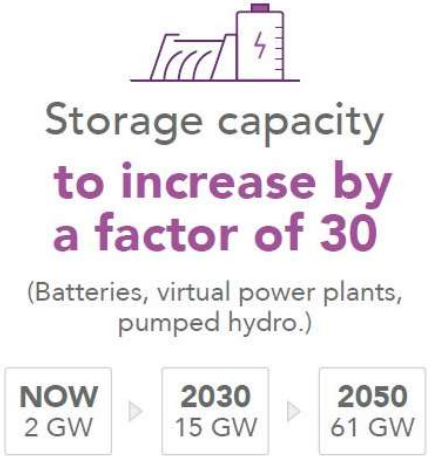
Variable power supply = Variable power demand
every ms, s, hr, day, season, year

Time
=
Storage



Expected energy transition to 2050
('Step Change' scenario)

More batteries

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Historically:

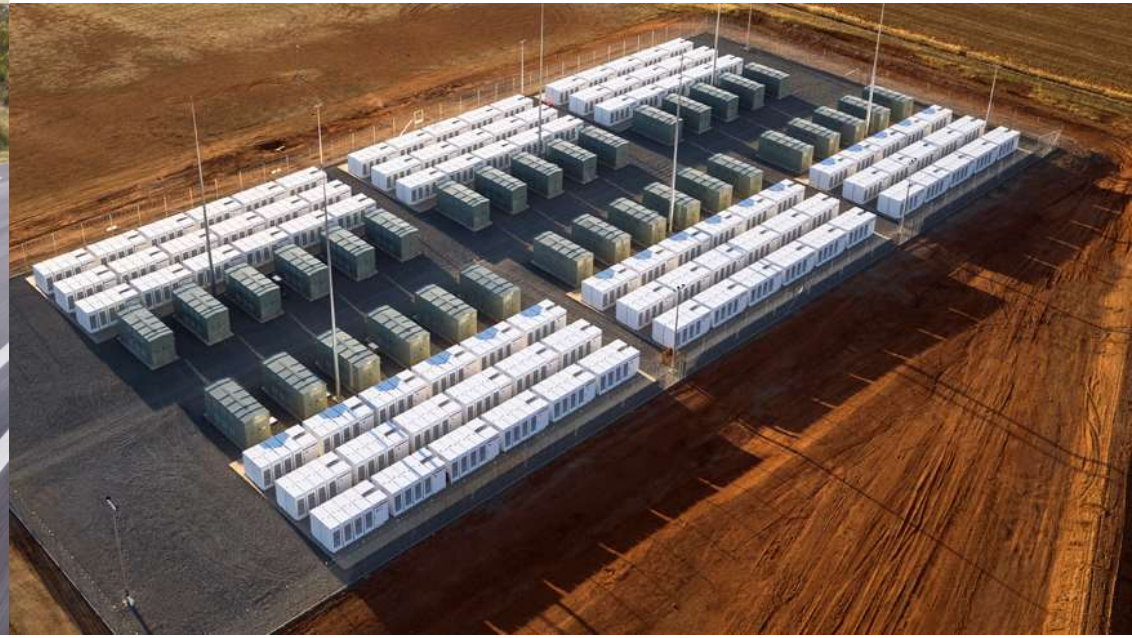
Portable electronics → EVs → Grid batteries

Prioritised light weight

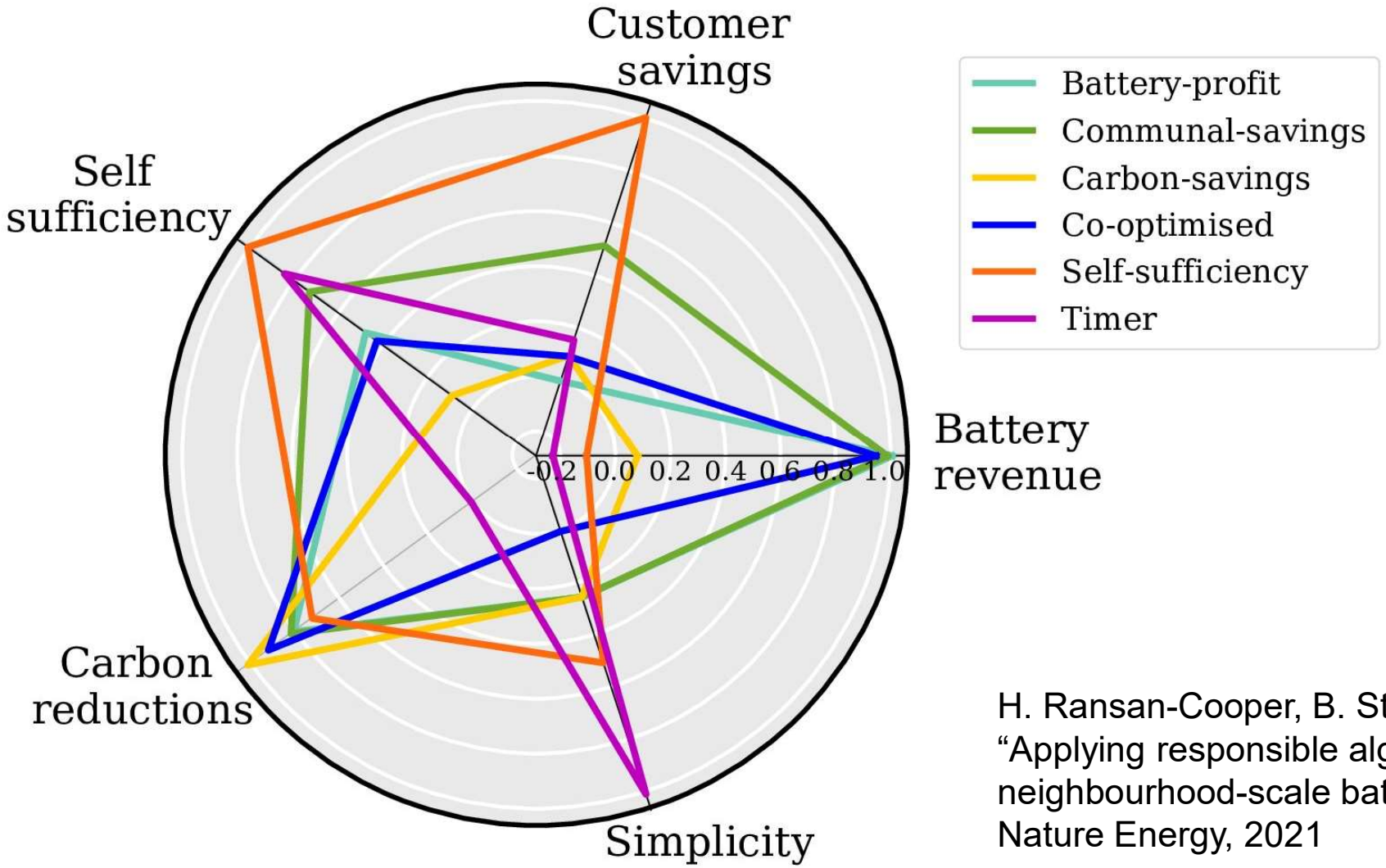
Future:

Various energy-power-weight combinations

New chemistries, flow batteries, etc



Trade-offs in uses



H. Ransan-Cooper, B. Sturmberg et al.
"Applying responsible algorithm design to neighbourhood-scale batteries in Australia"
Nature Energy, 2021

More hydro

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Expansion & pumping upgrades
Snowy 2.0
Tassie “Battery of the Nation”

“Off river”
ANU found 1,500 sites next to existing reservoirs

Variable power over space-time

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Variable power supply = Variable power demand
every ms, s, hr, day, season, year

Time
=
Storage

Space
=
Transmission

More transmission

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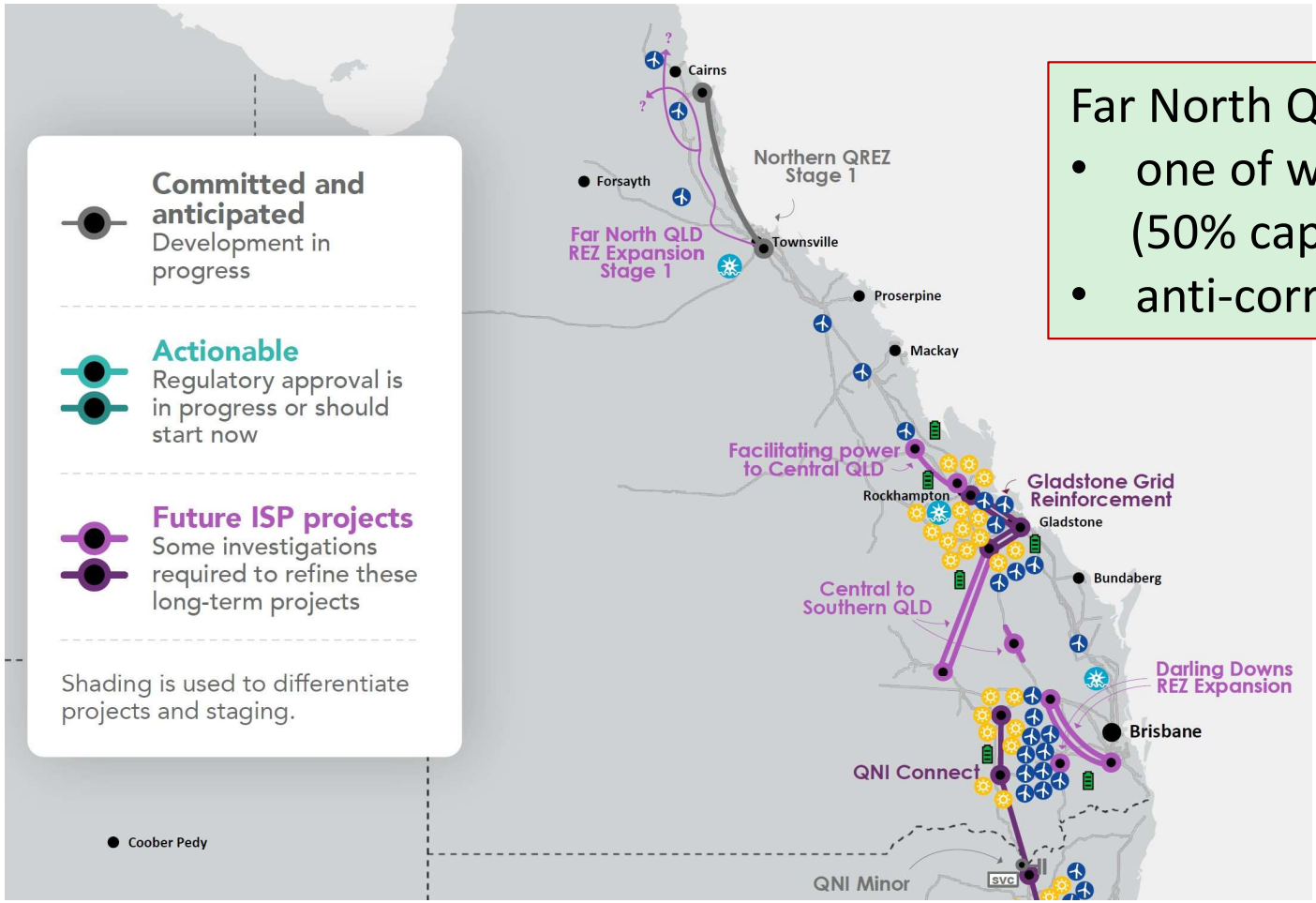
No transition without transmission



Far North Qld

- one of worlds best wind resource (50% capacity factor)
- anti-correlation compared with SE Aus

More transmission

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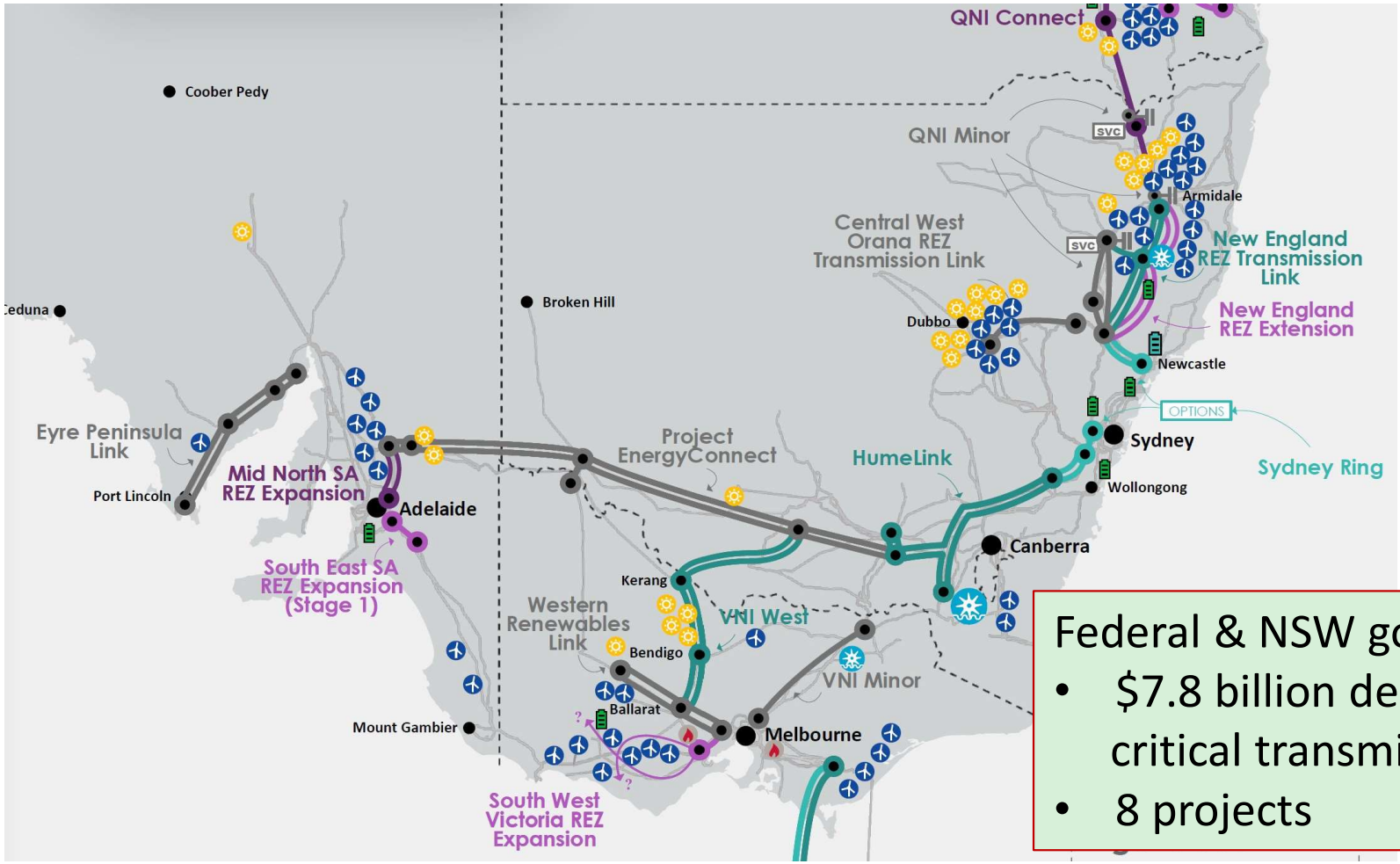
No transition without transmission



Federal & NSW gov committed (Dec 22)

- $7.8 billion deal
  critical transmission and REZ
- 8 projects

More transmission

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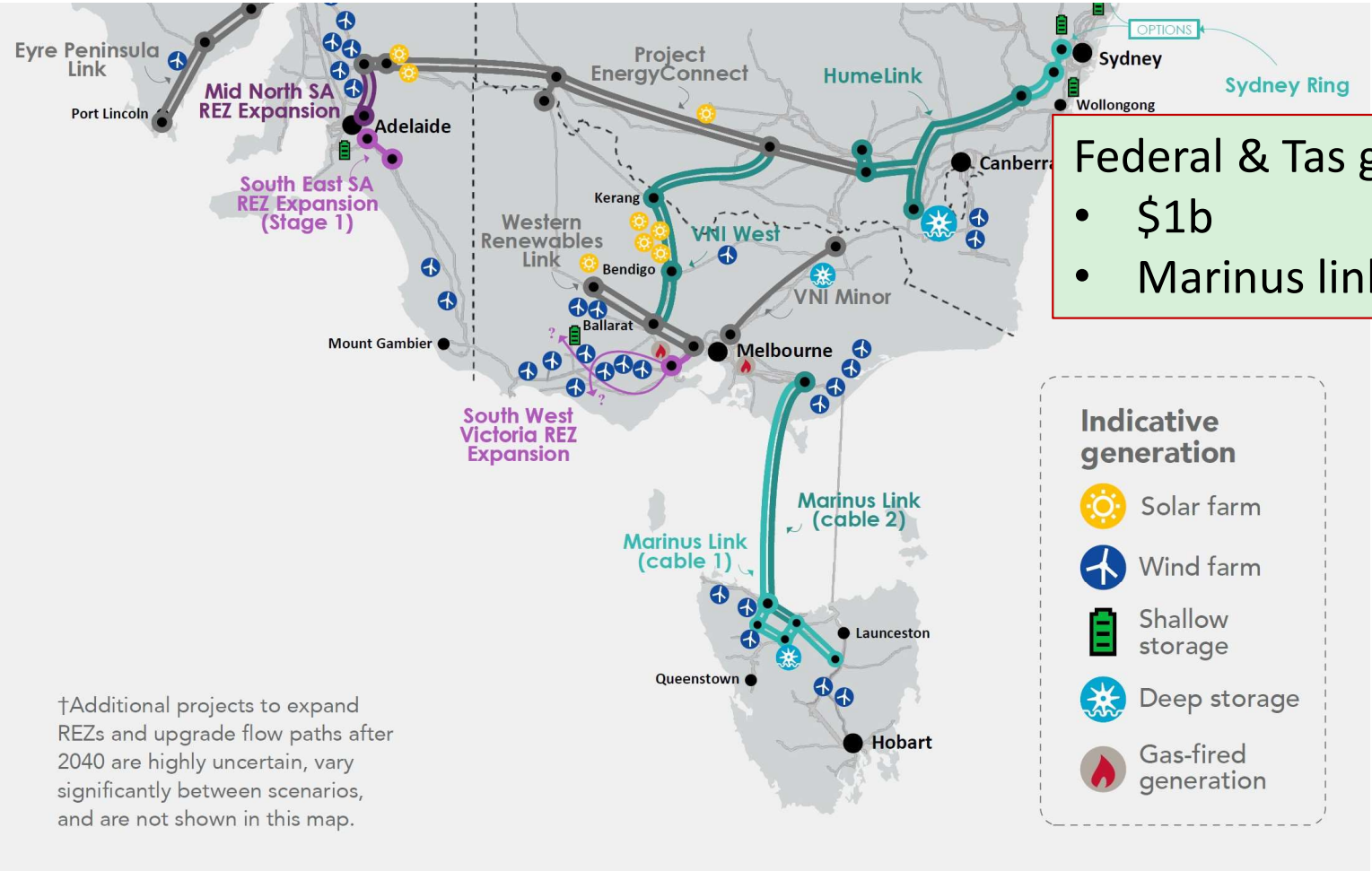
No transition without transmission



Federal & Tas gov committed (Oct 22)

- $1b
- Marinus link

More transmission?

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No transition without transmission

No transmission without trust

environment victoria

Queensland Conservation Council

RE-ALLIANCE
CONNECTING PEOPLE & POWER

CLIMATE COUNCIL

SolarCitizens

Nature Conservation Council
The voice for nature in NSW

AUSTRALIAN CONSERVATION FOUNDATION

Friends of the Earth Melbourne

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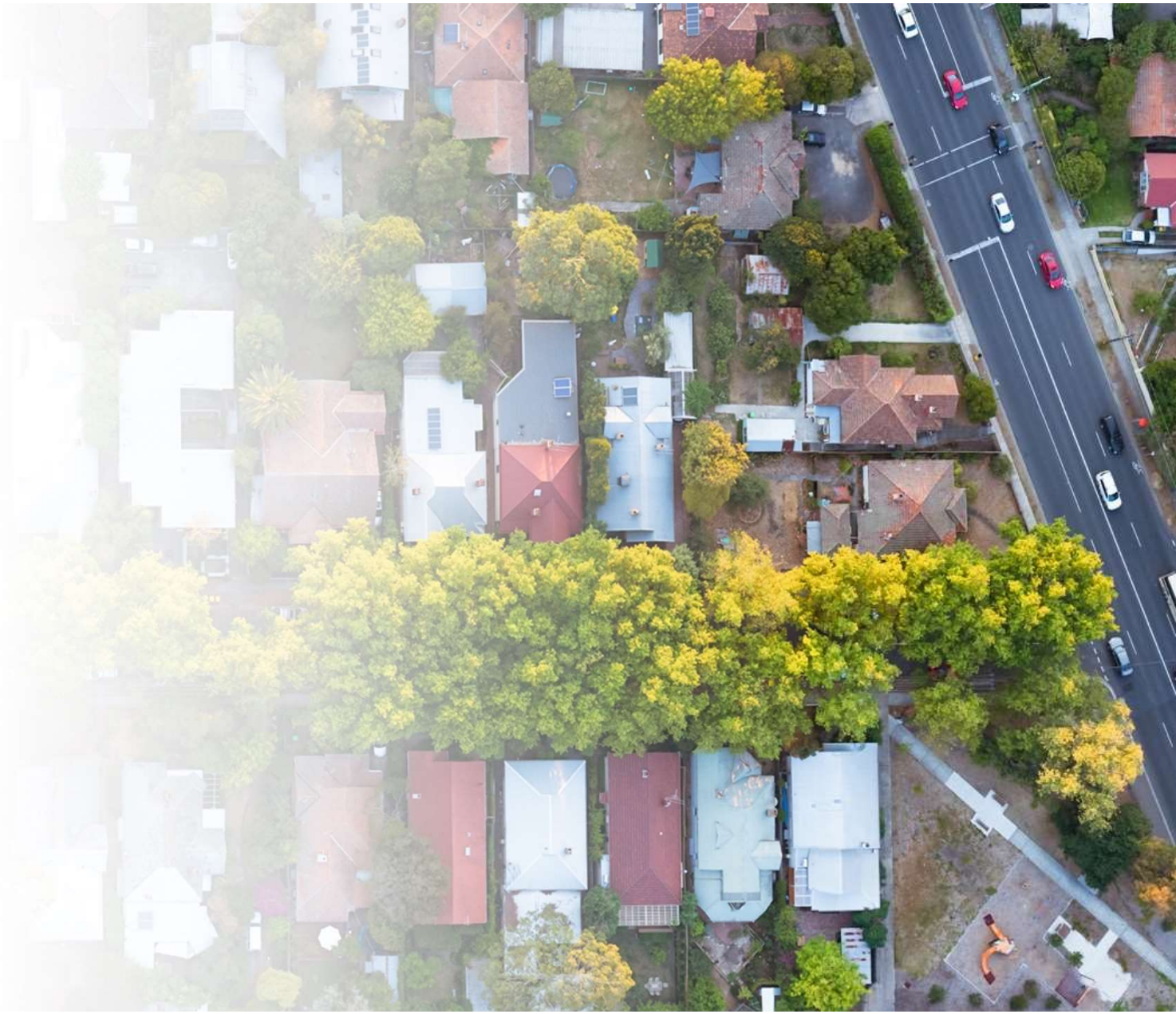

Demand

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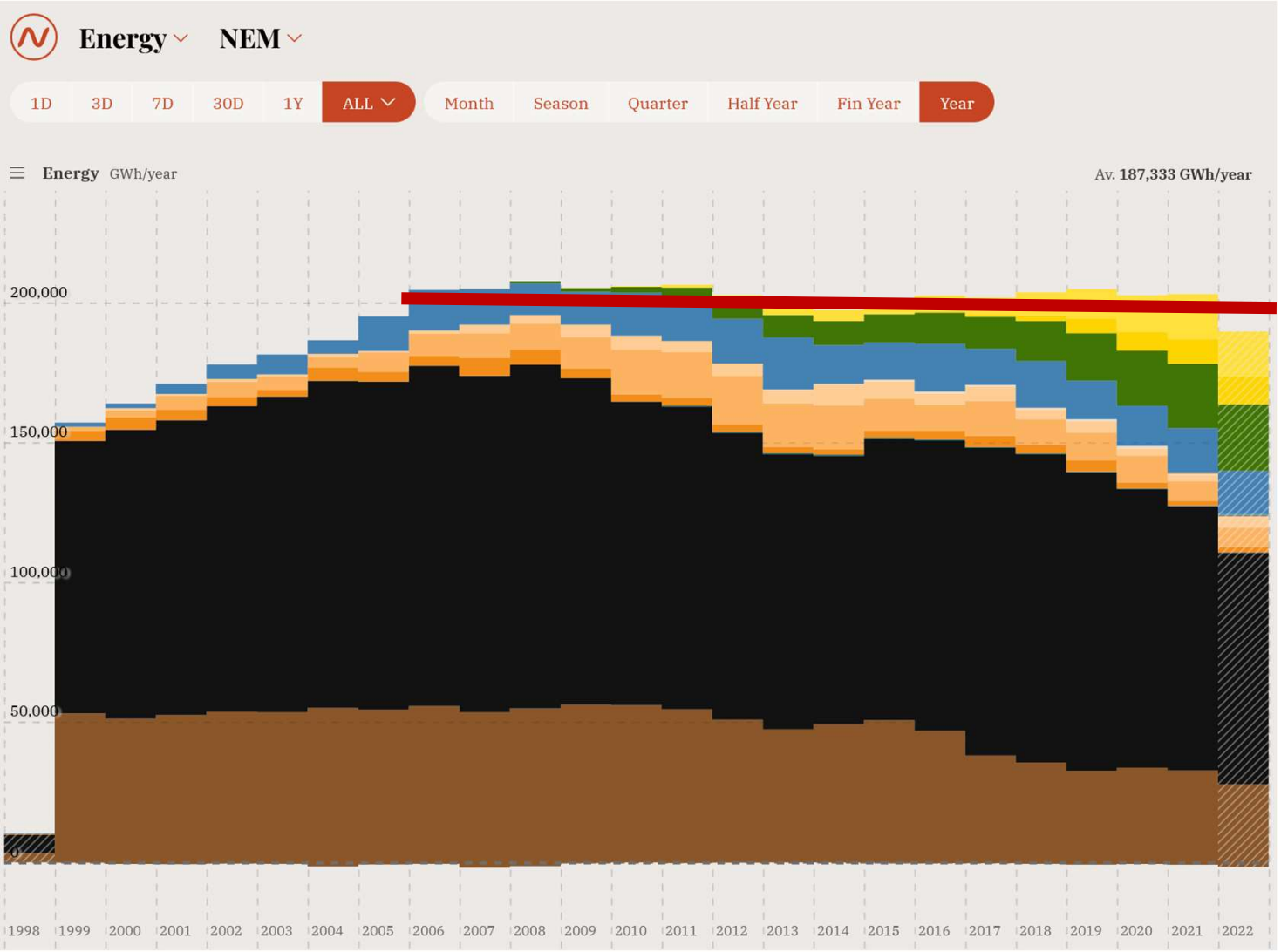

Demand solutions

- **Resource efficient – most economically efficient**
- **Reliable across day/seasons/etc – reduce variability**

Demand solutions

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- **Resource efficient – most economically efficient**
- **Reliable across day/seasons/etc – reduce variability**

1. Reduction

- Behaviour change
- Sealing, insulation (roof, floors, walls, windows)

2. Electrification

- Heat pumps >3x efficiency to best gas heater
- Flexibility match variability in generation

Electrify homes/buildings

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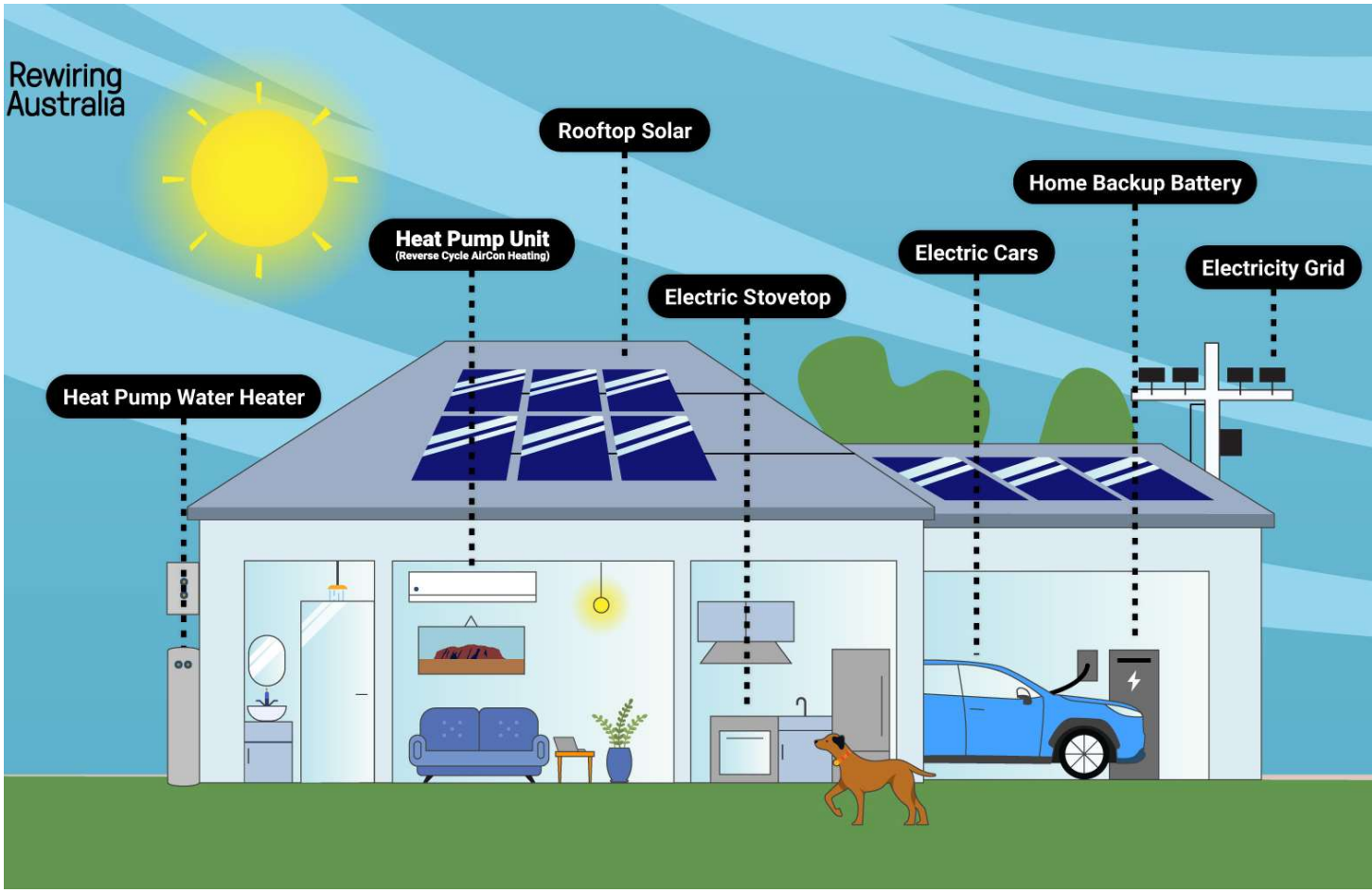
Residential homes = 12% of Australia's emissions.

Need to reduce 45% by 2025 to meet 1.5 degree pathway

All-electric homes can save $1500/year

Appliances upgrades possible for renters & apartments



Electrify vehicles

Far more efficient that oil – where 60% energy lost as heat

Less emissions today, fewer as clean electricity system

10x fewer moving parts in engine – halves maintenance

4% sales in 2022 needs to be 100% sales by 2035

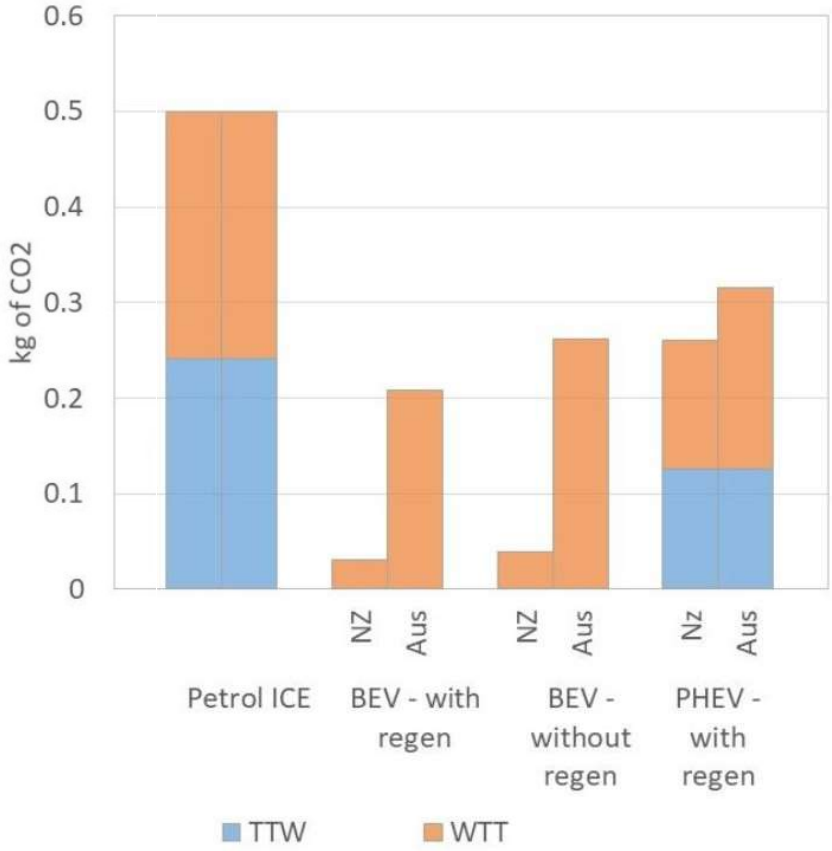
By the Numbers

27,000 km

Breakeven driving distance for equal 2020 BEV and ICE lifecycle CO2 emissions in the U.S.

1.5 years

Estimated time taken to pay back EV manufacturing emissions from driving an EV in the U.S. today



M. Shenga et al. “Well-to-wheel comparison of emissions and energy consumption for electric vehicles: Oceanian perspective”, 2021

Charging poses challenges

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EVs could increase peak power demand by 30-50%

Batteries present opportunities

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EVs are no silver bullet

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	 ICE Cars	 Electric Cars! NEW!
Congestion	✓	✓
Urban Sprawl	✓	✓
Pedestrian Deaths	✓	✓
Noise	✓	✓
Parking Lots	✓	✓
Emissions	✓	Reduced!

Poor (sedentary) health

Social isolation

Particulate emissions

Clean Transport Strategy

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1. **AVOID** unnecessary trips and shorten trip distances where possible

2. Where trips are unavoidable, encourage a **SHIFT** to more efficient modes for moving people and goods

3. **IMPROVE** the energy efficiency of transport by transitioning to low and zero emission vehicles & vessels

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- Power **demand**

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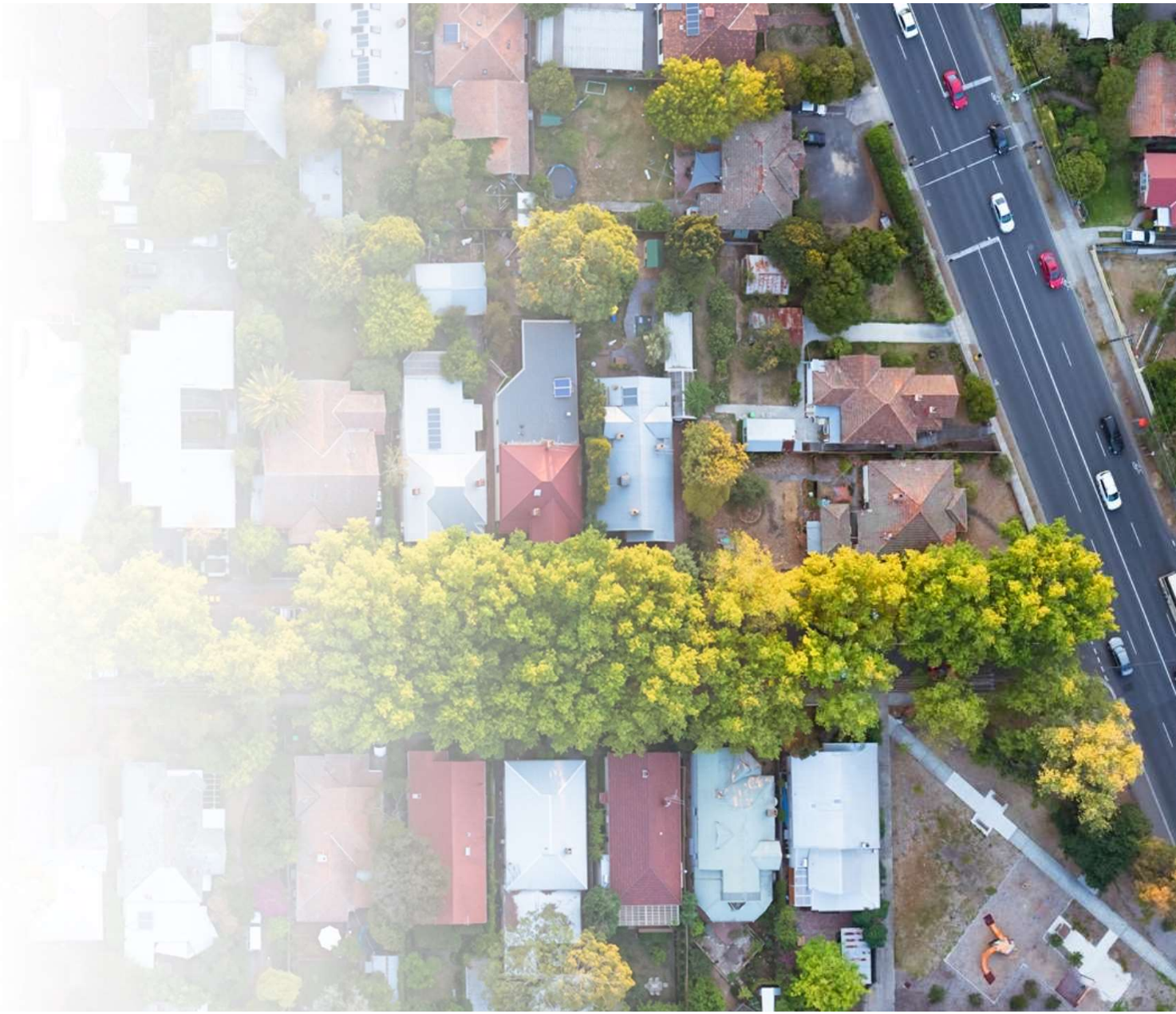
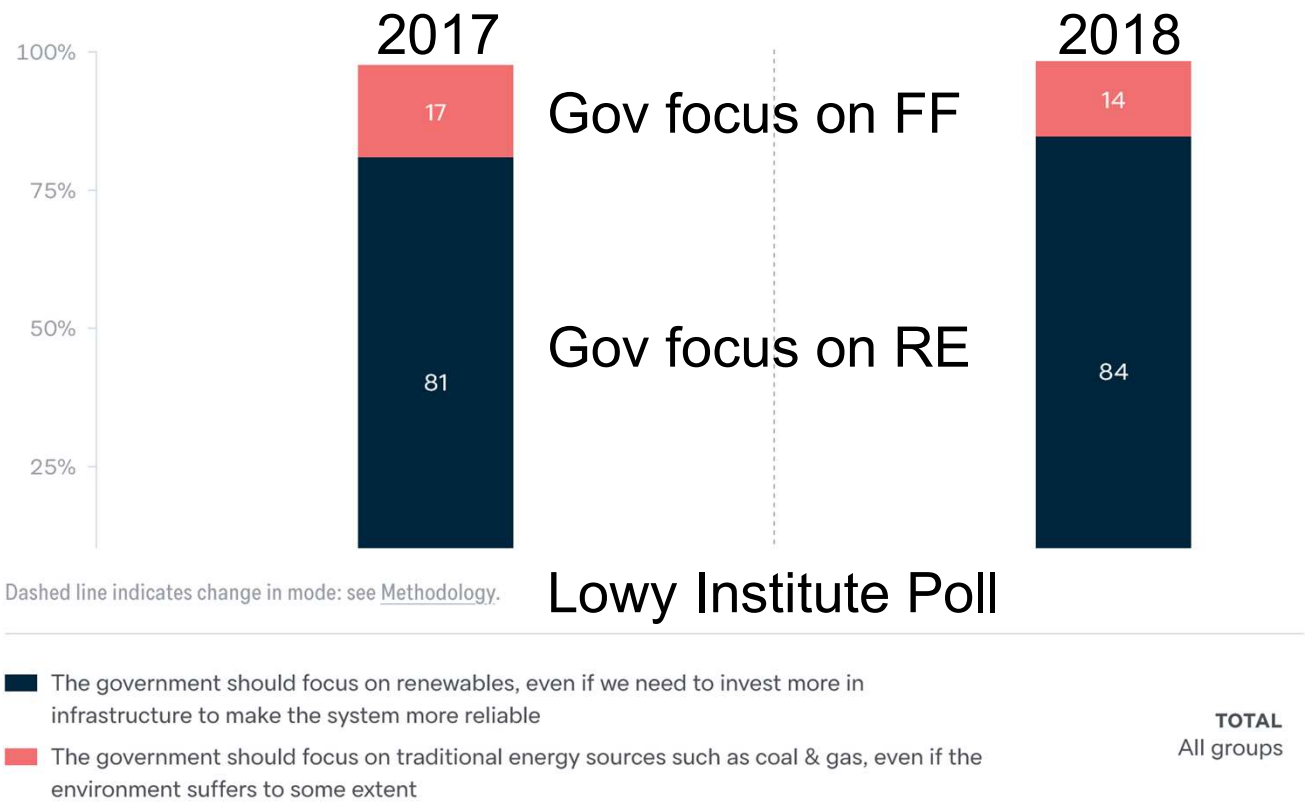


Strong support for renewables

Australian National University

Battery Storage and Grid Integration Program
An initiative of The Australian National University



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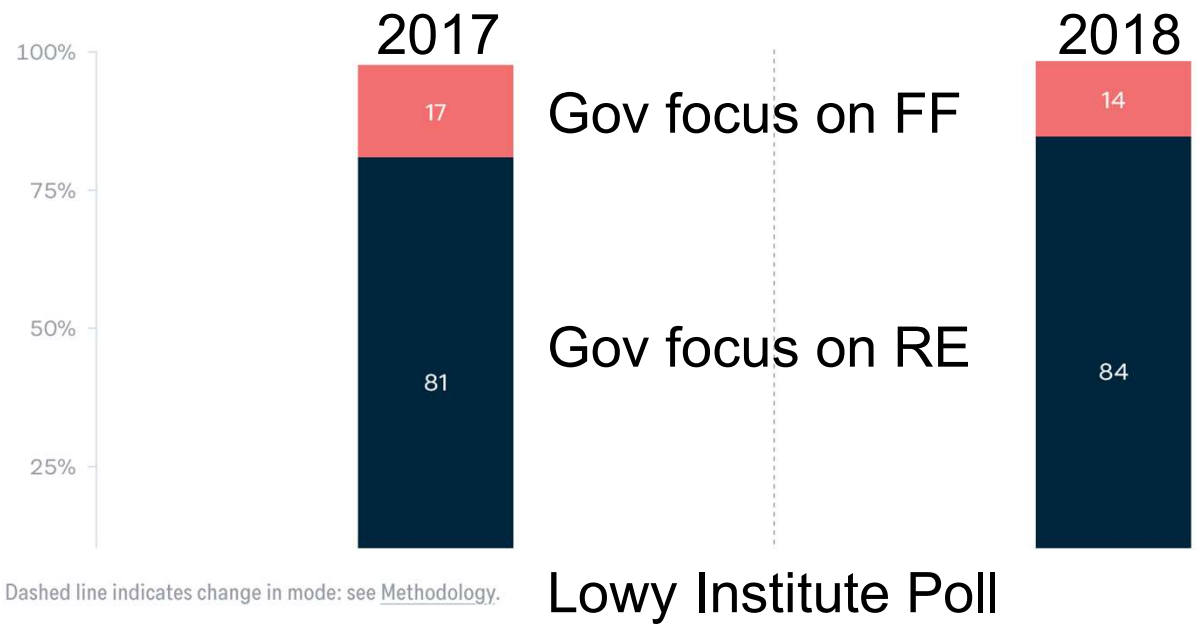

2022 energy crisis

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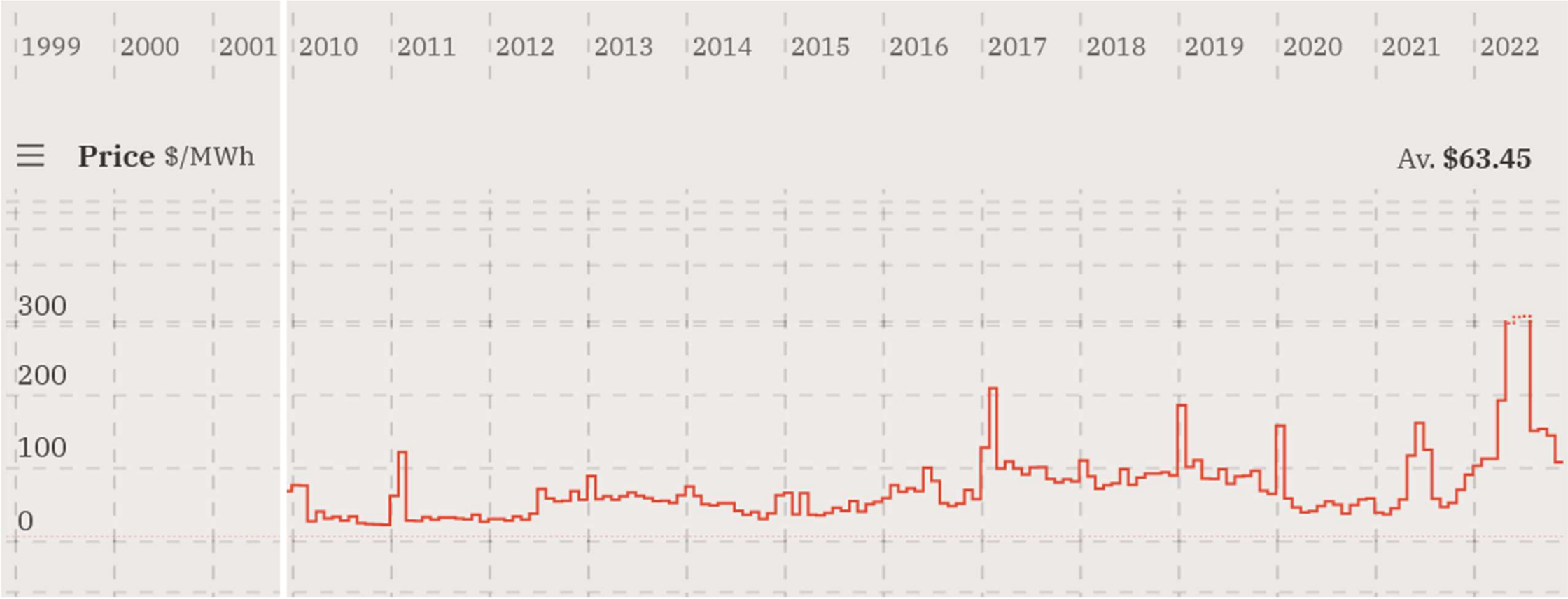
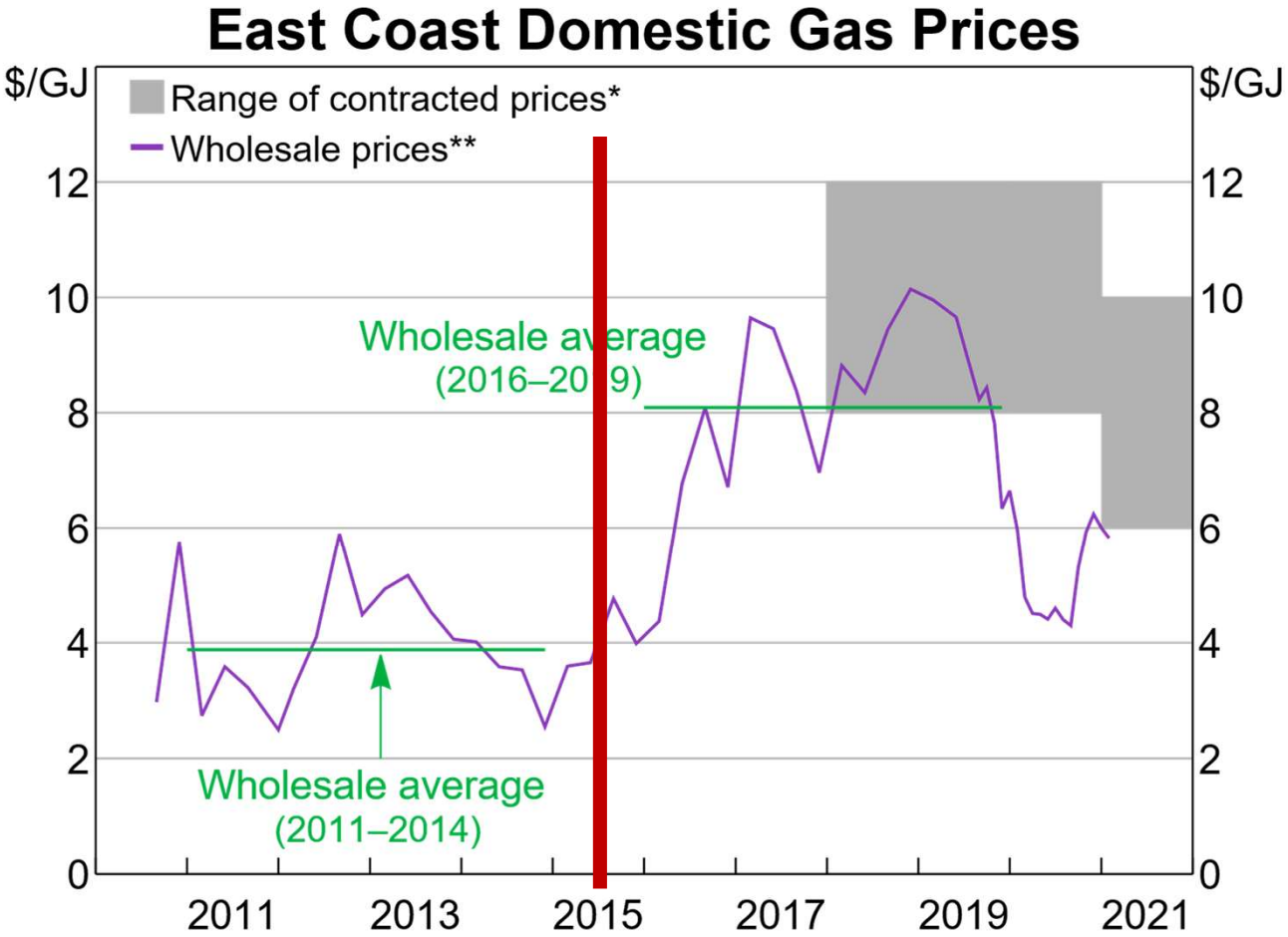


Gas prices



* Commercial and industrial users; prices offered in prior year

** Population-weighted by major city; spot prices; quarterly

Sources: ACCC; AEMO; AER; RBA

Gas prices

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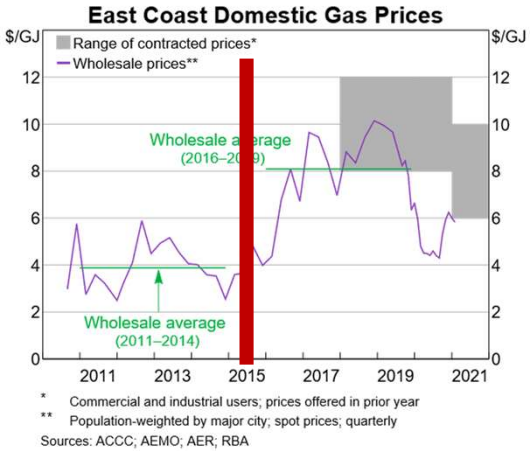
● 2022



Australian coal power stations

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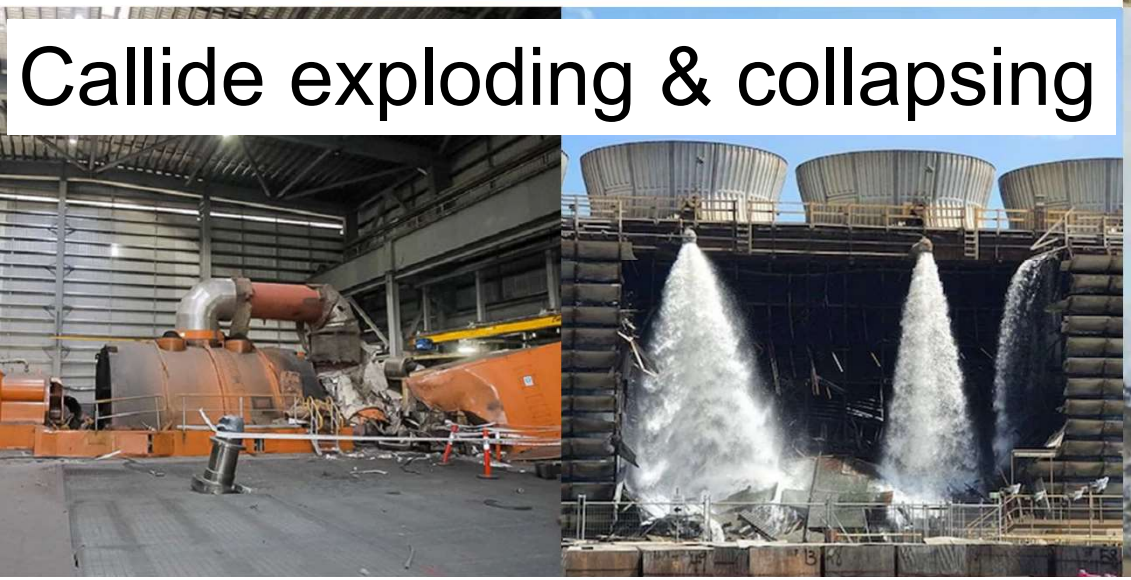
Old - compared to design life
Old - compared internationally

Inefficient - Hazelwood least carbon efficient power station in the OECD



Government action/“intervention”

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A “good” transition?

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Mass resource extraction is neither

- Socially just, nor
- Ecologically sustainable

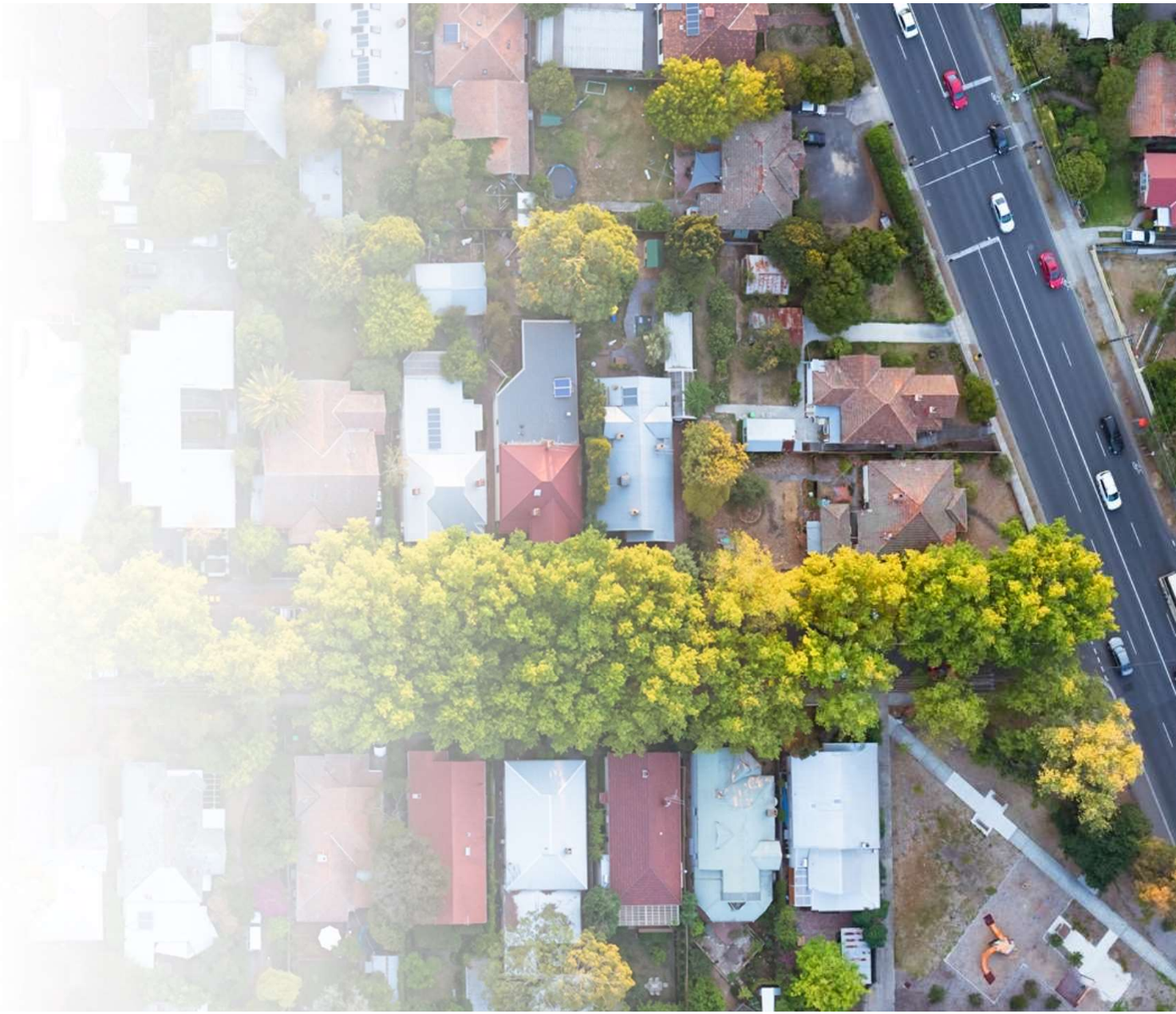
Cobalt mining in Congo

Silicon mining in Xinjiang

Lithium mining Chile

Outline

- **Key messages**
  Choices & power are in your hands
  Transition needs to be Fast & Fair
- Power **supply**
- Power **demand**
- Socio-political **sentiment**
- Discussion with **Prof Ian Lowe AO**



Thanks & remember…

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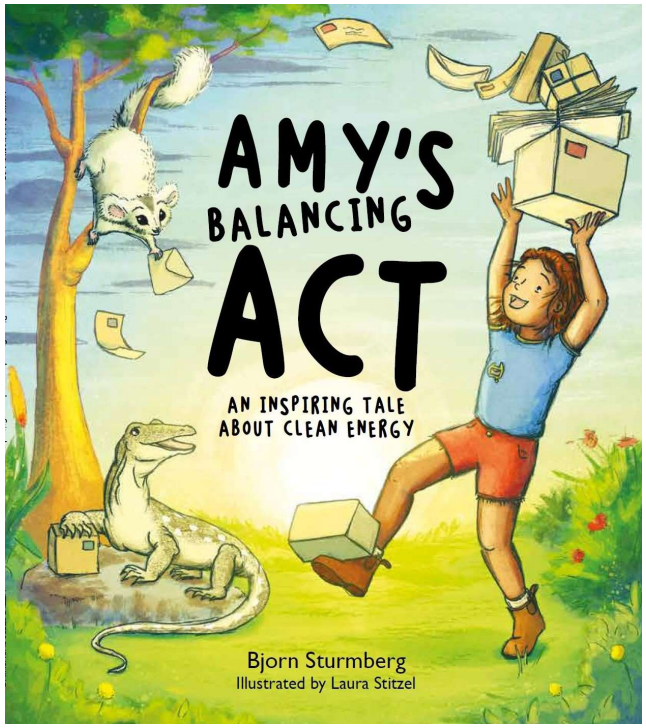
Amy's Balancing Act is in the Festival Store

SCHEDULES

Amy's Balancing Act

Join the author and discover how a young girl and her animals collide with the science of renewable energy.

Fri, Dec 30 8:45AM – 9:45AM Puppet Joint



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Discussion w Prof Ian Lowe

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Government action/ “intervention”

Australian manufacturing

Energy superpower

Hydrogen

Nuclear

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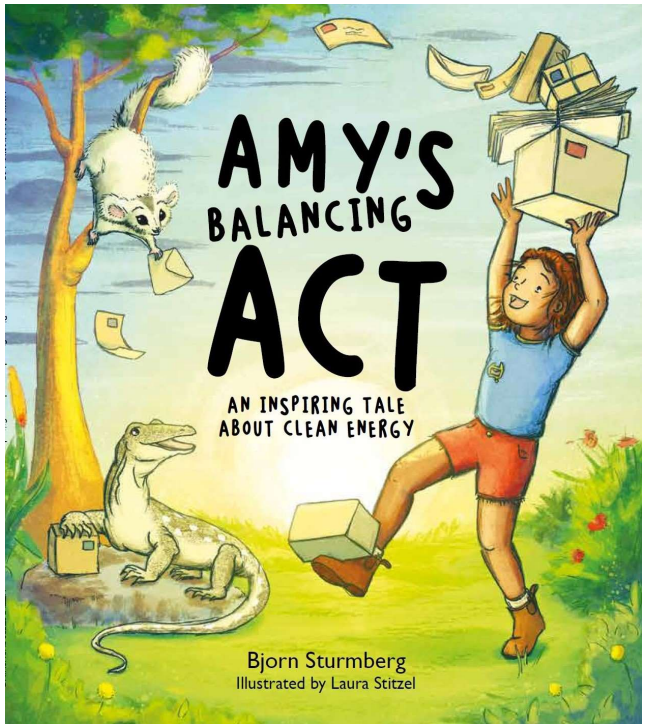

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