AUSTRALIAN EXPERIENCE IN DECARBONISING THE ELECTRICITY SECTOR

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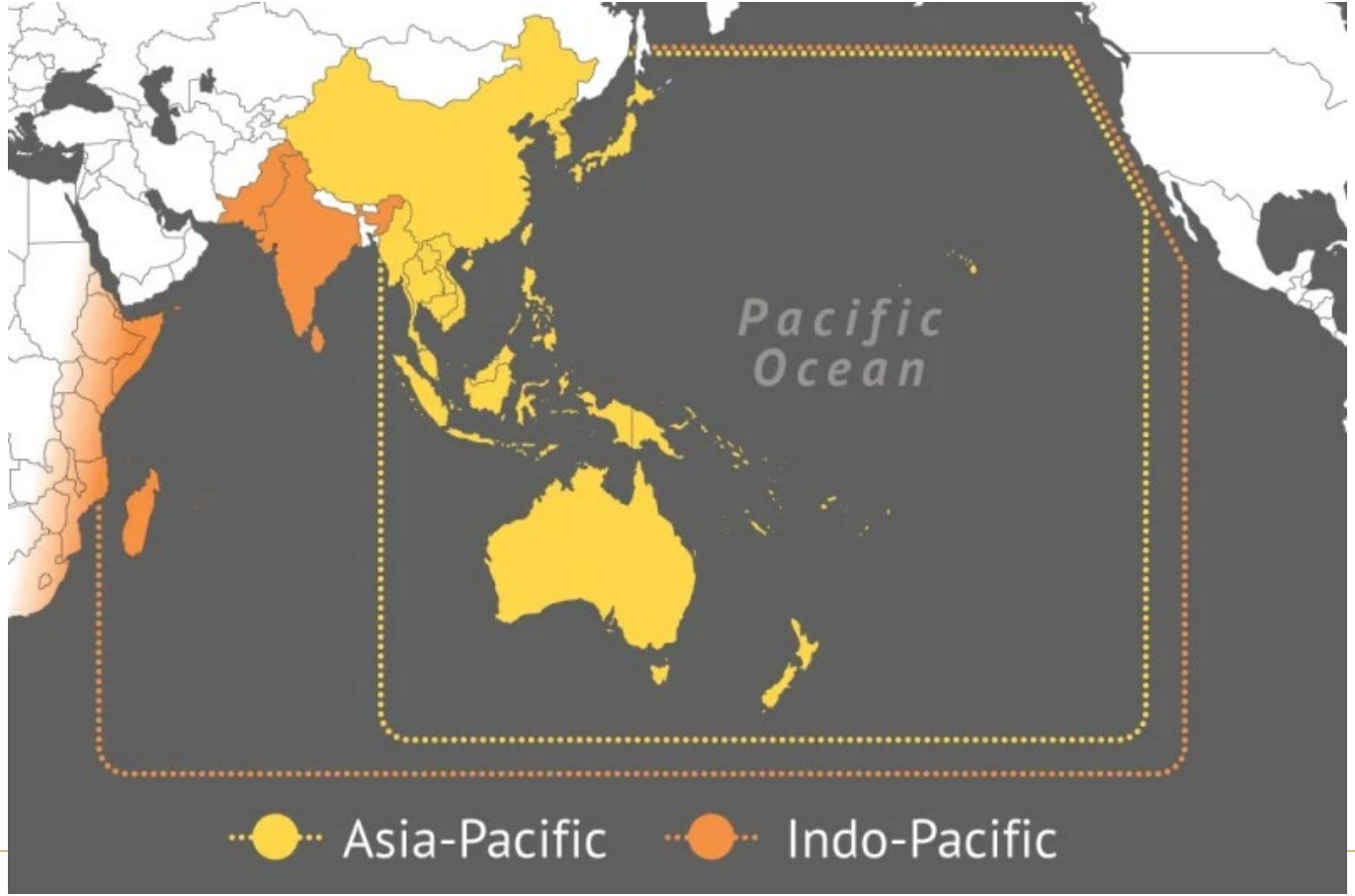
Australian National University

Australia’s role in the Indo-Pacific



Key role in providing energy resources

Australia exports large quantities of:

- Coal (metallurgical and thermal), and
- Gas (LNG).

Climate policies may change:

- Demand for fossil fuels,
- Energy security (less reliance on imports), and
- Geopolitics.

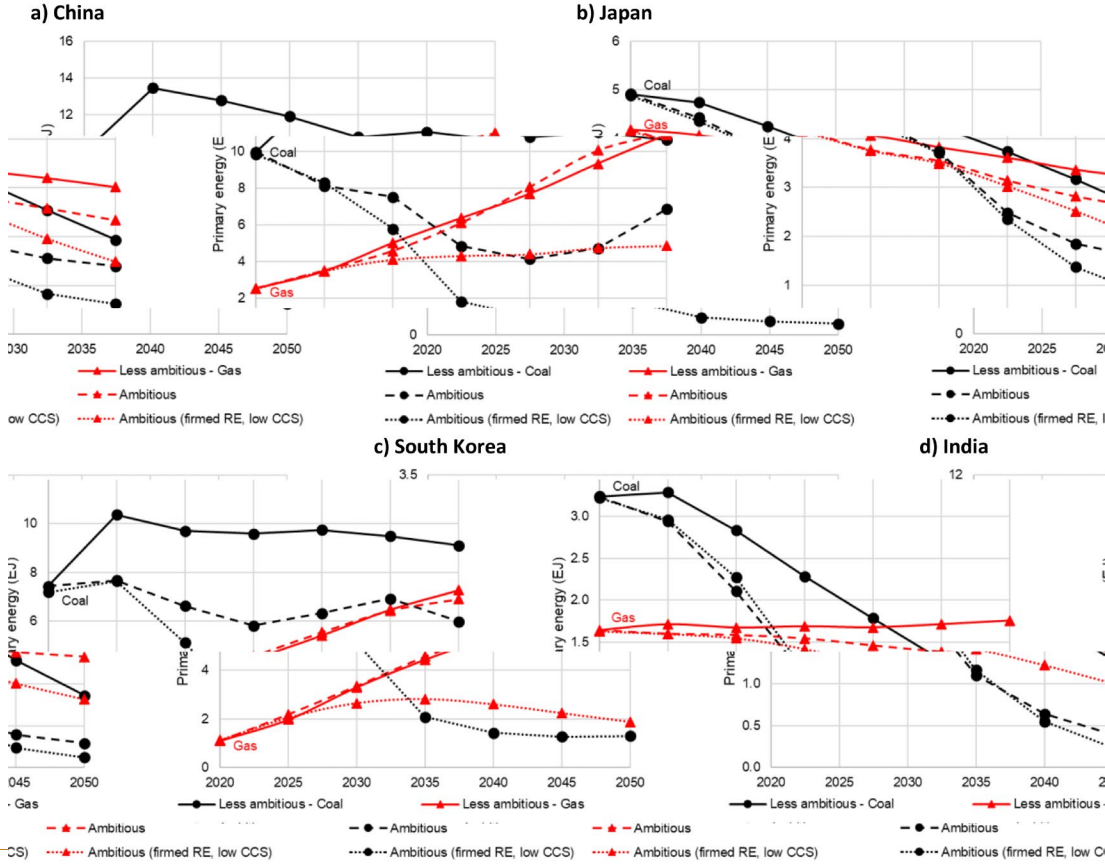
The Global Change Analysis Model (GCAM)

- offers a useful tool for examining decarbonisation pathways pursued by governments, and
- examining the implications for Australia's role as a supplier of energy security to the region.

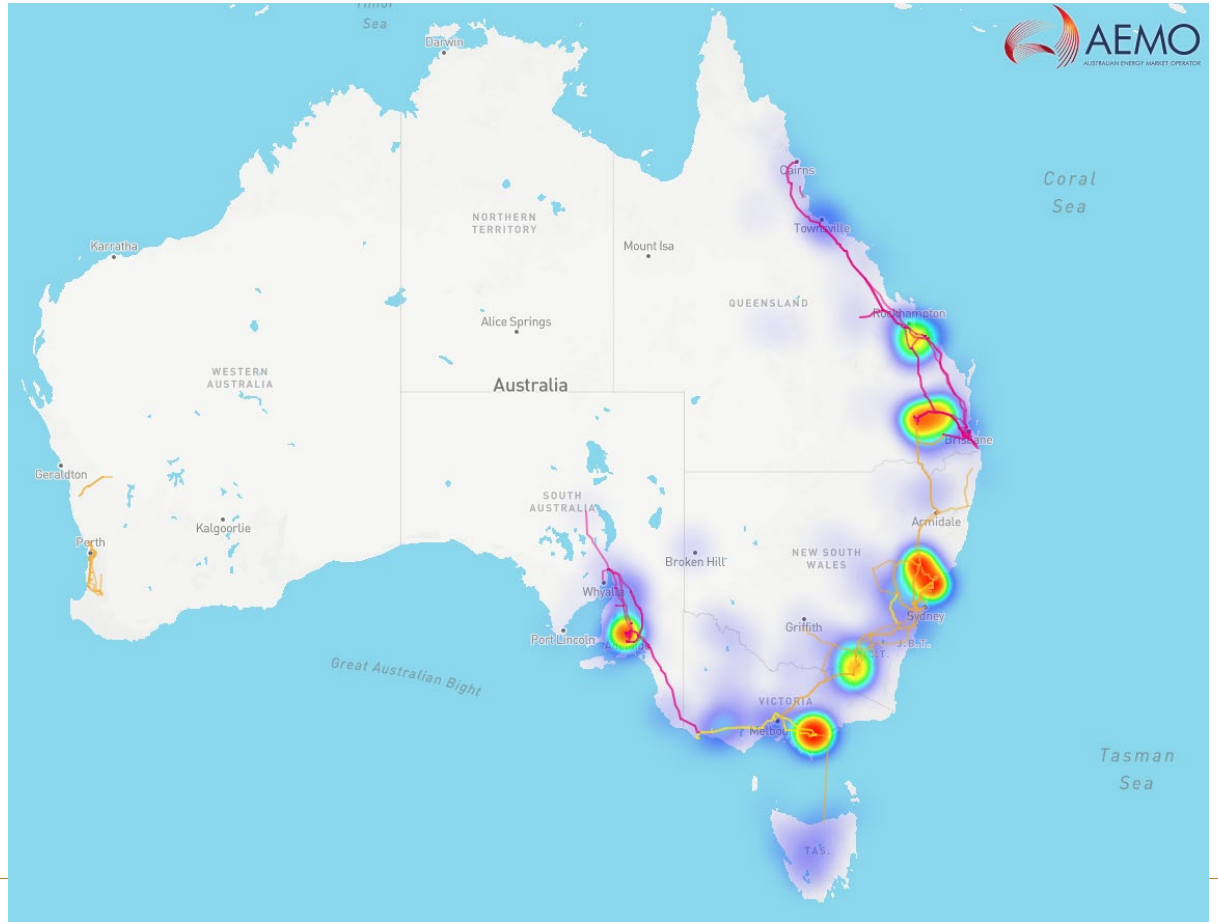
Project info:

- Disruptive Technologies: Model-based Scenario Analysis of Decarbonisation and National Security Risks in the Indo-Pacific, funded by the Commonwealth Department of Defence.

FIGURE 1: COAL AND GAS IMPORTS IN SELECTED INDO-PACIFIC COUNTRIES

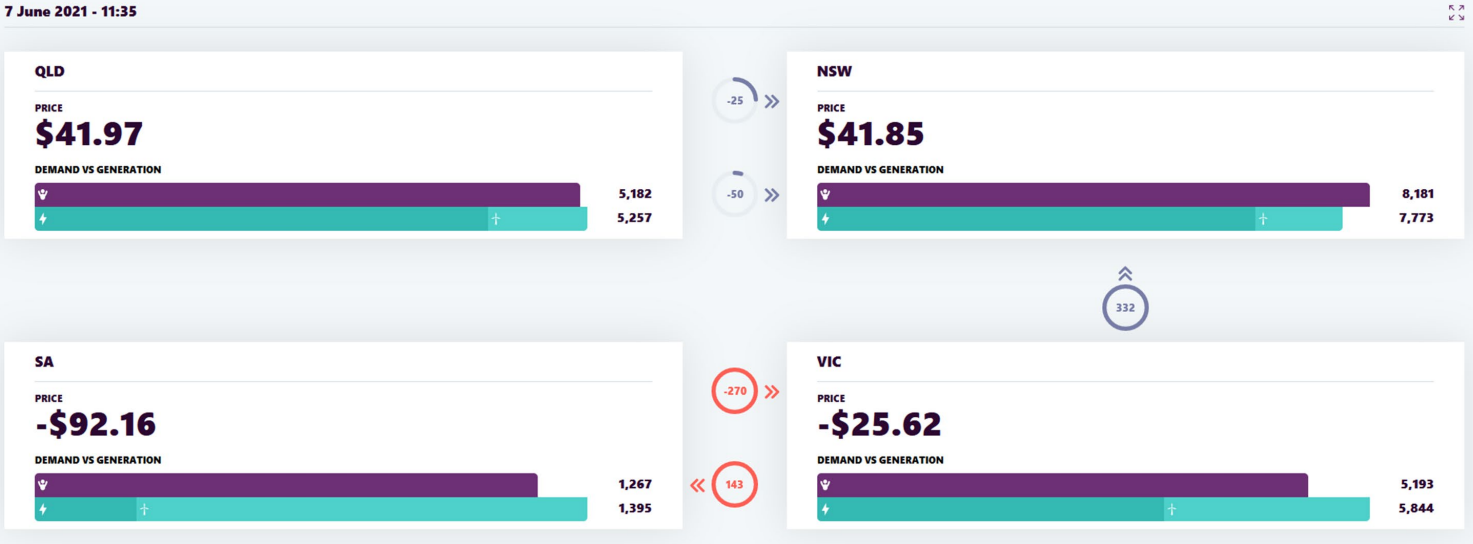


National Electricity Market (NEM)

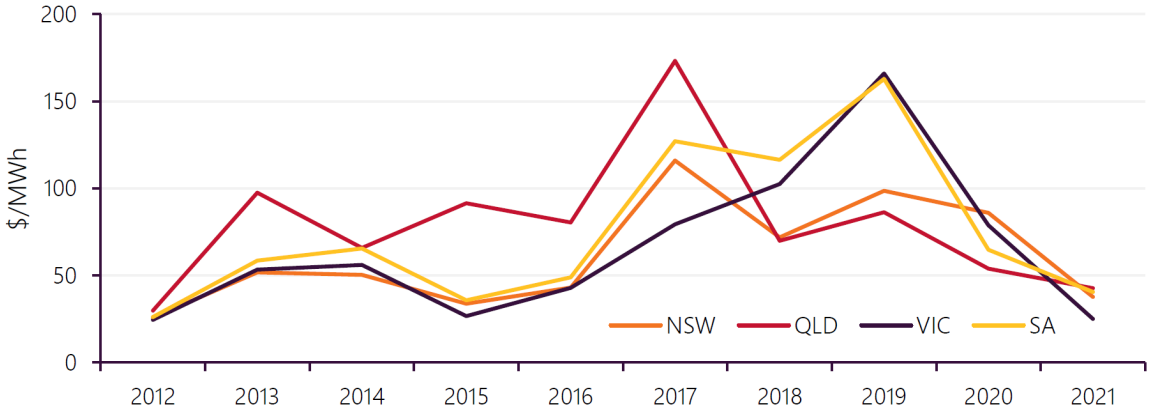


Real-time data is available via AEMO website →

https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem

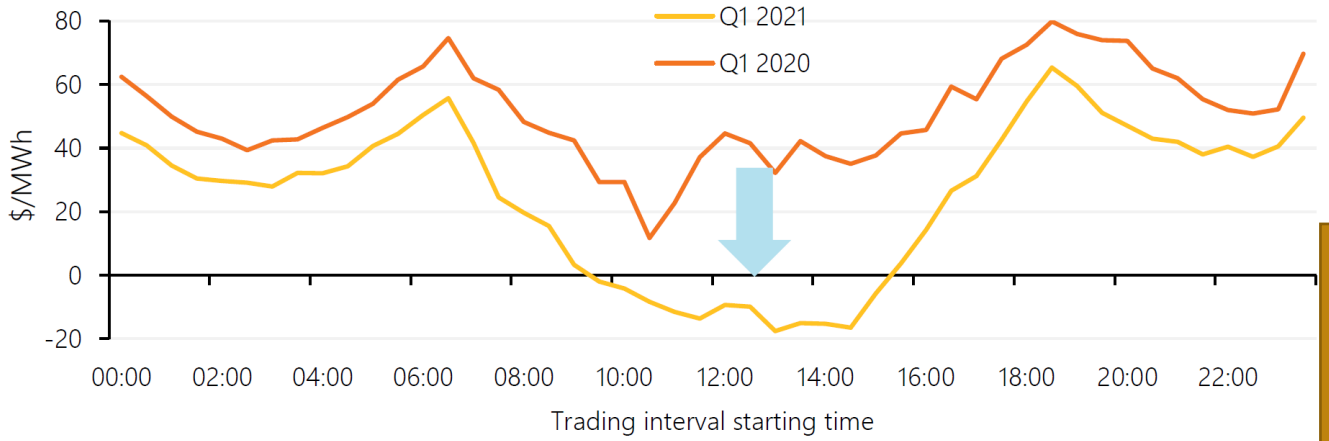


Average mainland wholesale electricity price by region (Q1s)[11]



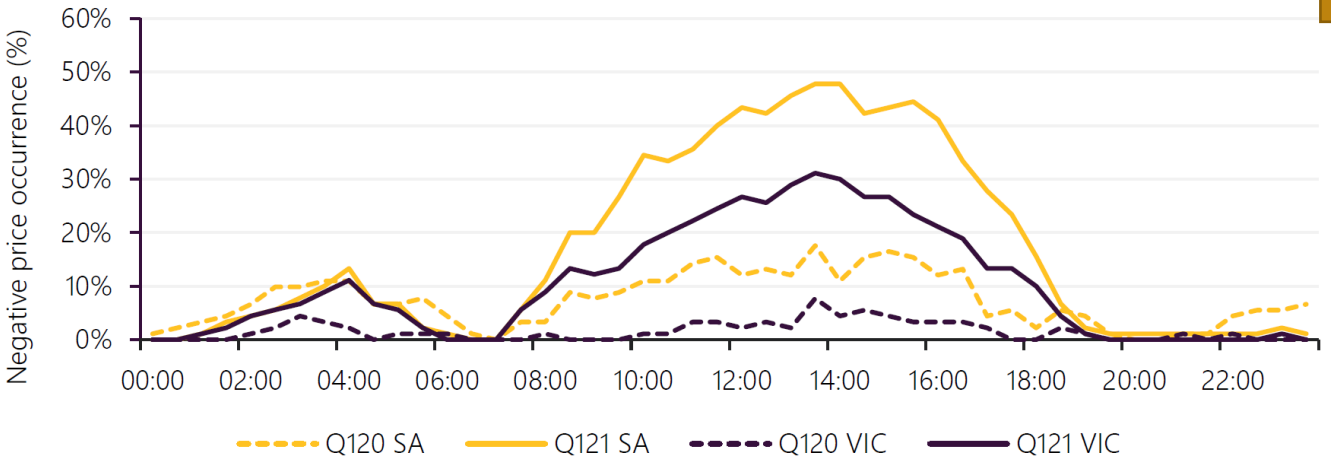
← Wholesale electricity prices have fallen over the last few years.
AEMO Quarterly Dynamics

South Australian average underlying electricity price[12] by time of day – Q1 2021 and Q1 2020



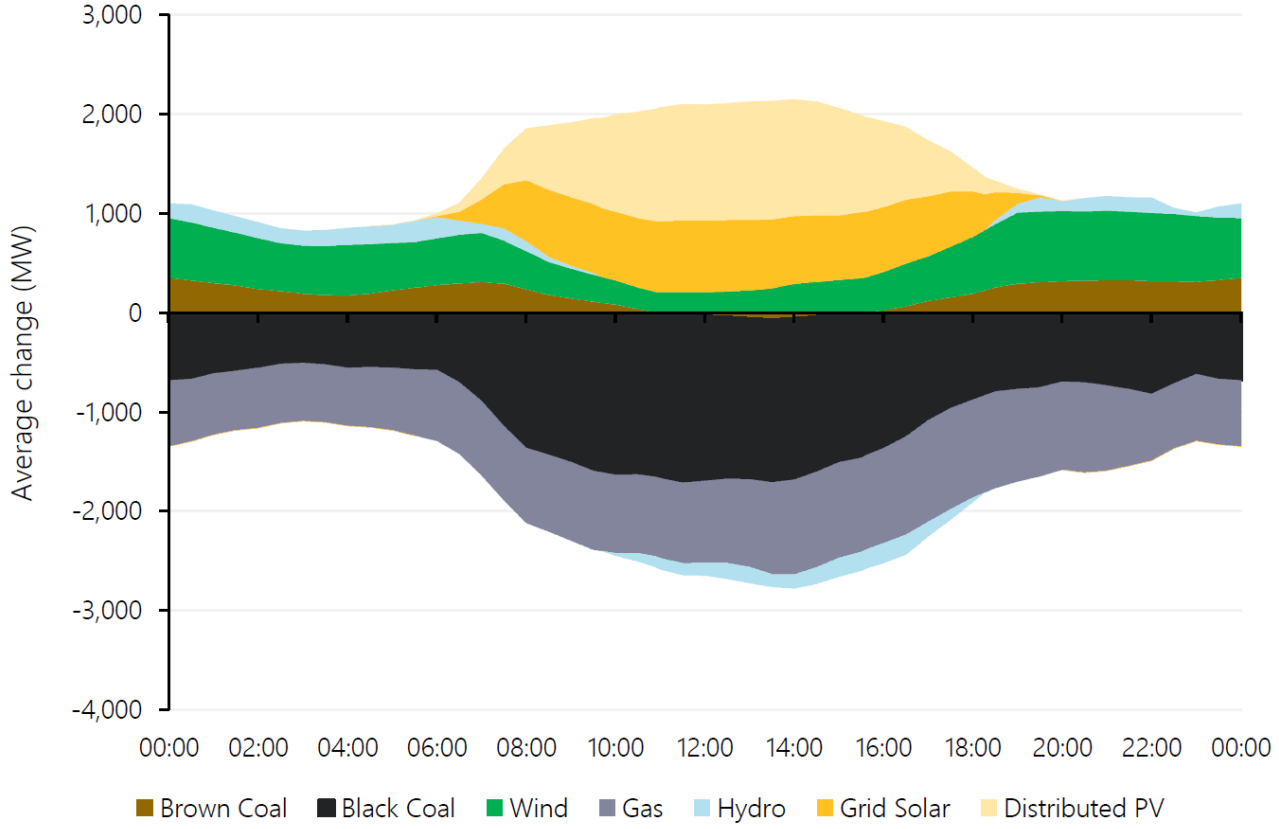
Dynamics of prices is changing – negative prices are more common.

South Australia and Victoria Q1 negative price percentage occurrence by time of day – Q1 2021 versus Q1 2020



AEMO Quarterly Dynamics

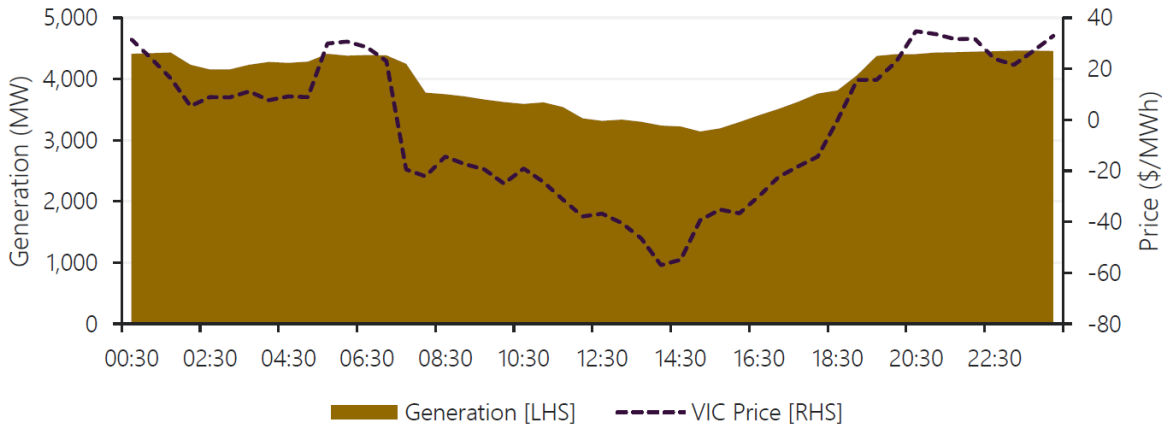
Change in supply – Q1 2021 versus Q1 2020 by time of day



Solar and wind are displacing coal and gas, particularly during the daytime.

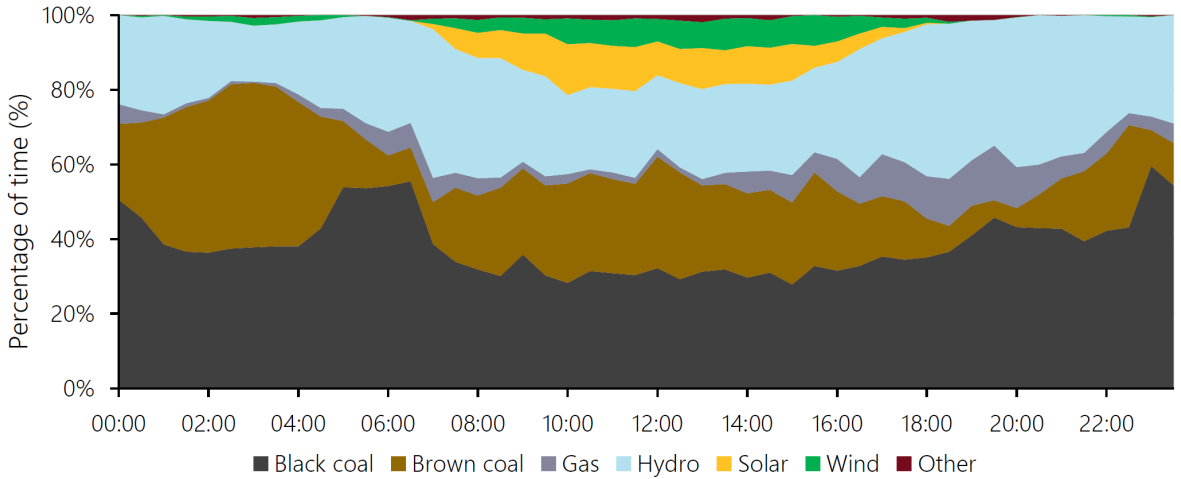
AEMO Quarterly Dynamics

Brown coal generation and Victoria spot prices – 16 Jan 2021



Brown coal generation is responding to negative prices. (wo carbon price)

Victoria's price-setting by fuel type and time of day – Q1 2021



Combined wind and solar has set Victoria's price more frequently than gas.

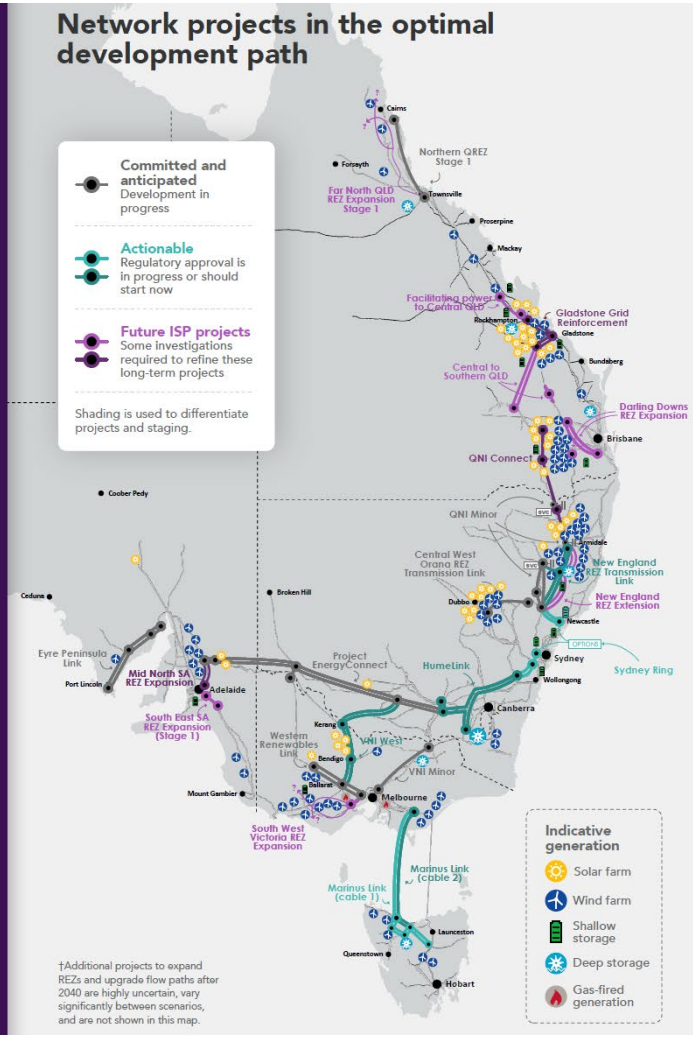
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

2022 Integrated System Plan (ISP)

The Australian Energy Market Operator (AEMO) has published the 2022 ISP, a 30-year roadmap for essential and efficient investment in the National Electricity Market (NEM).

The 2022 ISP supports Australia's highly complex and rapid energy transformation, switching from higher-cost, high-emission energy to lower-cost renewable energy, doubling capacity to power transport and industry, and at all times providing consumers with reliable, secure and affordable power.

Network projects in the optimal development path



†Additional projects to expand REZs and upgrade flow paths after 2040 are highly uncertain, vary significantly between scenarios, and are not shown in this map.

1 Consultation

The 2022 ISP is based on rigorous economic and engineering analysis, and almost two years' in-depth stakeholder engagement with energy consumers and providers, State and the federal governments, and energy regulators and analysts.

- Over **1,500** individual stakeholders
- Discussions convened through **31** webinars and **39** reports
- Detailed feedback received through **198** submissions

2 Considerations

- Market reforms
- Government policies
- Economic growth
- Emission targets
- Grid technologies and services
- Consumer investment in DER

3 Expected energy transition to 2050

('Step Change' scenario)

Storage capacity **to increase by a factor of 30**
(Batteries, virtual power plants, pumped hydro.)

NOW	2030	2050
2 GW	15 GW	61 GW

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

Electricity usage from the grid **to nearly double**

NOW	2030	2050
180 TWh	184 TWh	320 TWh

Gas-fired peaking plants **to increase**
While current mid-merit plants will all retire within that period.

NOW	2050
7 GW	10 GW

Coal generation **to be withdrawn**
Capacity to be retired by:

2030	2043
60%	100%

4 Optimal development path (ODP)

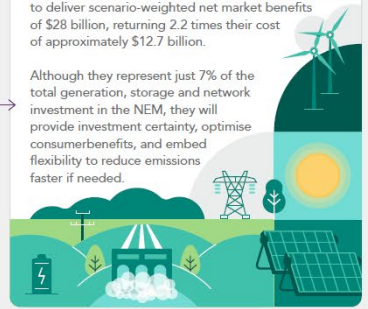
The ODP identifies five projects as immediately actionable which should progress as urgently as possible – HumeLink, VNI West, Marinus Link, Sydney Ring and New England REZ Transmission Link.

While delivery dates are as advised by project proponents, earlier delivery would provide valuable insurance for any faster transition or additional benefits to consumers. Supporting policies and mechanisms from the Commonwealth and jurisdictional governments may be able to assist in earlier delivery.

Net benefits

The transmission projects within the ODP are forecast to deliver scenario-weighted net market benefits of $28 billion, returning 2.2 times their cost of approximately $12.7 billion.

Although they represent just 7% of the total generation, storage and network investment in the NEM, they will provide investment certainty, optimise consumerbenefits, and embed flexibility to reduce emissions faster if needed.



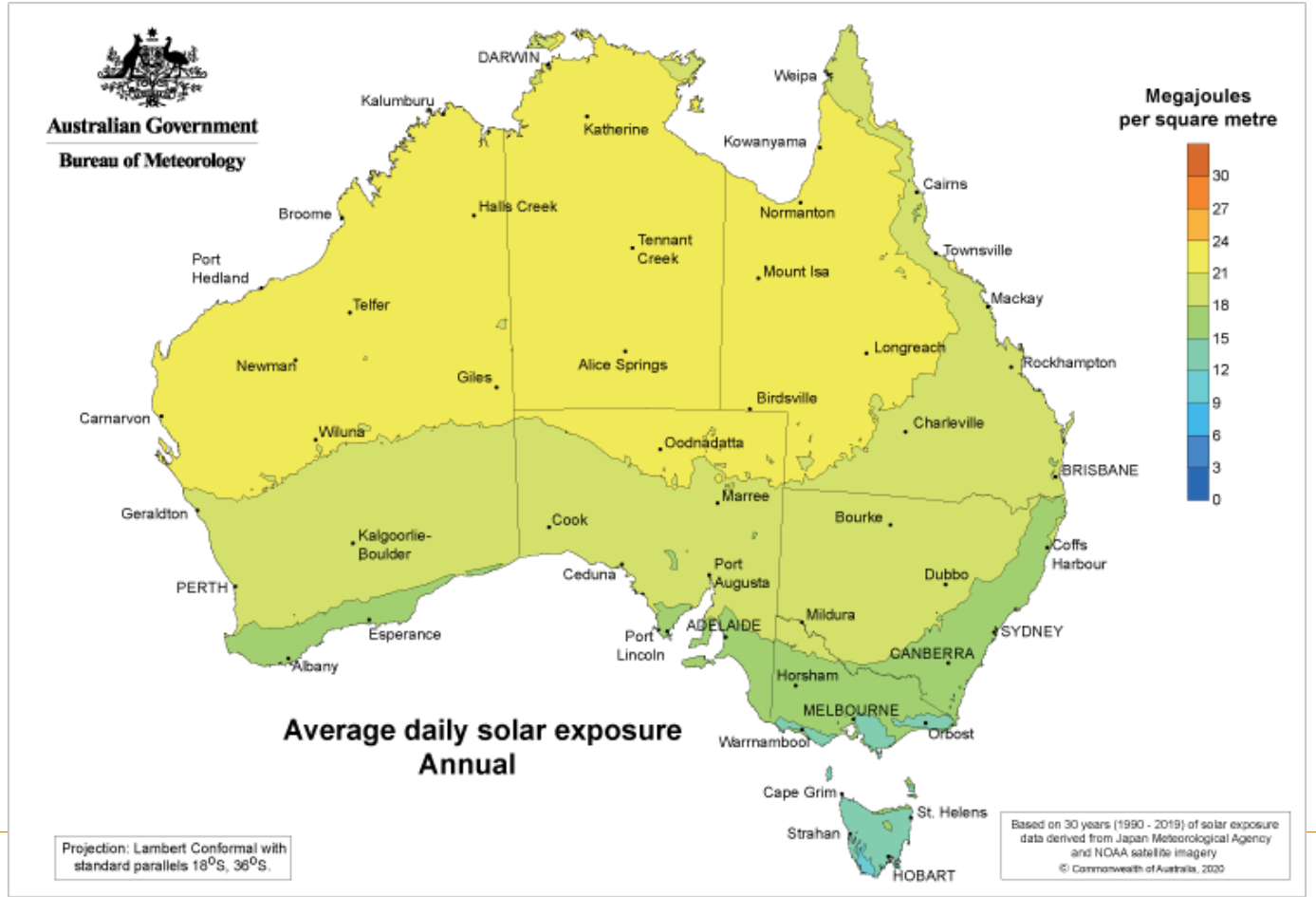
Rooftops - cities

TABLE 2
Propensity Score Matching Results: Solar Panels Average Treatment Effect, 2012

	Dependent variables, binary		
Details for solar panel average treatment effect	Could not pay electricity, natural gas, or telephone bill on time (1)	Could not pay electricity, natural gas, or telephone bill on time often or always (2)	Received disconnection warning from electricity or natural gas company (3)
Solar panels installed > 2 years ago	−0.040**	−0.028***	−0.014
	(0.020)	(0.009)	(0.017)
Solar panels installed > 2 years ago, probit	−0.050**	−0.023**	−0.031*
	(0.025)	(0.011)	(0.017)
Solar panels installed > 2 years ago and minimum of 2 matches	−0.060***	−0.029***	−0.027***
	(0.013)	(0.006)	(0.009)
Solar panels installed any time	−0.042**	−0.021	−0.031***
	(0.020)	(0.014)	(0.011)

Note: ***Significant at the 1%, **5%, *10% level. Average treatment effects are shown. Standard errors are in parentheses below the coefficients. The covariates include all of the explanatory variables from Table 1 plus a binary variable to identify households that are not concerned about energy conservation. The data are from the 2012 HEC survey.

Rooftops - remote



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NATURE INDEX | 07 September 2022

Data are key to proving green-energy benefits

Scientists are working with poorer communities worldwide to improve access to clean and safe energy sources.

Gemma Conroy

Employees of Ben Hill Electrical and Original Power work on rooftop solar installation at Norman Frank Jupurrurla's home in Tennant Creek. Credit: Original Power

https://www.nature.com/articles/d41586-022-02831-4

nature energy

ARTICLES

https://doi.org/10.1038/s41560-021-00942-2

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Energy insecurity during temperature extremes in remote Australia

Thomas Longden[1,2], Simon Quilty[3], Brad Riley[2,4], Lee V. White[2,5], Michael Klerck[4,6]✉, Vanessa Napaltjari Davis[6] and Norman Frank Jupurrurla[7]

Indigenous communities in remote Australia face dangerous temperature extremes. These extremes are associated with increased risk of mortality and ill health. For many households, temperature extremes increase both their reliance on those services that energy provides, and the risk of those services being disconnected. Poor quality housing, low incomes, poor health and energy insecurity associated with prepayment all exacerbate the risk of temperature-related harm. Here we use daily smart meter data for 3,300 households and regression analysis to assess the relationship between temperature, electricity use and disconnection in 28 remote communities. We find that nearly all households (91%) experienced a disconnection from electricity during the 2018–2019 financial year. Almost three quarters of households (74%) were disconnected more than ten times. Households with high electricity use located in the central climate zones had a one in three chance of a same-day disconnection on very hot or very cold days. A broad suite of interrelated policy responses is required to reduce the frequency, duration and negative effects of disconnection from electricity for remote-living Indigenous residents.

Indigenous communities in remote Australia face temperature extremes that can increase their use of electricity and amplify their risk of being disconnected. Energy is a necessary resource for work, education, participation in social life and for maintaining healthy living practices at home[1–6]. Energy insecurity remains a pressing issue globally, including in countries with an abundance of wealth and resources[4,7–10]. It can be defined as 'an inability to meet basic household energy needs'[6] and is broadly synonymous with the concept of energy poverty[11–13]. Insufficient access to energy has been linked to poor health (both mental and physical) as energy is required to maintain essential services, including food security, lighting, essential medical equipment and thermal comfort/safety during extreme weather[4,5,14–22].

There is a need to better understand the extent of energy insecurity experienced by Australia's remote Indigenous communities, in particular the role that temperature plays in shaping energy insecurity. The vulnerabilities associated with energy insecurity vary spatially on the basis of underlying characteristics, which can be highly regionalized and locally specific[23]. Socio-economic, demographic and behavioural factors, as well as occupancy and structural characteristics (including the size, type and quality of housing stock and appliances), are all key drivers of energy consumption; while the prevailing temperature can affect the security of electricity supply due to the cost of heating or cooling[18,23].

Temperature extremes are likely to act as a risk multiplier, worsening energy insecurity for those at greatest risk as 'vulnerable households typically live in poorer quality housing, and have least resource or opportunity to invest in improvements to its efficiency and heating technology'[6]. The importance of access to energy has prompted governments worldwide to implement policies maintaining this access, many with special attention to reducing the health effects of heat and cold[7,24,27].

The climate of the Northern Territory (NT) ranges from equatorial and tropical regions in the north to hot dry grassland regions in Central Australia (Fig. 1a). Remote Indigenous communities in the NT are mostly off-grid and unregulated by the guidelines of the Australian Energy Regulator[28]. In a situation unusual in Australia, remote living residents prepay for access to electricity and regularly experience disconnection on non-payment. Distant from Australia's urban centres and major electricity grids, these communities have long relied on diesel and gas-fired generators. In recent years, there has been incremental integration of renewable energy into these isolated, high-cost electricity networks.

Australia's remote Indigenous communities face some of the highest temperatures nationally and are vulnerable to the effects of a warming climate (Fig. 1b–d)[29]. Exposure to extreme temperatures has been associated with a range of adverse health outcomes and death[23,30–35]. In the three hottest climate zones in Australia, between 4.5 and 9.1% of all deaths were associated with heat-related mortality, which is an estimate that is much higher than in other Australian regions (2% nationally)[31]. The challenge of maintaining thermal comfort and safety during temperature extremes is a pressing issue for author N.F.J.: "We can't do anything about climate change except turn the power up, but it costs a lot too, don't forget that. Electricity, you're using more power when you turn that air conditioner up!." Temperatures over 35 °C, and even over 40 °C, are increasingly common in the NT as the climate changes (Fig. 1d). There is a need to better understand how extreme temperatures already shape the experience of energy insecurity in remote Indigenous communities.

Because of the health implications of energy disconnection and the subsequent loss of essential services, there are questions around how strongly disconnection events relate to temperature and whether disconnections occur more frequently during extreme

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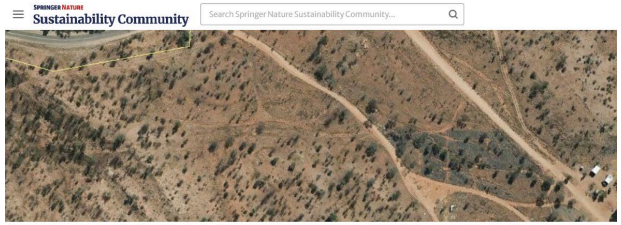

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BEHIND THE PAPER

Temperature extremes exacerbate energy insecurity – Australia needs to better support remote Indigenous communities to prepare now

Remote Indigenous communities in Australia face some of the highest temperatures nationally, worsening energy insecurity for residents who mostly prepay for access to electricity. We need to do better at providing protections from disconnection to improve Indigenous health and wellbeing.

Vanessa Davis and 2 others View all
Senior Aboriginal researcher, Tangentyere Council

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Published Dec 17, 2021

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Werte (hello/welcome).

This blogpost tells the story behind our paper *Energy insecurity during temperature extremes in remote Australia*, published in Nature Energy this month.

Co-workers and I at Tangentyere Council Research Hub started investigating the relationship between temperature, electricity use and involuntary self-disconnection in 2018. Extreme heat is a big issue, and the number of extreme temperature days in 2018/19 surpassed even the most severe projections of what we could expect under future climate change scenarios. It concerned our team greatly. Aboriginal social housing residents from Mpwartne/Alice Springs, its Town Camps and remote Central Australia were also reporting frequent disconnection from prepaid residential energy services and concerns about the amount of money spent to power their homes.

With the cooperation of our local utility, our preliminary investigation of 426 households prepaying for electricity in Town Camp housing revealed that 91 per

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policy brief

ENERGY SECURITY

Temperature extremes exacerbate energy insecurity for Indigenous communities in remote Australia

For remote Indigenous communities prepaying for electricity in Australia's Northern Territory, temperature extremes increase reliance on the services that energy provides and the risk of disconnection of those services. Policy should focus on reducing the frequency, duration and negative impacts of disconnection, within the context of a warming climate.

Thomas Longden[1,2], Simon Quilty[3], Brad Riley[2,4], Lee V. White[2,5], Michael Klerck[4,6]✉, Vanessa Napaltjari Davis[6] and Norman Frank Jupurrurla[7]

BASED ON: T. Longden et al. *Nature Energy* https://doi.org/10.1038/s41560-021-00942-2 (2021).

The policy problem

In Australia's Northern Territory, most remote Indigenous households are provided with or elect to use prepayment electricity meters. This payment method is associated with high disconnection rates and is uncommon in other Australian urban and rural communities. These remote communities also experience some of the most extreme temperatures in Australia (Fig. 1a). Electricity use to sustain safe indoor temperatures can rapidly deplete available means, resulting in disconnection with little warning. As such, safe temperatures cannot be maintained, and households lose access to other essential services that electricity provides, such as food storage, washing and cooking. This raises the need to understand both the extent of current disconnections and the degree to which they are triggered by temperature. Without this understanding, the existence and severity of problems cannot be identified, and policy cannot be designed to mitigate current harms or prevent future ones.

The findings

Among 28 remote communities in the Northern Territory, we found that 91% of households experienced a disconnection event at least once during the 2018/19 financial year; 74% of households were disconnected over 10 times, and 29% of all disconnections occurred during extreme temperatures. In mild temperatures (20–25 °C), households had a 1 in 17 chance of disconnection on a given day (Fig. 1b). This increased to a 1 in 11 chance during hot days (34–40 °C) and a 1 in 6 chance during cold days (0–10 °C). Households with high electricity use in the central Australian climate zones had a 1 in 3 chance of a same-day disconnection during temperature extremes. Energy insecurity is worsened when energy use is heightened owing to heating or cooling needs (Fig. 1c). Our analysis does not explore all of the complexities underlying energy insecurity in these communities, but we expect that these findings will inform discussions of energy insecurity in regions with extreme temperatures.

Messages for policy

- Electricity disconnections among households with prepayment meters are more frequent during temperature extremes, curtailing access to essential services.
- Households with high electricity use experience more disconnection events, so policy responses should account for household structure and occupancy, as well as the opportunity to use rooftop solar.
- Greater visibility and understanding of data on disconnections in these communities is needed to determine the extent of their energy insecurity.
- Policy should seek to reduce the frequency and duration of involuntary self-disconnections in remote communities, particularly during extreme temperatures.
- To account for the multifaceted nature of energy insecurity, policy responses need to be informed by residents, local councils, healthcare professionals and other relevant organizations.

The study

This analysis used daily smart-meter data from 3,300 households across 28 remote communities in Australia's Northern Territory to identify the incidence of disconnection events. These smart-meter data were matched with daily temperature observations from the closest weather station using data from the Australian Bureau of Meteorology. We estimated the probability of disconnection

[1]Crawford School of Public Policy, Australian National University (ANU), Canberra, Australian Capital Territory, Australia. [2]Zero Carbon Energy for the Asia Pacific Grand Challenge, ANU, Canberra, Australian Capital Territory, Australia. [3]Research School of Population Health, ANU, Canberra, Australian Capital Territory, Australia. [4]Centre for Aboriginal Economic Policy Research (CAEPR), ANU, Canberra, Australian Capital Territory, Australia. [5]School of Regulation and Global Governance (RegNet), ANU, Canberra, Australian Capital Territory, Australia. [6]Tangentyere Council Aboriginal Corporation, Alice Springs, Northern Territory, Australia. [7]Julalikari Council Aboriginal Corporation, Tennant Creek, Northern Territory, Australia. ✉e-mail: michael.klerck@tangentyere.org.au

Paper: https://rdcu.be/cDlYQ

Blog: http://go.nature.com/31WxDNn

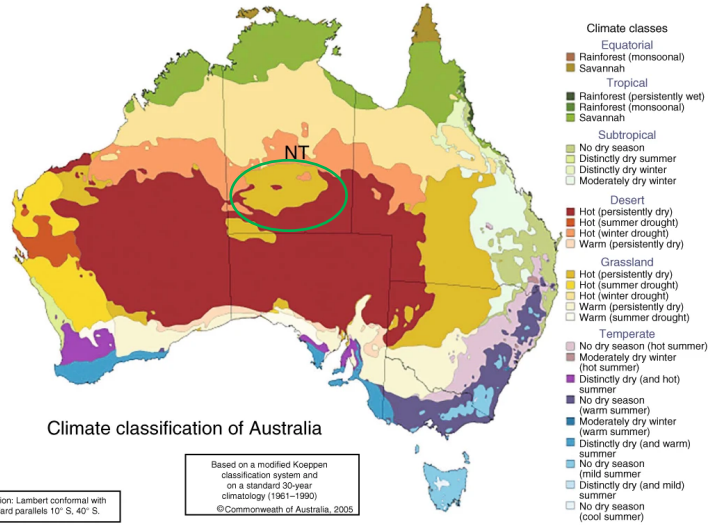
Policy Brief: http://rdcu.be/cFDaF

Energy insecurity during temperature extremes in remote Australia. **Nature Energy**

Key findings:

- We find that nearly all households (91%) experienced a disconnection from electricity during the 2018–2019 financial year.
- Almost three quarters of households (74%) were disconnected more than ten times.
- Households with high electricity use located in the central climate zones had a one in three chance of a same-day disconnection on very hot or very cold days.
- Disconnections differed by climate zone and size of house/household.

a



Climate classification of Australia

Based on a modified Koeppen classification system and on a standard 30-year climatology (1961–1990)

Projection: Lambert conformal with standard parallels 10° S, 40° S.

Climate classes

Equatorial
- Rainforest (monsoonal)
- Savannah

Tropical
- Rainforest (persistently wet)
- Rainforest (monsoonal)
- Savannah

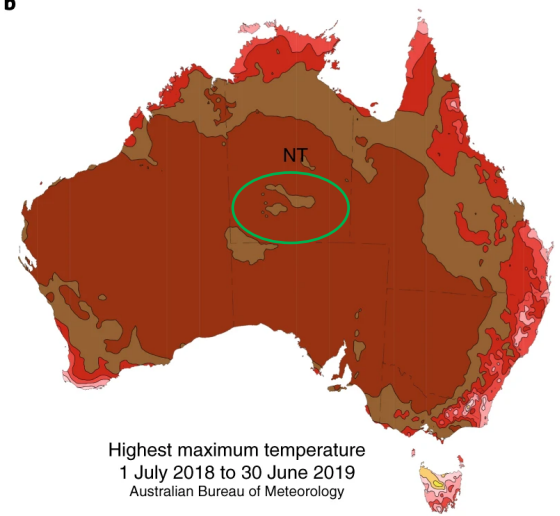
Subtropical
- No dry season
- Distinctly dry summer
- Distinctly dry winter
- Moderately dry winter

Desert
- Hot (persistently dry)
- Hot (summer drought)
- Hot (winter drought)
- Warm (persistently dry)

Grassland
- Hot (persistently dry)
- Hot (summer drought)
- Hot (winter drought)
- Warm (persistently dry)
- Warm (summer drought)

Temperate
- No dry season (hot summer)
- Moderately dry winter (hot summer)
- Distinctly dry (and hot) summer
- No dry season (warm summer)
- Moderately dry winter (warm summer)
- Distinctly dry (and warm) summer
- No dry season (mild summer
- Distinctly dry (and mild) summer
- No dry season (cool summer)

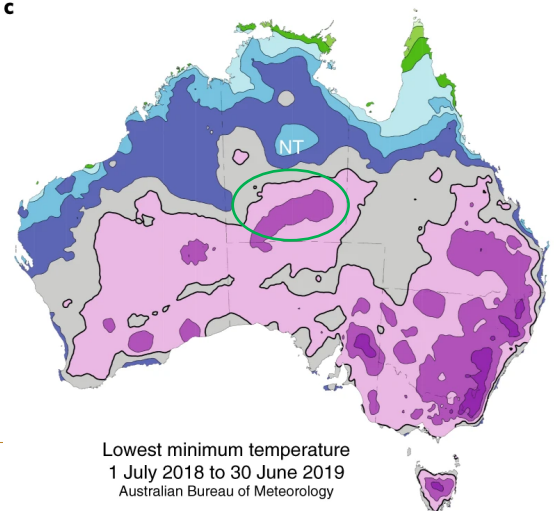
b



45 °C 5 °C
42 °C 2 °C
39 °C 9 °C
36 °C 6 °C
33 °C 3 °C
30 °C 0 °C
27 °C 7 °C
24 °C 4 °C
21 °C 1 °C
18 °C 8 °C
15 °C 5 °C
12 °C 2 °C
9 °C °C
6 °C °C
3 °C °C
0 °C °C
–3 °C 3 °C
–6 °C 6 °C

Highest maximum temperature
1 July 2018 to 30 June 2019
Australian Bureau of Meteorology

c



45 °C
42 °C
39 °C
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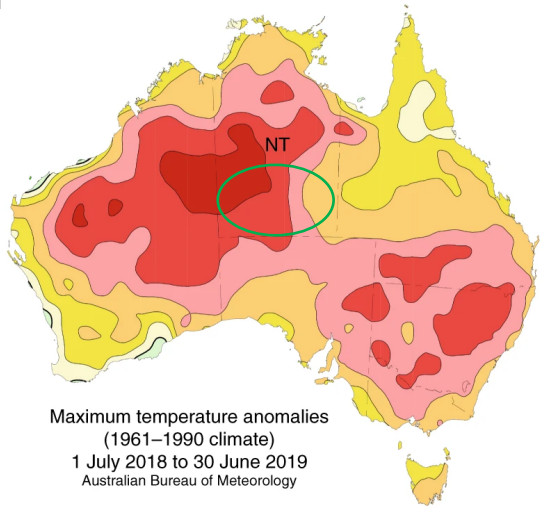
30 °C
27 °C
24 °C
21 °C
18 °C
15 °C
12 °C
9 °C
6 °C
3 °C
0 °C
–3 °C
–6 °C

Lowest minimum temperature
1 July 2018 to 30 June 2019
Australian Bureau of Meteorology

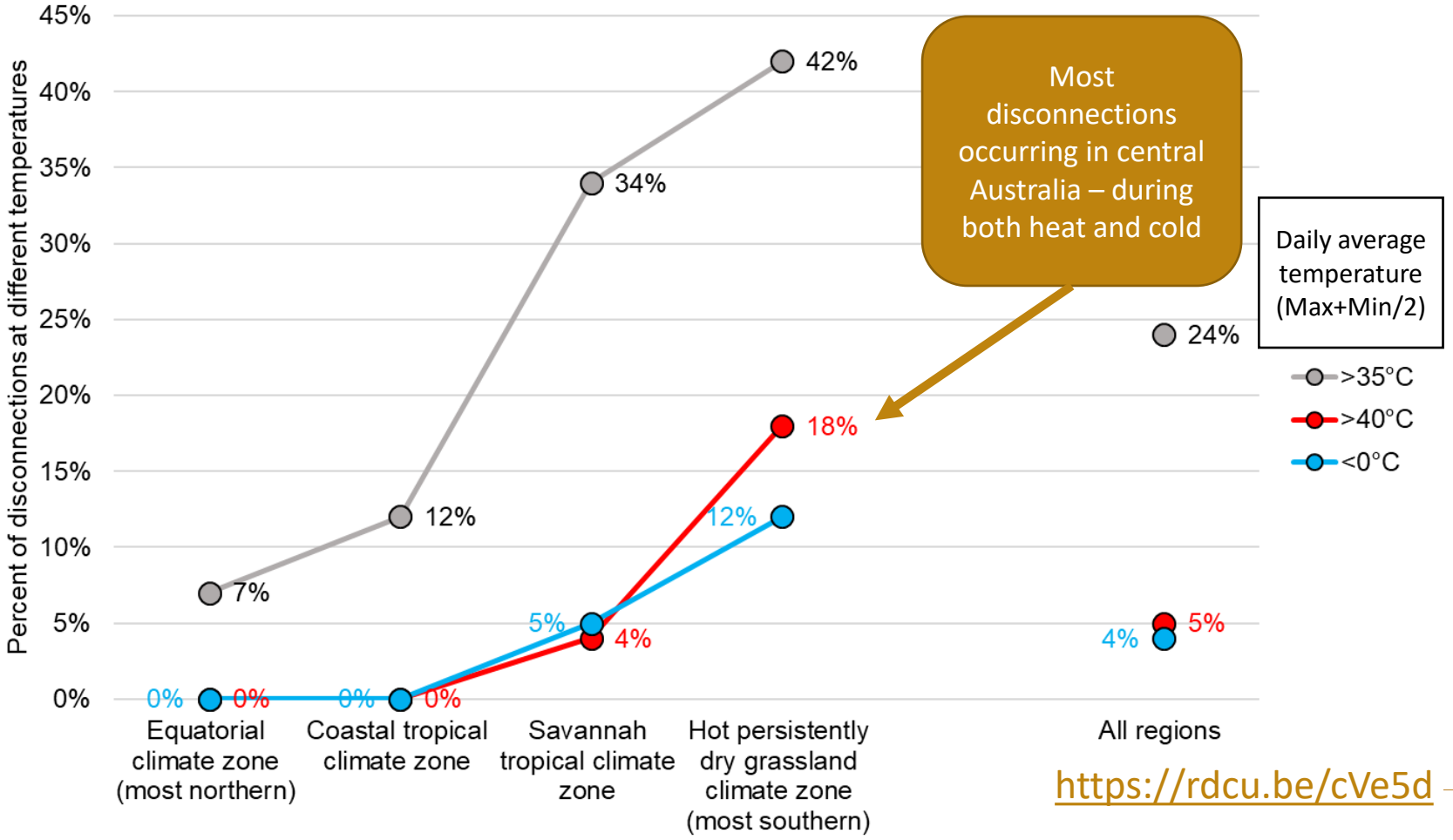
d



3.0 °C .0 °C
2.5 °C .5 °C
2.0 °C .0 °C
1.5 °C .5 °C
1.0 °C .0 °C
0.5 °C .5 °C
0 °C °C
–0.5 °C–0.5 °C
–1.0 °C–1.0 °C
–1.5 °C–1.5 °C
–2.0 °C–2.0 °C
–2.5 °C–2.5 °C
–3.0 °C–3.0 °C

Maximum temperature anomalies
(1961–1990 climate)
1 July 2018 to 30 June 2019
Australian Bureau of Meteorology

Percent of disconnections by climate zones



https://rdcu.be/cVe5d

Issues for the discussion

- Importance of competition and allowing new entrants.
- Replacing coal and reducing gas is key to decarbonising electricity. Health co-benefits and better energy security.
- Long-term planning is needed to link renewable energy zones with large demand centres. Plus speedy grid connections for better investor certainty.
- Roof-top PV is important as it leads to direct savings for business or residents. Also crucial for remote areas via micro-grids.
- Equity and policy is important for a just transition.

Next time we'll discuss the same national and local issues – with a focus on policy.