

Great expectations - how do we align electricity sector needs with gas commercial realities?

Looking at changing electricity sector expectations, the modelling challenges in considering gas supply, and the potential role of gas substitutes moving forward

AEMC Connecting Policy and Research Forum:
'Relationship status: it's complicated - exploring the electricity-gas nexus in Australia

Dr Dylan McConnell

14 July 2025



UNSW
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Collaboration on Energy and Environmental Markets

The UNSW Collaboration on Energy and Environmental Markets (CEEM) undertakes interdisciplinary research into the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks.

CEEM brings together UNSW researchers from the UNSW Business School, UNSW Engineering, and UNSW Arts, Design & Architecture, working alongside a growing number of Australian and international partners.

- Our research focuses on the challenges and opportunities of clean energy transition within market-oriented electricity industries.
- Effective and efficient renewable energy integration is key to achieving such energy transition, and CEEM researchers have been exploring the opportunities and challenges of market design and policy frameworks for renewable generation investment, as well as investment in the necessary flexible resources to facilitate its integration, for the past two decades.
- As distributed energy resources (DERs) such as solar PV, batteries and demand response are deployed at increasingly high penetrations, their successful integration into electricity industries will be critical to managing cost, reliability and the integration of variable renewable energy. CEEM studies emerging markets, regulatory approaches and business models for DER integration, and their technical, economic and social outcomes.

SFL Scenarios for Future Living →	Energy Trends Visualisation Tools This project aims to provide clear and truthful information to assist stakeholders in understanding the changes in the industry better and how those changes can benefit consumers. →	Plus ES Demand Flexibility Plus ES South Australian Demand Flexibility Trial. →
Lobbying influence on climate standards The influence of lobbying submissions on the ISSB's standard IFRS S2 Climate Related Disclosures. →	24/7 TRUZERO Tracking Renewables Utilisation for Zero Emission Reporting and Operation. →	Energy Masters Demonstrating aggregated household flexibility in the South Australian Power Network. →
CICCADA The project aims to understand better the integration of consumer energy resources (CER) into the National Energy Market (NEM). →	OpenISP An accessible and transparent electricity system model based on the Australian Energy Market Operator's 'Integrated System Plan'. →	Off-grid solar in Vanuatu Facilitating off-grid solar maintenance, repair, and entrepreneurship in Vanuatu. →
SunSPOT Discover the savings your roof can make with solar and batteries. →	SolarShift Soaking up excess solar with electric hot water systems. →	Solar E-Waste Africa Solar E-Waste in Sub-Saharan Africa: facilitating the right to repair. →

Outline

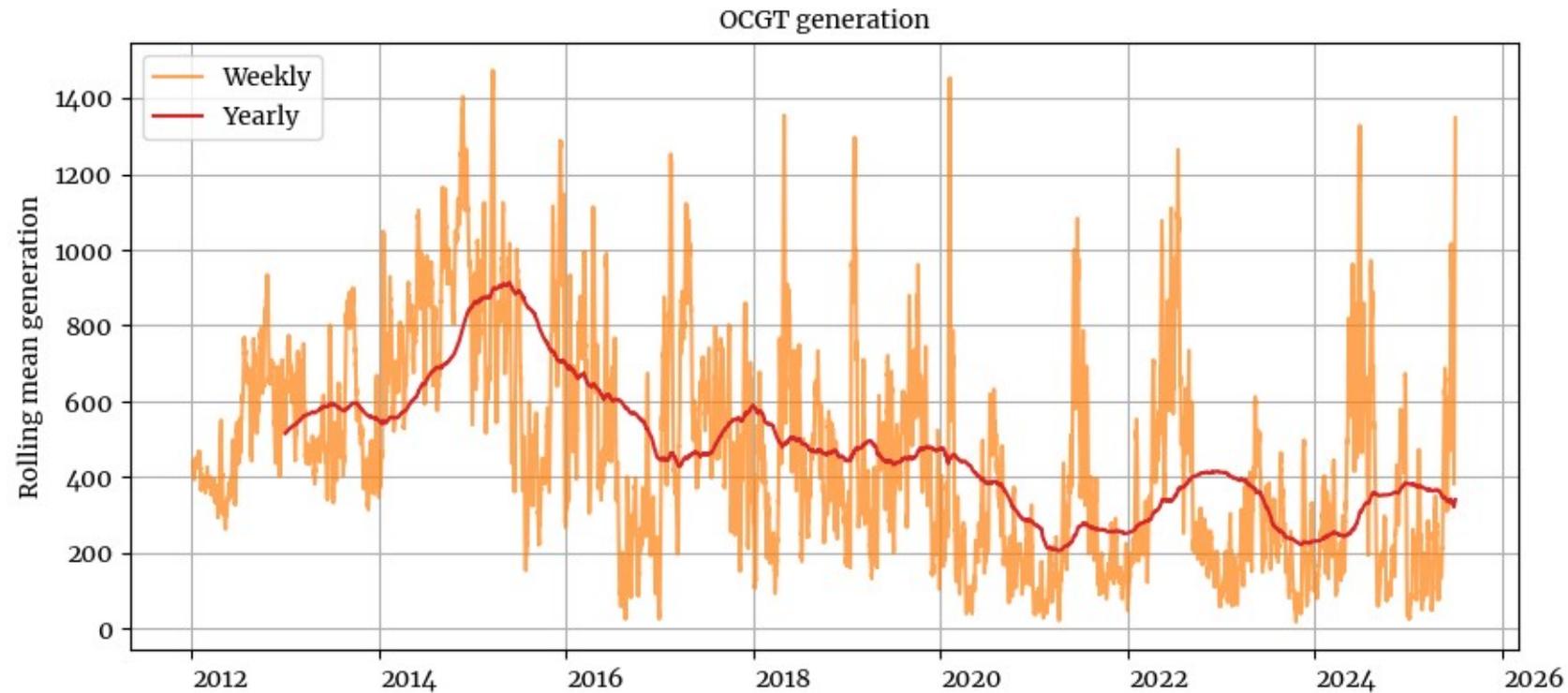
- **The changing role of Gas Power Generation**
 - Trends over time
 - Seasonal changes
- **The projected role of Gas Power Generation**
 - Energy and capacity
 - Drivers
 - Projected daily patterns
- **Questions, challenges and alternatives**
 - What is actually driving gas capacity?
 - Can the gas system deliver this?
 - Alternatives – liquid fuels and demand response
- **Looking to the future**
 - Integrated system modelling
 - Expanding definition of storage

1. The changing role of Gas Power Generation



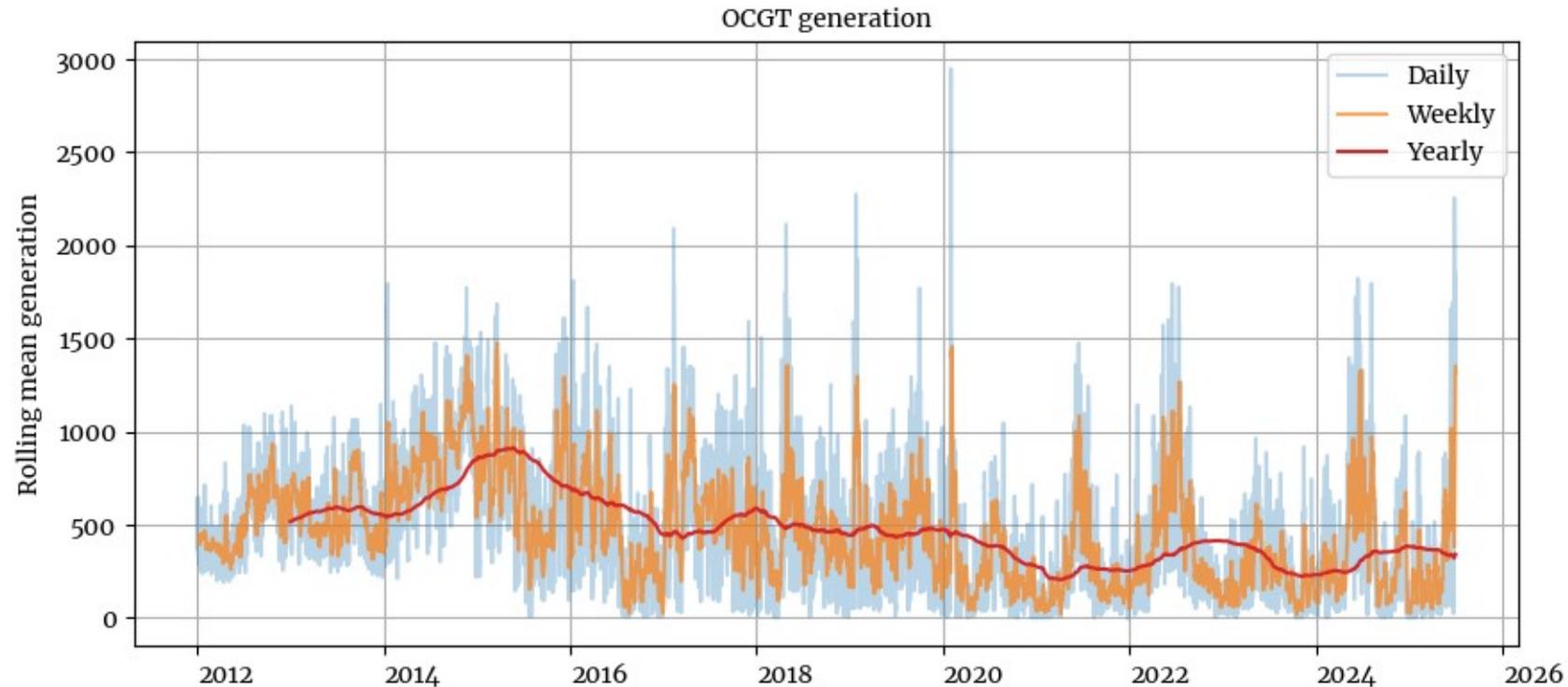
Trend over time

- **Gas generation has been trending down annually**
 - But weekly average peaks - not really!
 - (These are proxy for energy generated in the week)



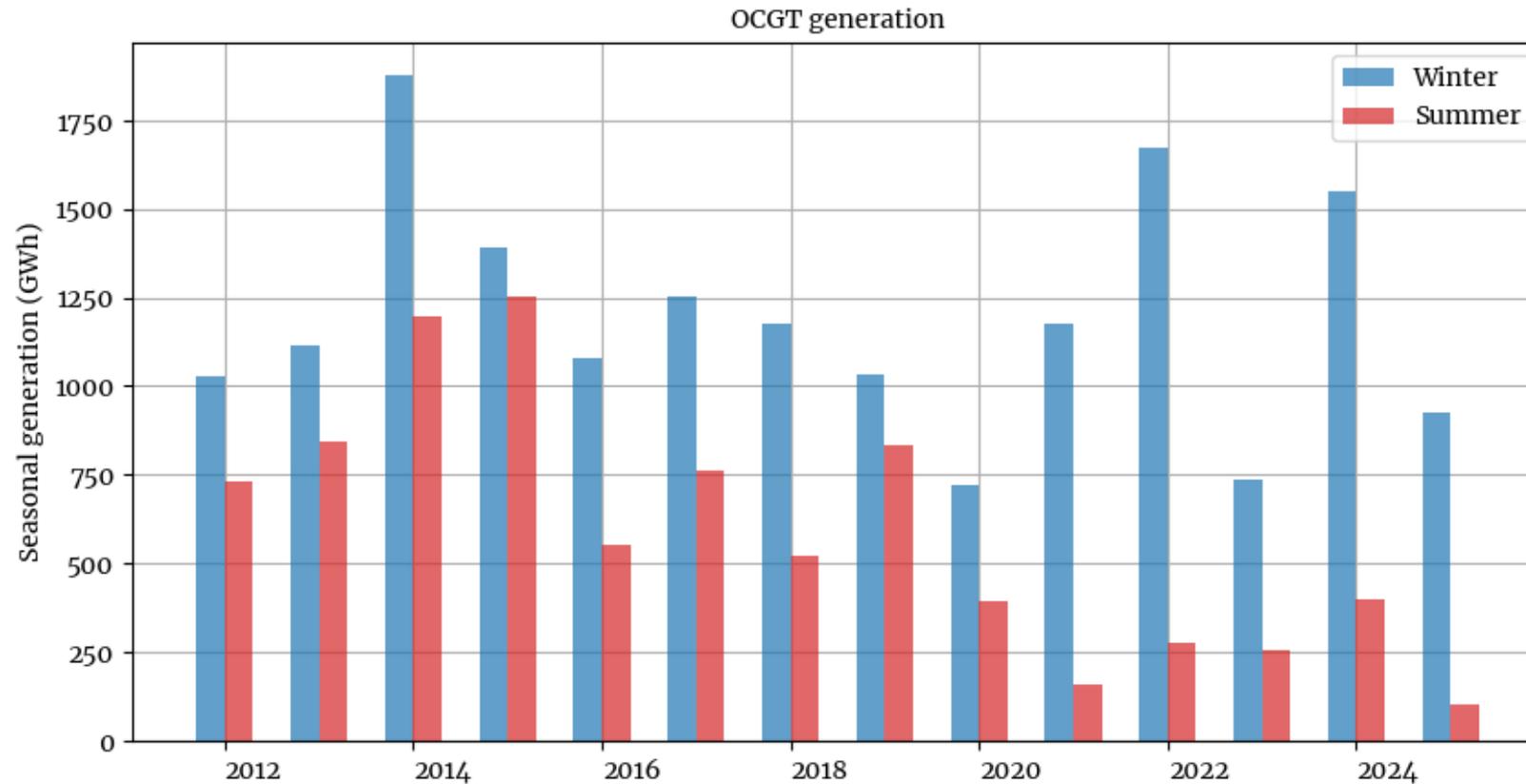
Trend over time

- **Gas generation has been trending down annually**
 - But weekly average peaks - not really!
 - (These are proxy for energy generated in the week)
 - Neither for daily energy peaks
 - (perhaps less of challenge)



Seasonal

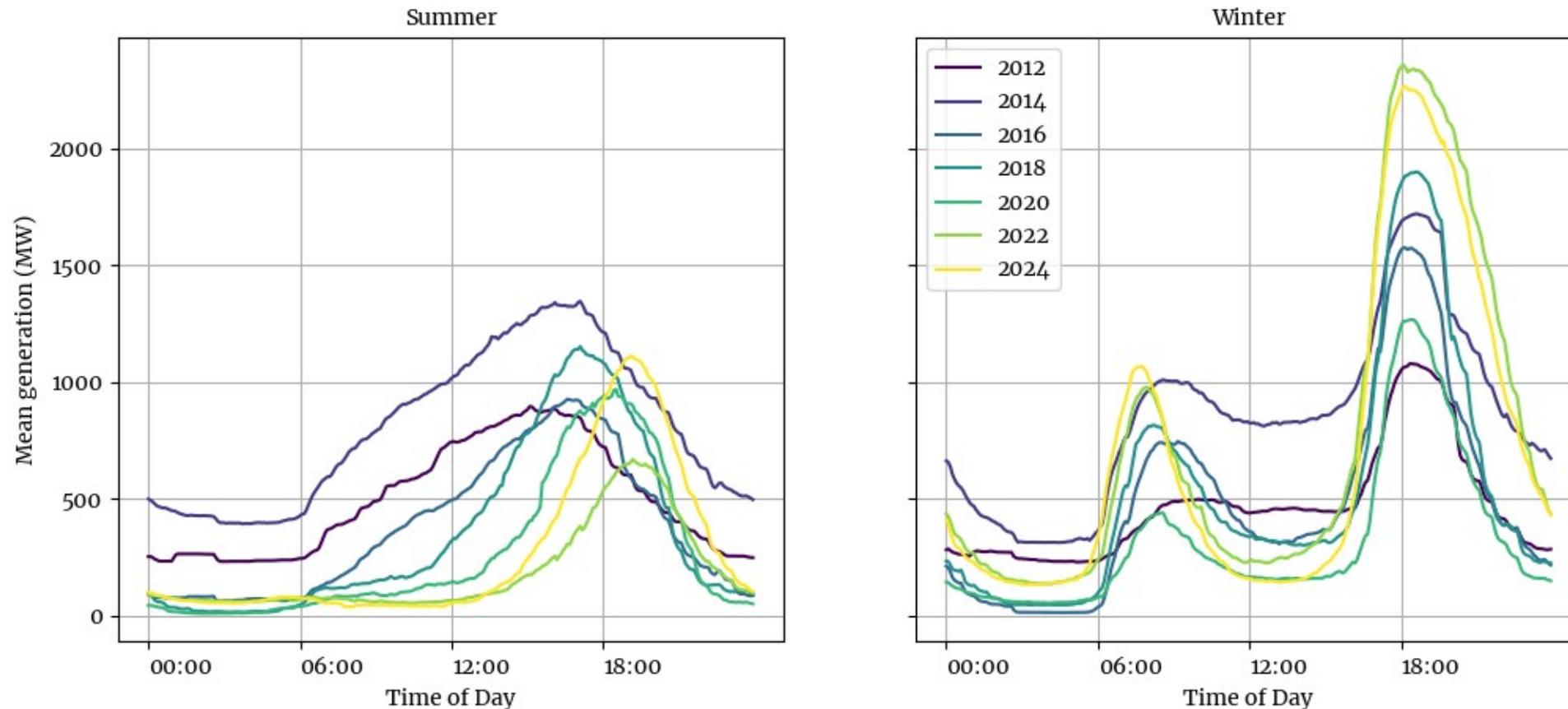
- **Big shift in seasonal gas generation**
 - Summer generation is declining, winter is not
 - Moving to a winter dominated generation profile



Seasonal

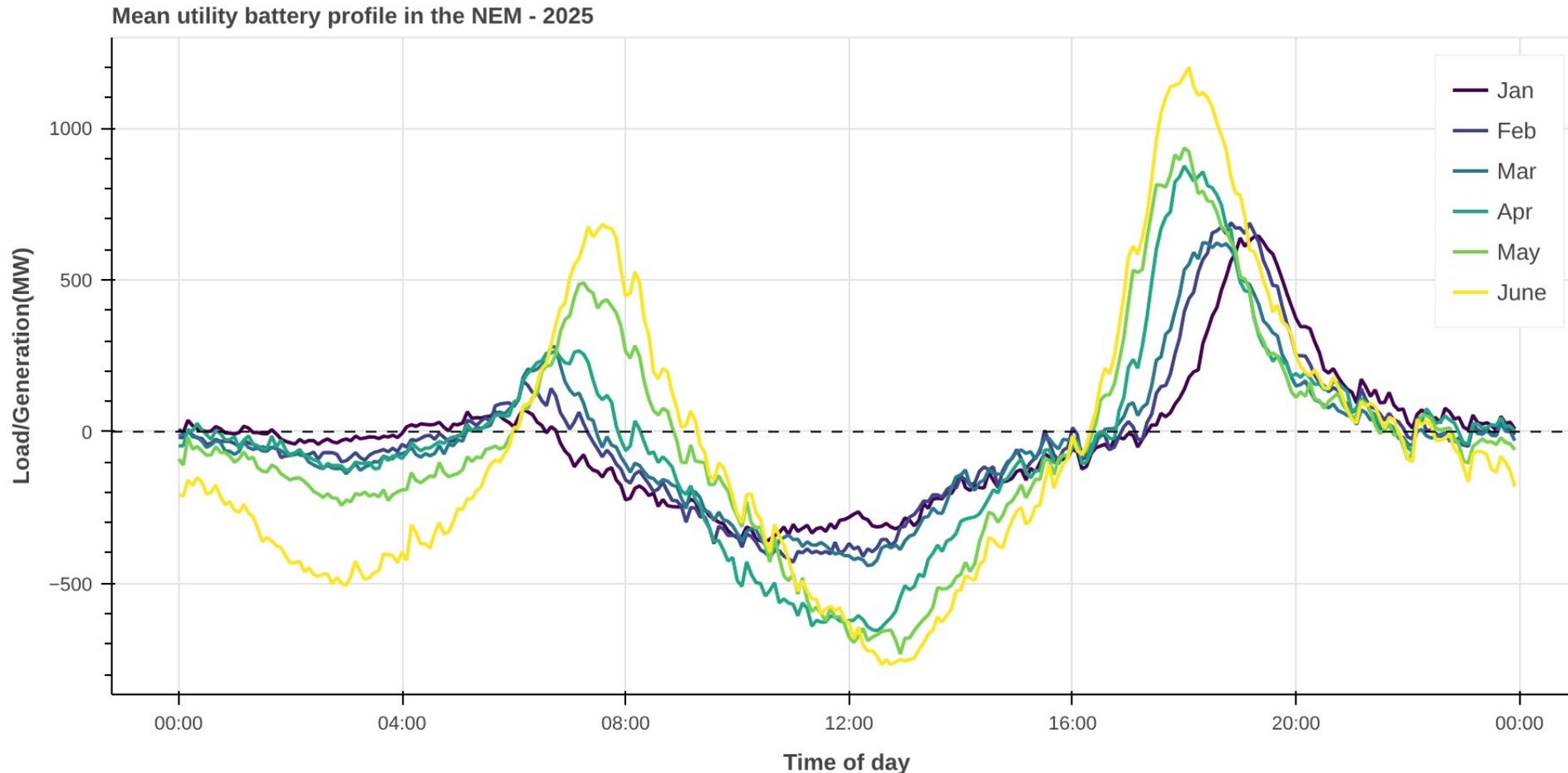
- **Big shift in seasonal gas generation**
 - Significant difference in operating profiles across the seasons as well.

OCGT generation profile



Coming soon...?

- **The influx of batteries in last ~12 months may change the profile even more**
 - Some (early) evidence that battery generation displacing peaking gas
 - Gas profile will evolve further

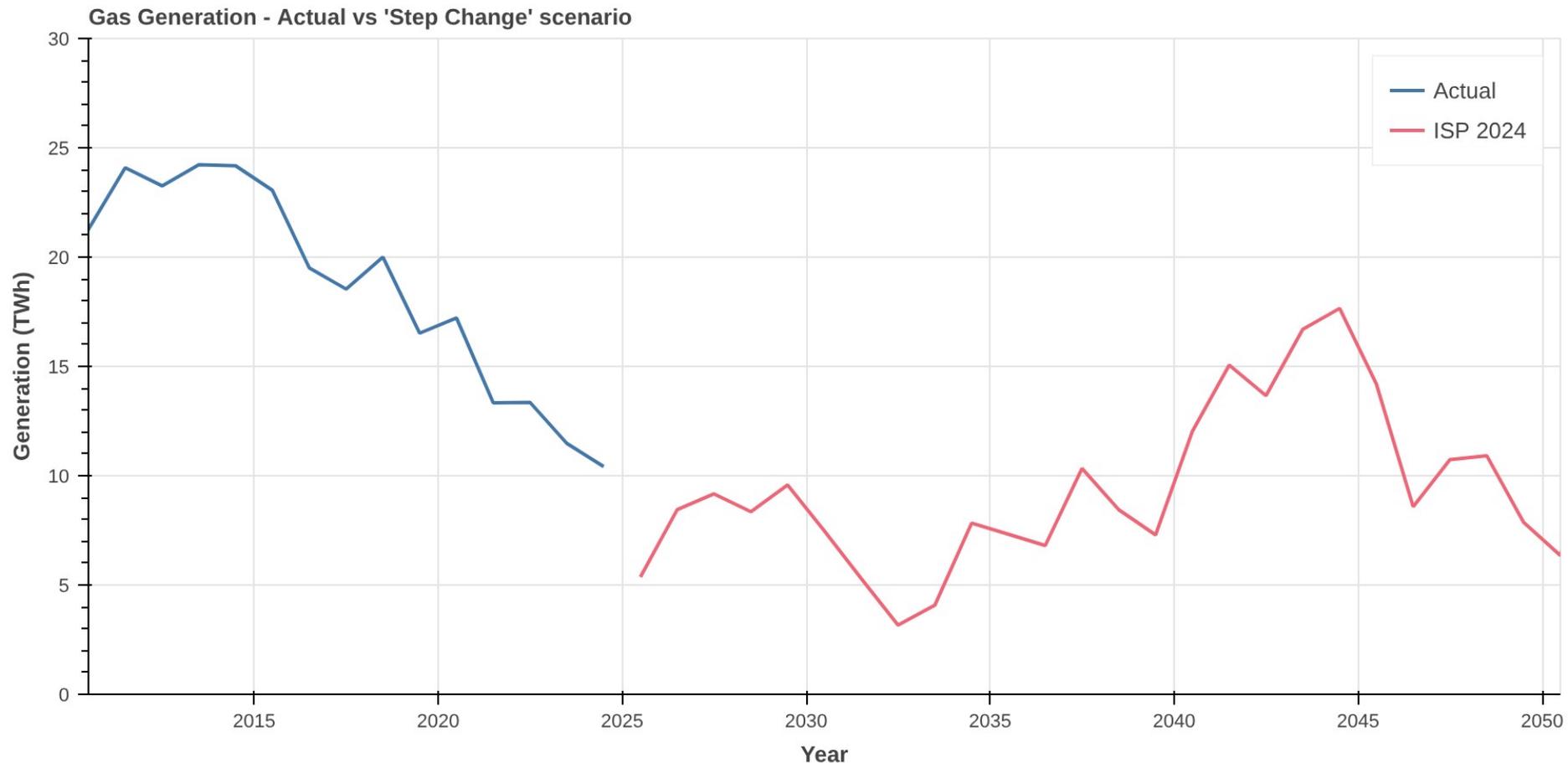


2. The projected role of Gas Power Generation



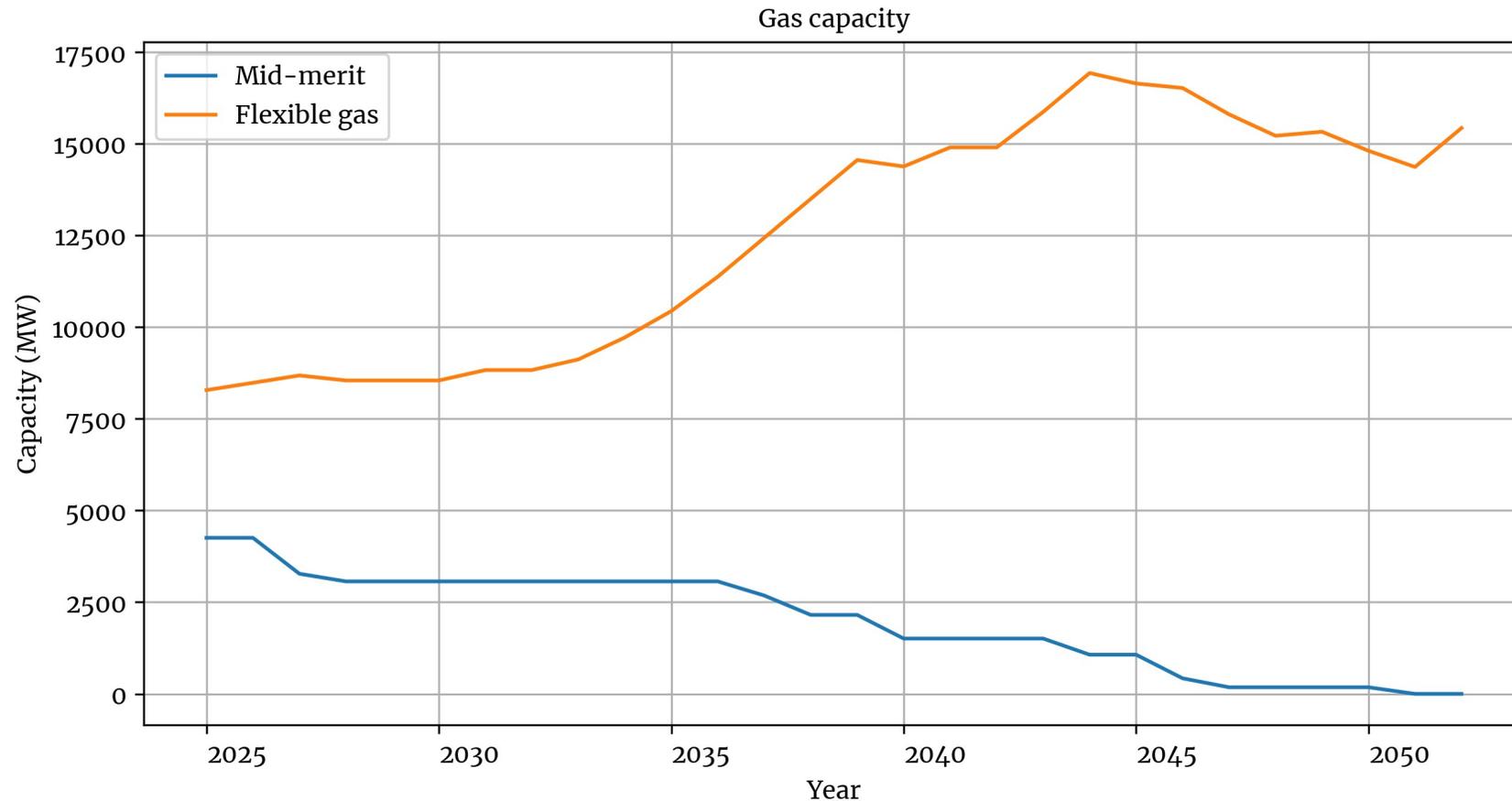
Generation

- **The projected role of gas power generation (ISP 2024)**
 - Lower than historical aggregate levels
 - However some years with relatively high generation (driven by weather-year assumptions)



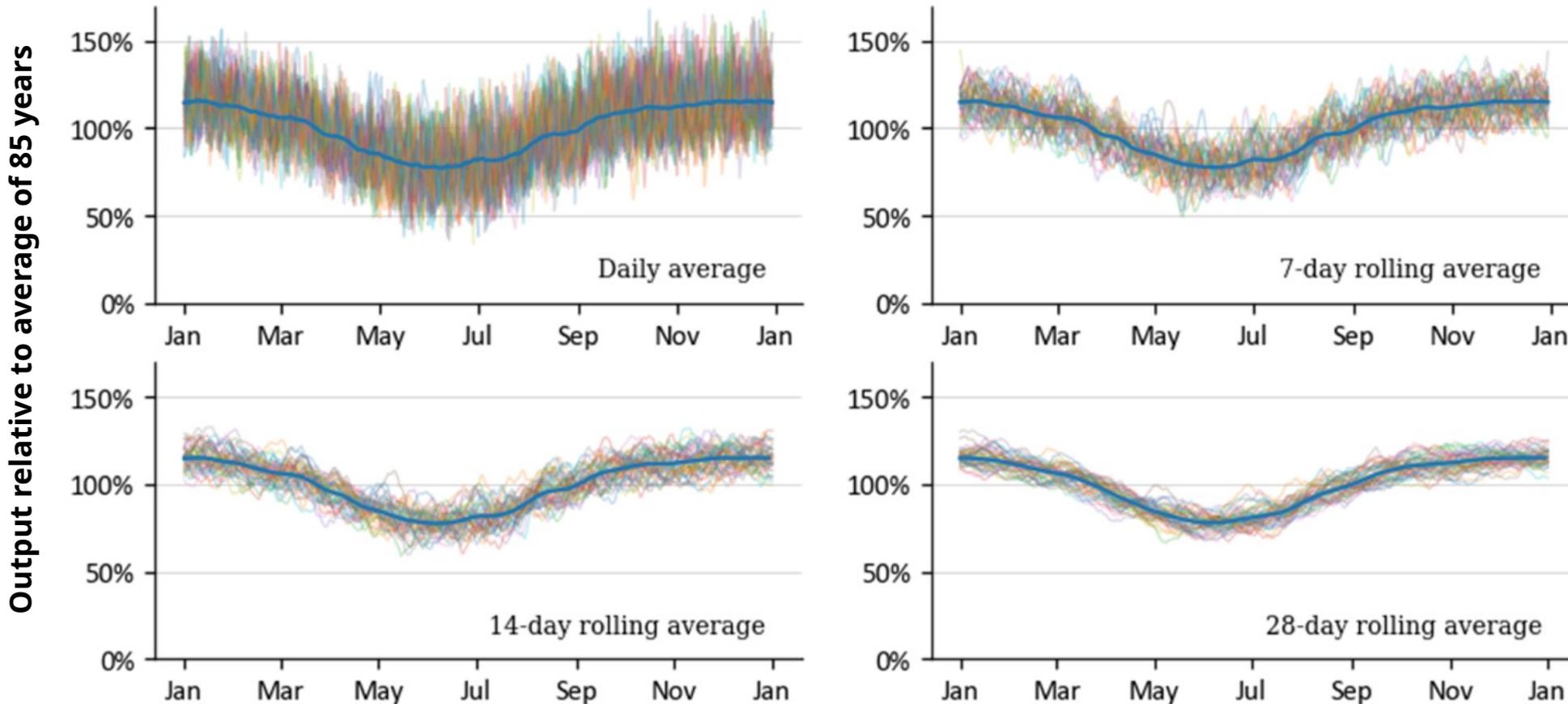
Capacity

- **The projected role of gas power capacity (ISP 2024)**
 - Mix is projected to change from mid-merit to “flexible gas”



Drivers

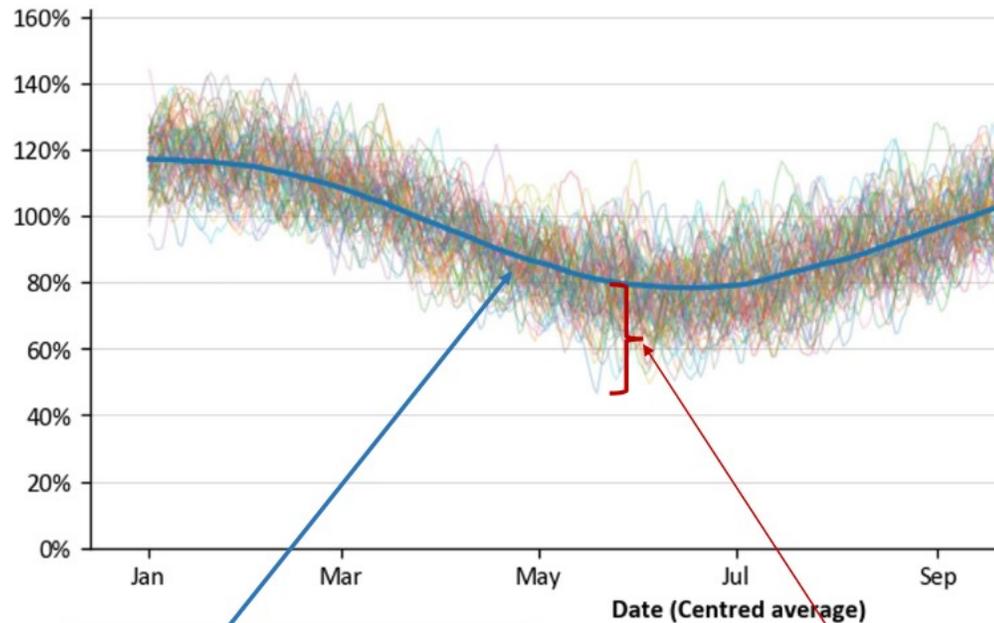
- **Drivers: In part, managing “Renewable Energy Droughts”**
 - *Gilmore et al used ~85 years of global re-analysis weather data to explore historical observations*



[Source: Gilmore, Joel, Tim Nelson, and Tahlia Nolan. 2025. “Quantifying the Risk of Renewable Energy Droughts in Australia’s National Electricity Market (NEM) Using MERRA-2 Weather Data.” *Economic Analysis and Policy* 86 (June):912–28. <https://doi.org/10.1016/j.eap.2025.03.040>.]

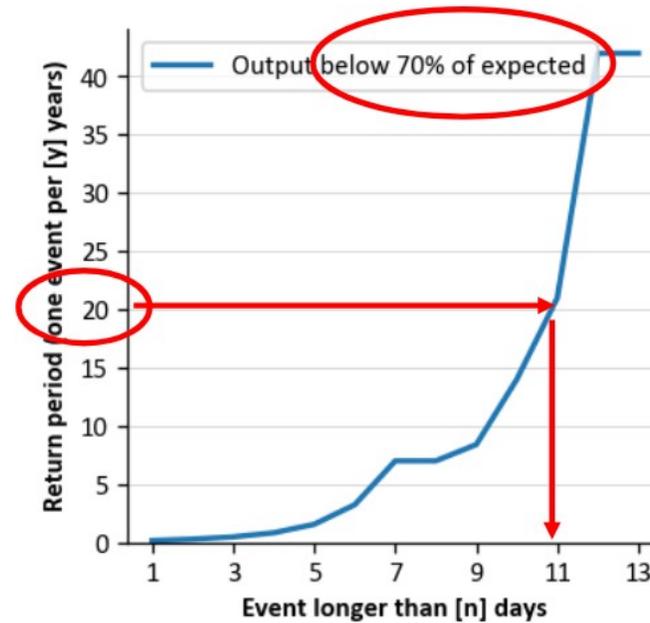
Drivers

- **Drivers: Managing “Renewable Energy Droughts”**
 - *There are challenging conditions to manage*
 - *Key finding was that renewable energy “droughts” are not actually a major issue*
 - *(But could be role for government to protect against rare events)*



Predictable seasonal dip – not a “drought”

Weather variability – “VRE drought” risk

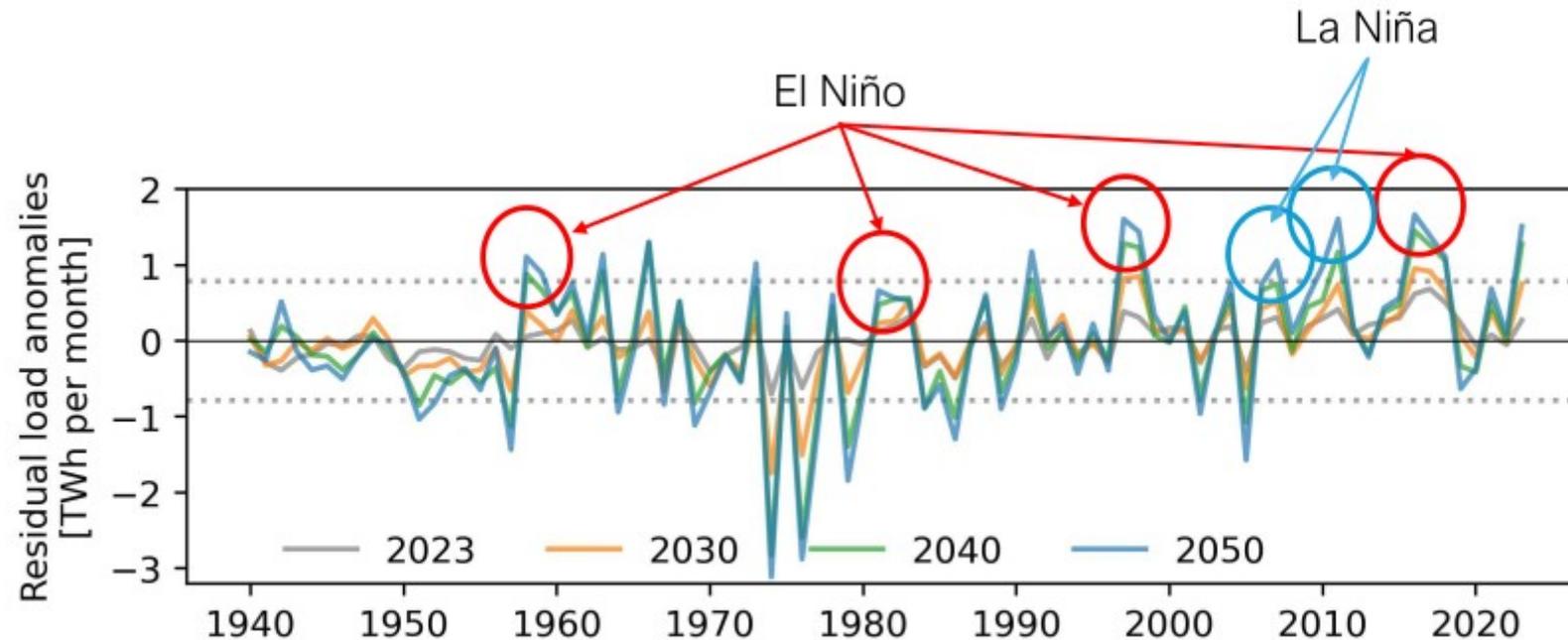


Taking into account seasonal predictability

[Source: Gilmore 2025. “Gilmore, Joel. 2025. “Firming a Low Emissions Grid.” Presented at the NEM Review: Lunch and Learn, 21 March 2025]

Drivers

- **Drivers: Managing “Renewable Energy Droughts”**
 - Involved in some forthcoming work looking at residual load anomalies at UNSW.
 - Residual energy shortfall significant in some historical weather years.



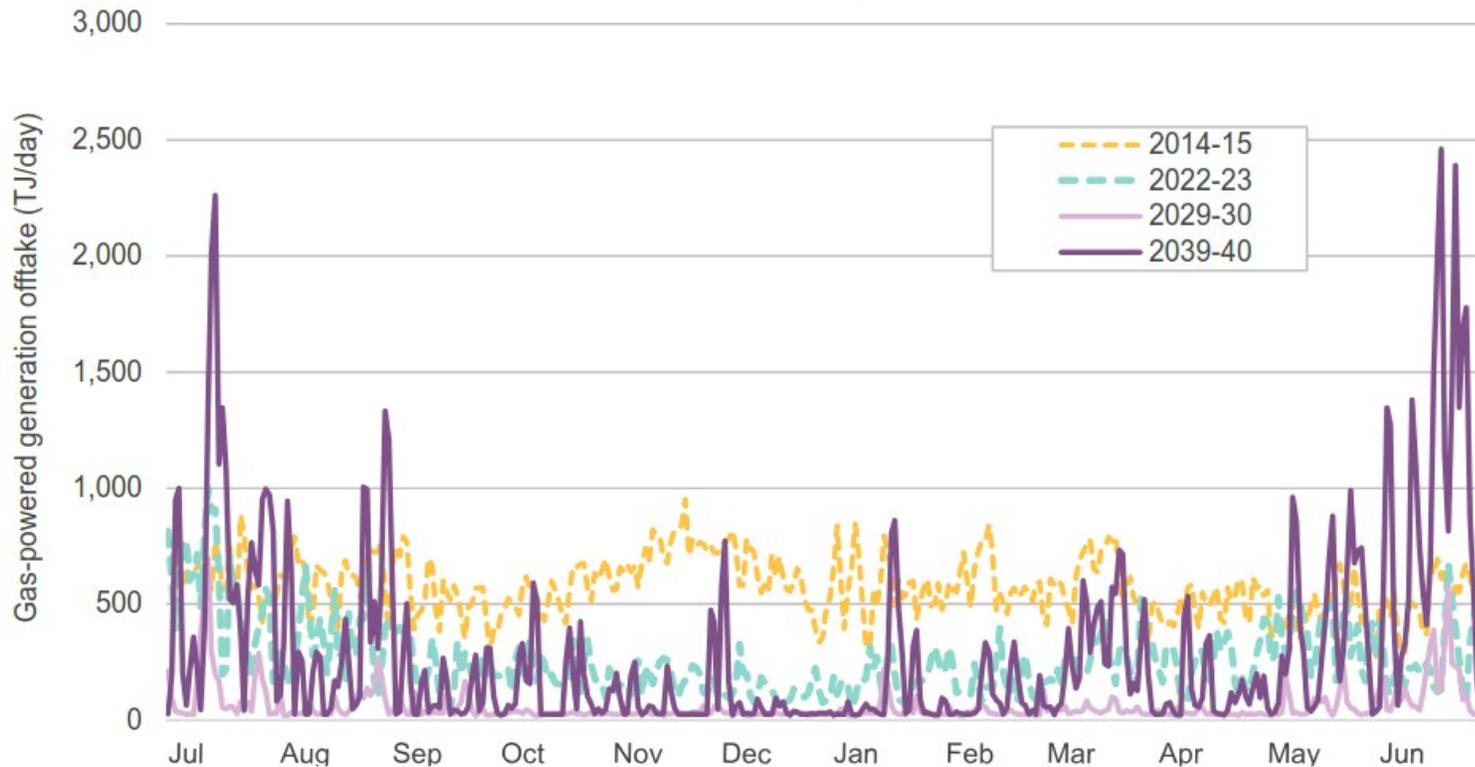
[Source: Analysis from Doug Richardson, UNSW - presented at “Roundtable: Keeping the Lights On.” 2025. 21st Century Weather and the CSIRO National Energy Analysis Centre., June 12. https://21centuryweather.org.au/wp-content/uploads/21stCenturyWeather_CSIRO-NEAC_Roundtable_SLIDES.pdf.]

Projected daily patterns

What might this look like on a daily level?

- Change from more continuous 'mid-merit' gas to a strategic, back-up role (which we've seen is already happening)
- Daily peaks in consumption from GPG considerably higher

Figure 23 Gas-powered generation offtake, NEM (TJ/day 2014-15 and 2039-40, Step Change)



[Source: AEMO. 2024. "2024 Integrated System Plan." Australian Energy Market Operator.

<https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp.>]

Projected daily patterns

What might this look like on a daily level?

- Lane et al (2025) simulated NEM operation based the inputs and results from the ISP
- Show distribution daily gas demands spreading substantially and largest demands growing significantly

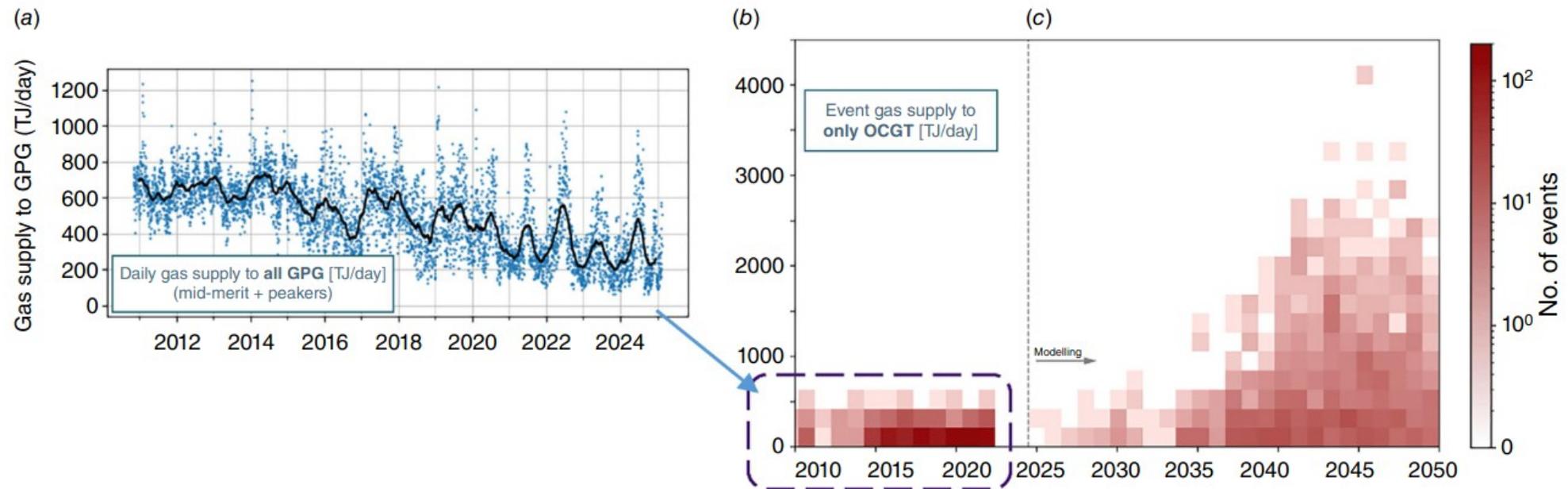


Fig. 1. (a) Historical trend of NEM-wide GPG activity, in terms of daily gas supply demands. (b) Peaker plant data only characterised in terms of discrete events. (c) Forward-looking results from our re-model of the ISP-2024 Step Change scenario, using one specific weather-scenario. GPG, gas-pPowered generation; OCGT, open-cycle gas turbine.

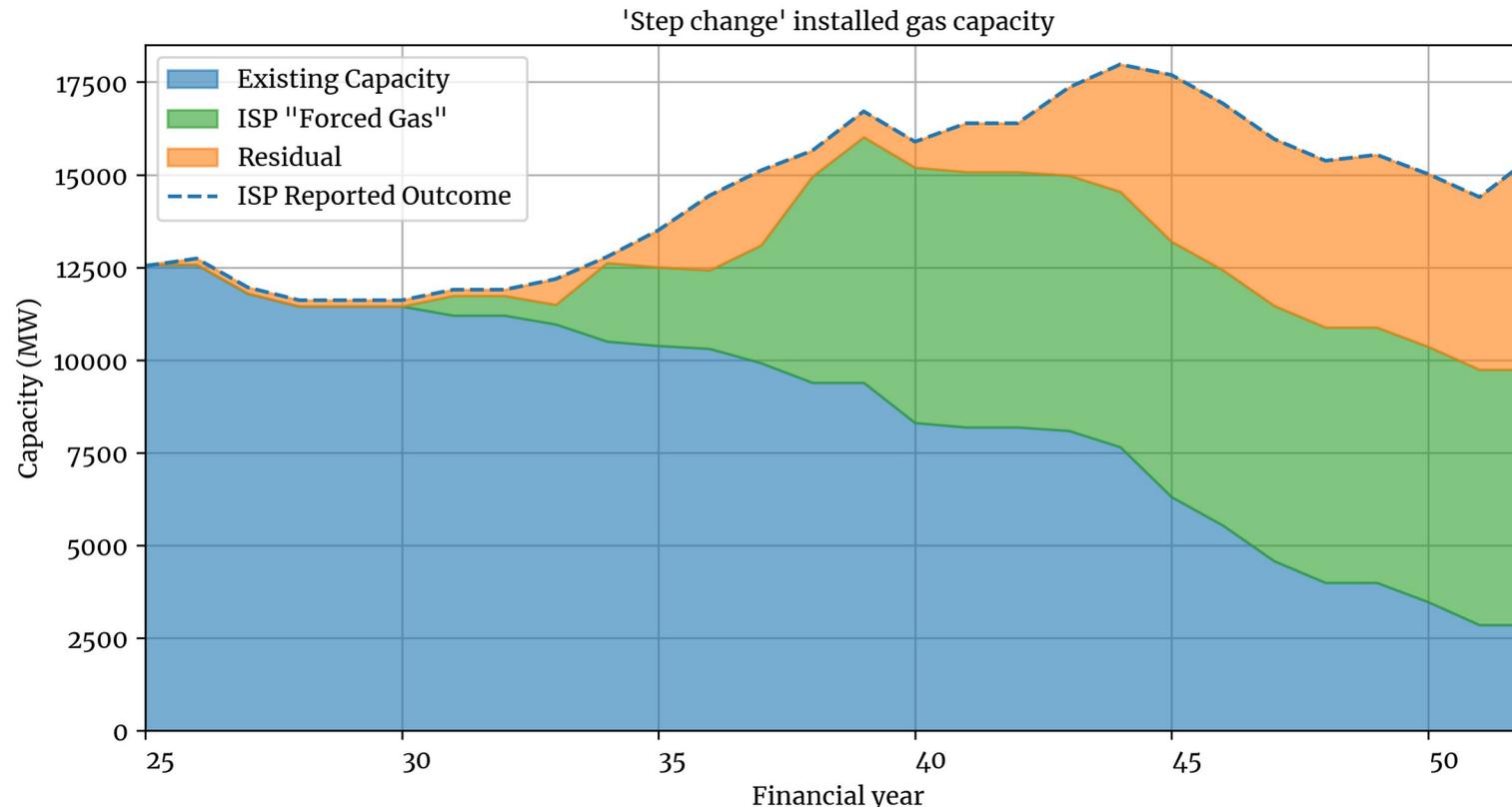
[Source: Lane, Joe, Iain Rodger, Andrew Garnett, and David Close. 2025. "Planning Challenges for the Changing Paradigm of Gas-Powered Generation Operations." *Australian Energy Producers Journal* 65 (2). <https://doi.org/10.1071/EP24237>.]

3. Questions, challenges and alternatives



What is actually driving gas capacity?

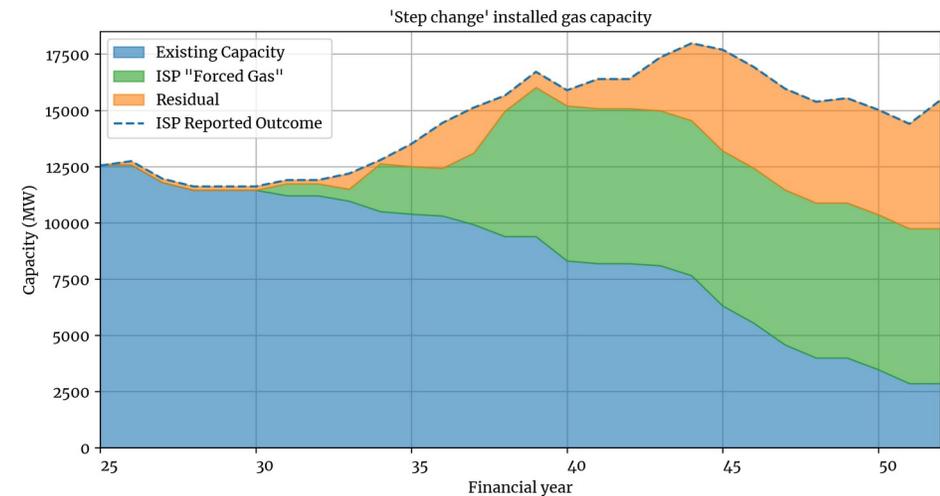
- **Is the projected gas capacity exogenous or endogenous?**
 - Much of the gas capacity in the 2024 is reflected in an **input** constraint (“Min Units Built”)
 - In step change as approximately 67% of OCGT capacity built throughout the modelling horizon in the ISP appears to be forced in via this constraint



[Source: Conor Rush-Fellay. 2025. "Transmission Planning & Investment in Australia: The Role and Potential Impact of the AEMC's Value of Emissions Reductions." Sydney, Australia: UNSW Sydney.]

What is actually driving gas capacity?

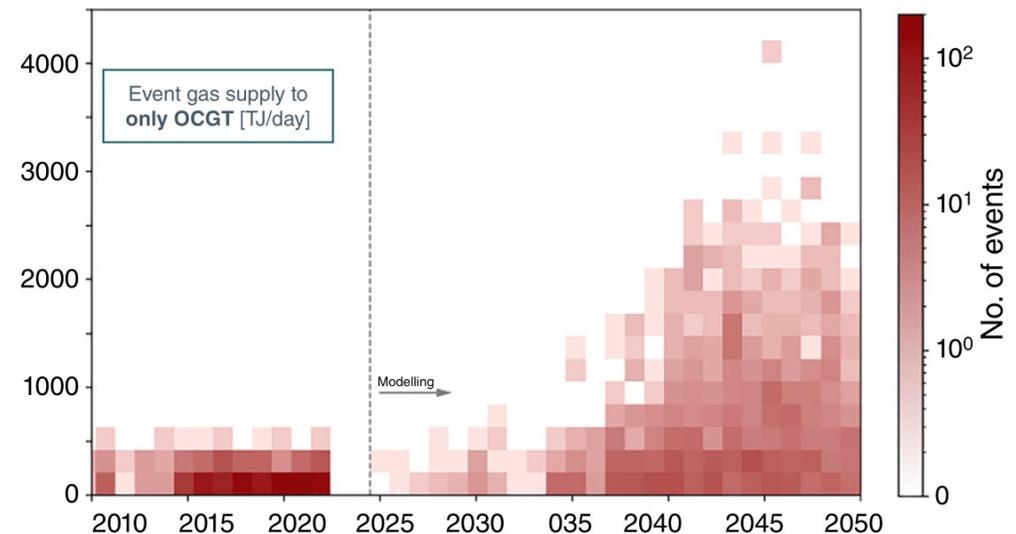
- The endogenous values are much closer to the 2022 ISP results
 - ~9GW ... coincidence?
- **Caveats!**
 - The interaction between constraints and modelled outputs is complex and difficult to unpick
 - There could be a good reason for this constraint!
 - We just don't know what it is, and couldn't find reference or explanation for it
 - Speculation: system security related? Perhaps – but would be good to know that (and consider alternatives)
 - This may have unintended consequences
- Side note: Wouldn't it be good if there were some kind of open-source, transparent modelling tool that allowed to to unpick and unpick these (undocumented?) constraints?
 - <https://github.com/Open-ISP> (work in progress)



[Source: Conor Rush-Fellay. 2025. "Transmission Planning & Investment in Australia: The Role and Potential Impact of the AEMC's Value of Emissions Reductions." Sydney, Australia: UNSW Sydney.]

Can the gas system deliver this?

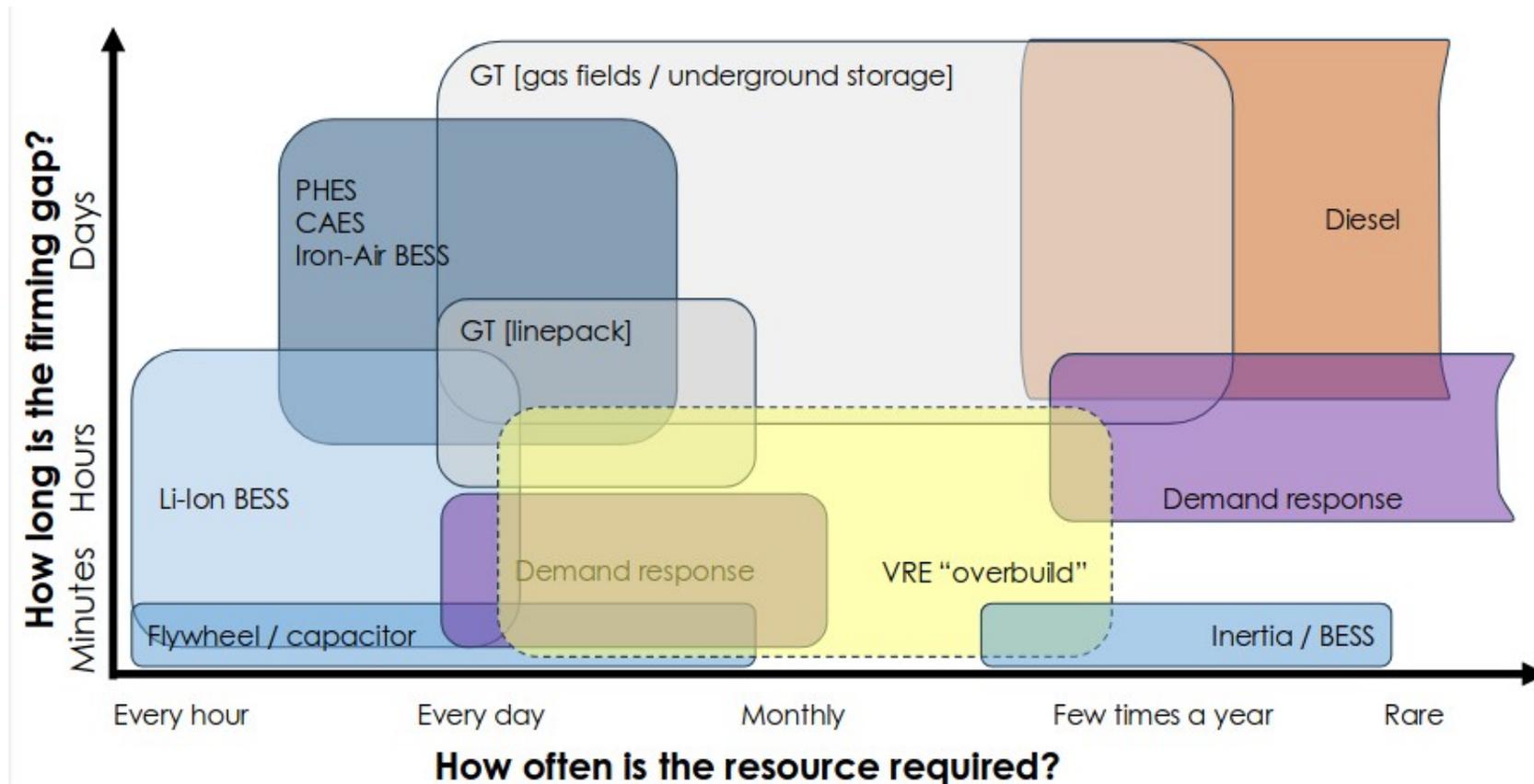
- **What was actually modelled?**
 - ...Not really the gas system!
 - Essentially assumes that GPG capacity and peak rates grow with reliable gas supply
 - Generally considered exogenous and not formally co-optimised
- **Challenges for upstream gas and pipeline:**
 - *"AEMO forecasts that if gas and electricity demands peak simultaneously, particularly during extreme conditions in winter affecting both electricity and gas demand, then there is a risk that gas supply to gas-powered generation may be curtailed by pipeline infrastructure constraints."*
 - *"..., developing on-site secondary fuel storages, and the infrastructure to refill them as needed, will be an important consideration for future gas generation developments to support power system reliability even when delivery of gas from the network is limited"*
 - One thing for an OCGT or reciprocating engine to have an operating profile like this
 - Quite another for upstream gas (including pipelines) to have to deliver this profile



[Source: Lane, Joe, Iain Rodger, Andrew Garnett, and David Close. 2025. "Planning Challenges for the Changing Paradigm of Gas-Powered Generation Operations." Australian Energy Producers Journal 65 (2). <https://doi.org/10.1071/EP24237>.]

Alternatives

- **A few time a year (or less) and days at a time?**
 - Looks like liquid fuels and demand response!
 - There are competitors for gas



[Source: Gilmore 2025. "Gilmore, Joel. 2025. "Firming a Low Emissions Grid." Presented at the NEM Review: Lunch and Learn, 21 March 2025]

Liquid fuel alternatives

- **What about diesel?**
 - Extremely dense form of energy storage!
 - We already store quite a lot of it (and if we manage to decarbonise transport, we may have spare capacity)
 - It is extremely cheap.
 - You don't need pipelines
 - you could build it where it suits the electrical network
- **Micro case study:**
 - Recently built 3x 30ML tanks at Viva refinery at Geelong as part of "Boosting Australia's Diesel Storage program"
 - About 3.5 PJ of primary energy
 - 386,000 MWh of electrical energy (through a reciprocating engine)
 - i.e. about equivalent to Snowy 2.0
 - Estimated to cost of ~\$75million
 - There is ~750ML capacity at Kurnell
 - Close to ~10 Snowy 2.0
- **A short note on emissions:**
 - The emissions impact of this is minor, in the scheme of both the NEM and national emissions – even if using diesel
 - There is likely to much more cost effective ways to reduce emissions than trying to solve this with (say) pumped hydro.



Photo from recent \$260 million "Boosting Australia's Diesel Storage program", which aims to build around 780ML across the county

Green liquid fuel alternatives

- **What about lower emissions alternatives?**

- Reason I am particularly interested in this is that there is likely to be other green liquid alternatives in the future for other uses (shipping and aviation). There are many options (including SAF, green methanol, ammonia, biofuels).
- This can be also used in reciprocating engines or OCGT at minimal (or no) cost

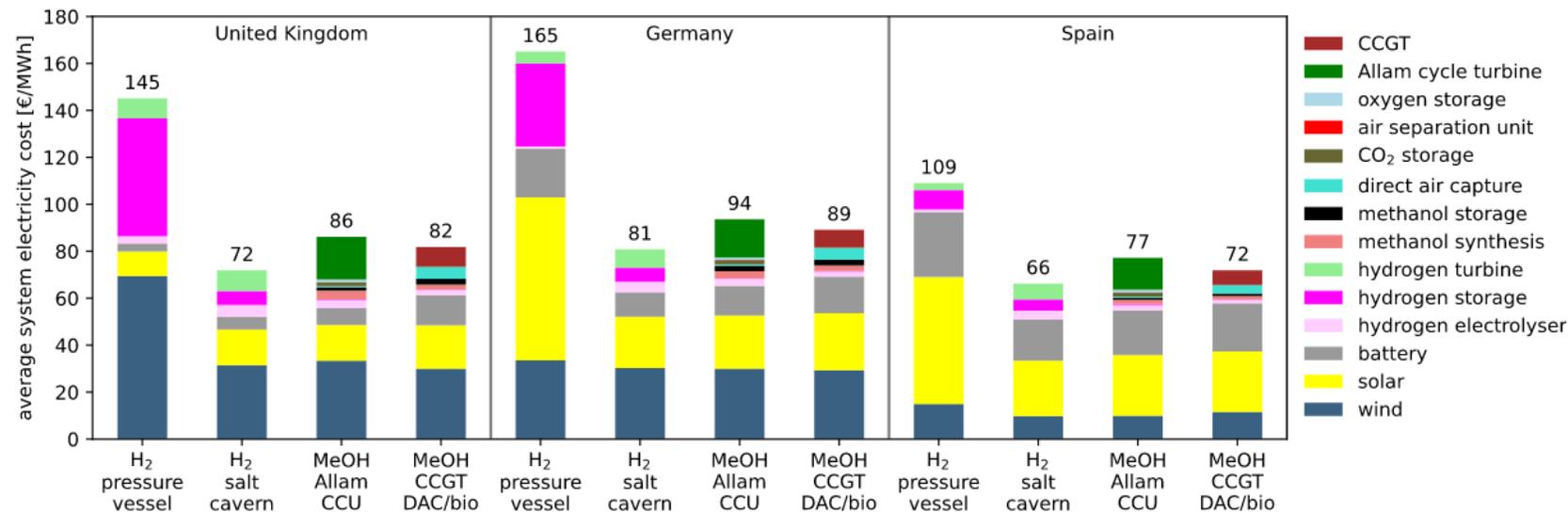


Figure 2. Average electricity costs for systems based on wind and solar

The first two scenarios use hydrogen (H₂) storage; the second two have methanol (MeOH) storage, the first with carbon cycled from an Allam turbine, while in the second, carbon dioxide is taken from direct air capture (DAC).

[Source: Brown, Tom, and Johannes Hampp. 2023. "Ultra-Long-Duration Energy Storage Anywhere: Methanol with Carbon Cycling." *Joule* 7 (11): 2414–20. <https://doi.org/10.1016/j.joule.2023.10.001>.]

4. Looking to the future



Integrated system modelling

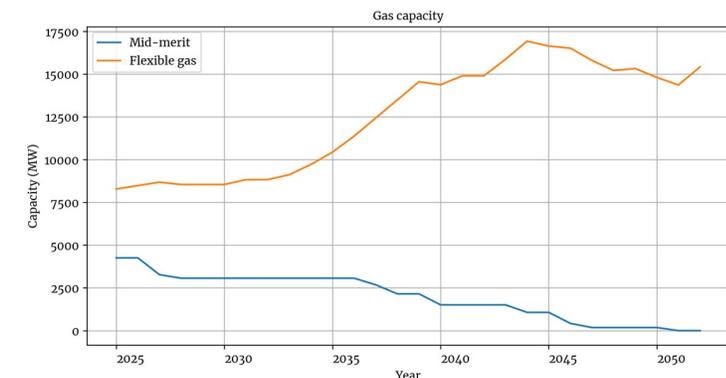
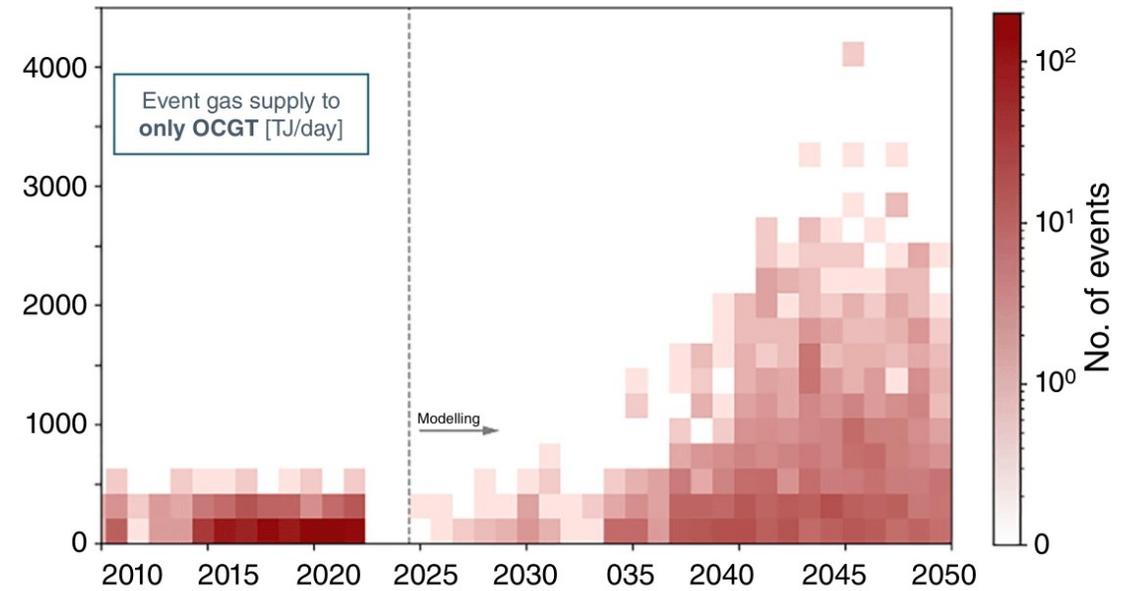
- **We do have an Integrated System plan!**
 - But historically not so integrated
 - Not well integrated with gas supply (or demand side, for that matter)
- **New changes in the 'pipeline':**
 - Changes to the NER as a result of the ISP Review mean that the contents of the ISP must now include 'gas development projections' which may include demand, prices, capacity of relevant facilities
 - AEMO proposes to incorporate gas development projections based on plausible gas development projections for ISP scenarios.
 - (though the development model will not attempt to provide an optimal development pathway for gas development given the aim of the ISP is to optimise electricity infrastructure investments)
- **This is an improvement but:**
 - The costs of these gas developments need to be appropriately compared against more alternatives:
 - Like liquid fuels!
 - (Including "green" ones)
 - Demand-side alternatives
- **Shameless plug:** perhaps need better, open-source, transparent modelling tools to help us investigate these options
 - (psa: PyPSA – model that sits behind openISP, has excellent 'sector coupling' capability).

Expanding definition of storage

- **The Integrating energy storage systems (IESS) into the NEM rule change introduced new framework for storage**
 - However, this is largely limited to battery storage (for example bi-direction units)
- **Some of the shortfalls of the pre-existing regime include:**
 - *Energy limit applies once over the whole trading day, rather than potentially multiple times within and across trading days*
 - *Model only applies to PASA and NEMDE Pre-dispatch, not NEMDE Dispatch and 5MPD*
 - *Model does not initialise to the current SCADA stored energy, but to the bid daily energy limit minus energy used since 0400 (based on dispatch targets)*
 - *Model does not recognise energy storage headroom limits*
- **The changing role of gas generation means these challenges may also apply to gas**
 - Moving to a more energy constrained system (rather than capacity constrained) means we should perhaps consider expanding the definition of what “storage” is, and what information is provided to the market
 - Gas (and coal) and just chemical forms of storage and perhaps should be included (and required to provide more granular “state of charge” as well).

Concluding comments

- **We do have some time...**
 - Expansion of gas capacity projected for >2035
 - A lot can change between now and then
 - We have a lot to do before then!
 - It is potentially a challenge, but is a challenge we can solve.
 - (imho there is a disproportionately high focus on this issue today)
- **Coming back to the title:**
 - *Great expectations - how do we align electricity sector needs with gas commercial realities?*
 - Perhaps we don't!
 - *Looking at changing electricity sector expectations, the modelling challenges in considering gas supply and the potential role of gas substitutes moving forward*
 - There are other alternatives and questions!



References

- Lane, Joe, Iain Rodger, Andrew Garnett, and David Close. 2025. *“Planning Challenges for the Changing Paradigm of Gas-Powered Generation Operations.”* Australian Energy Producers Journal 65 (2). <https://doi.org/10.1071/EP24237>.
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