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How much gas does the future grid need?

Analysing AEMO's Integrated System Plan

- *Despite featuring prominently in the narrative surrounding AEMO's 2024 Integrated System Plan, gas is forecast to play a reduced role in power generation for the National Electricity Market, and there are risks and uncertainties surrounding increased investment in gas.*
- *The need for gas power generation is expected to be below historic levels, and very small compared with the expansion of renewable generation and storage. As the role of gas narrows to focus on 'peaking' services, generators are expected to operate only 7% of the time on average.*
- *Gas is an expensive form of generation, and low utilisation rates will likely require gas generators to increase their prices even further. Meanwhile, batteries are seeing rapid cost reductions and are outcompeting gas in many jurisdictions.*
- *AEMO's forecasts are based on rapidly evolving assumptions, and carry inherent uncertainties, including the future frequency of 'low VRE' [variable renewable energy] events. This could further erode the profitability of gas generators.*

In the Australian Energy Market Operator (AEMO)'s 2024 edition of its Integrated System Plan (ISP), the role of gas received significantly more attention than it has in previous releases.

The 2024 ISP was released with the tagline: "Renewable energy connected by transmission and distribution, firmed with storage and backed up by gas-powered generation is the lowest-cost way to supply electricity to homes and businesses as Australia transitions to a net zero economy."

In this tagline, AEMO is referring to the fact that, although renewable energy is the least-cost form of new generation, 'firming' technologies are expected to be necessary to support renewables at times when wind and solar power output is low. This version of the ISP identified a role for gas power generation (GPG) to fulfill part of this need.

The ISP is a key planning document that lays out a pathway for the future of Australia's National Electricity Market (NEM). Some stakeholders have interpreted the 2024 ISP as affirming "the urgent need for investment in new gas supply and infrastructure".

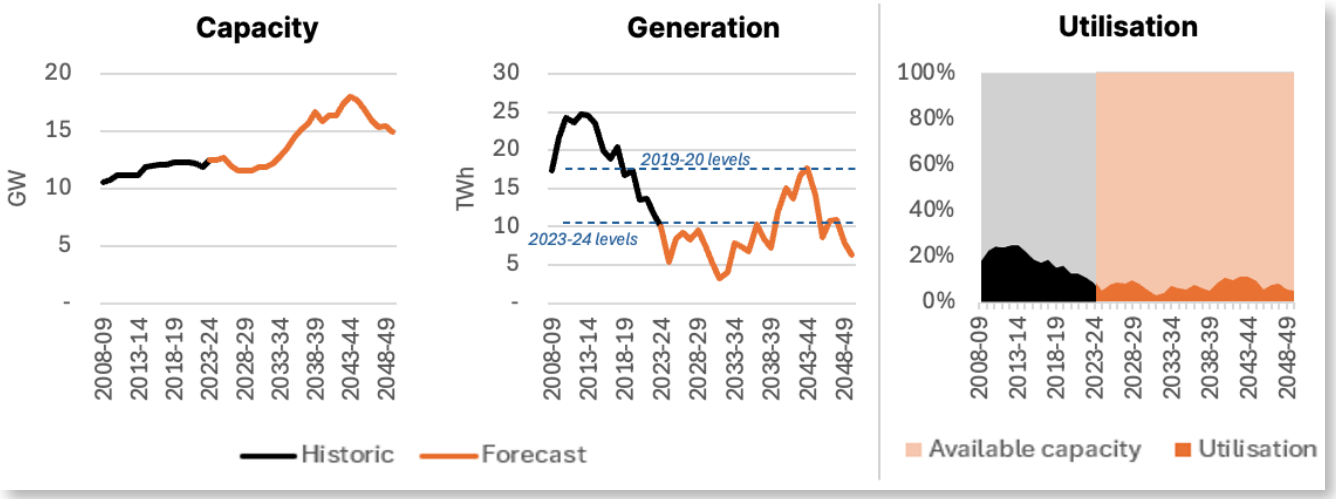
This briefing note seeks to unpack the analysis underlying the ISP, to understand just how much gas will be needed in the future grid, and the investments needed to support it.

Gas will be needed less frequently for power generation

Gas power generation makes up just under 20% of installed capacity in the NEM. It is one of the most expensive forms of electricity generation in the grid, but can increase or decrease output more quickly than other sources like coal.

When gas is needed, this tends to increase overall wholesale prices in the NEM. As a result, gas is not a preferred source of 'baseload' electricity, but tends to be called on only when needed – for example, to help meet evening peak demand.

Figure 1: Gas power generation forecasts in AEMO's 2024 ISP



Source: AEMO (utilisation calculated by IEEFA).

The three charts above display actual gas generation forecasts from the 2024 ISP. They show that from the mid-2030s, a steady increase in capacity (left) is forecast to be required.

However, the volumes of electricity generated from gas (middle) are not forecast to grow significantly. In fact, they sit at or below historic levels. Even during a brief resurgence forecast around 2039-45, AEMO does not expect gas generation to exceed levels seen in 2019-20.

The combination of these two graphs tells us that average GPG utilisation (right) is expected to remain broadly lower than historic levels. On average, gas generators are expected to be used 7% of the time between 2024-50, compared with an average of 19% between 2008-24.

As AEMO puts it, there will be "a change in the role of gas-powered generation from more continuous 'mid-merit' gas to a strategic back-up role", and that "A typical gas generator may generate just 5% of its annual potential, but will be critical when it runs."

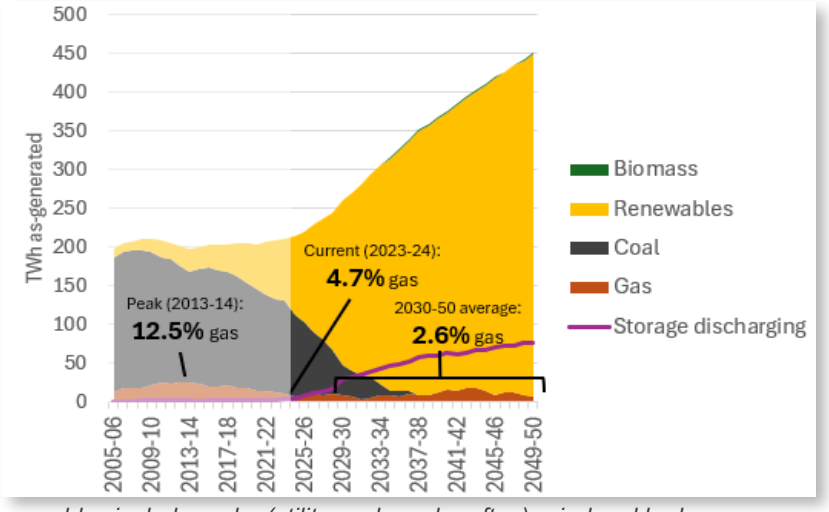
In other words, though the ISP forecasts the need for some new gas generators, their operators will need to be prepared for the reality that these facilities will sit idle for a large portion of the time – more so than in the past.

AEMO also distinguishes between 'mid-merit' and 'flexible' gas generators. 'Mid-merit' capacity follows a steady decline as it is less suited to operating at the very low utilisation rates required by AEMO's forecasts.

This evolving, and decreasing, role of gas in the NEM is best illustrated in Figure 2 below, which shows the total share of generation forecast by fuel type in AEMO's ISP.

Gas is expected to diminish from around 4.7% of total annual generation today, to an average of 2.6% across 2030-50. This is roughly one fifth of the historic maximum share of gas in the NEM, 12.5%, which occurred in 2013-14.

Figure 2: Generation mix in the NEM, *Step Change*



Source: AEMO. Note: Renewables includes solar (utility-scale and rooftop), wind and hydro.

Renewable energy has already taken over a considerable portion of the market share of both coal and gas. Going forward, AEMO expects renewable energy will continue to displace coal, while also scaling to meet new sources of electricity demand. From the mid-to-late 2020s, there is a ramp-up in firming technologies that are critical to support high levels of renewable energy. Most of this is met by storage (including battery storage and pumped hydro), with a small contribution from gas.

As AEMO puts it, the ISP "provides for the gas generation that is needed, and renewables are far cheaper for any additional need".

How certain are AEMO's gas generation forecasts?

The precise peaks and troughs in AEMO's forecasts must be taken with a grain of salt. The future utilisation of gas generation will be highly weather-dependent, as it increasingly serves as a back-up source of generation during periods of low variable renewable energy (VRE) output.

In particular, gas is one of a small set of technologies suitable to provide back-up generation during particularly prolonged periods of low VRE output. AEMO describes these periods as "VRE droughts".

These periods are characterised by low, but not no, VRE. The NEM is one of the world's largest interconnected electricity grids, covering a very broad range of climates and diverse VRE resources. This makes it highly unlikely that the NEM will experience periods where no VRE is available anywhere in the system.

AEMO itself has cautioned that "These extended VRE 'droughts' are rare and, over the long term, extremely difficult to predict in duration and intensity."

While it is possible that actual gas utilisation could be higher than what is forecast by AEMO, it is conversely possible that low VRE periods occur less frequently than AEMO expects, leading to even lower utilisation rates.

For example, researchers from Griffith University conducted modelling based on 42 years of real-world weather data, concluding that "we do not find evidence of extended time periods of low VRE production in the NEM", and that "A 30% reduction in expected energy [generation from renewables] is therefore the worst two-week historical VRE drought on record."

Additionally, to ensure the ISP maintains system operability under extreme conditions, AEMO has undertaken 'what-if' analysis that involves "applying some of the most severe weather conditions observed historically and extending their duration significantly", to test the resilience of the ISP's optimal development pathway (ODP). This led to the finding that "the ODP has demonstrated resilience to extreme weather conditions."

This demonstrates that although a scenario where low VRE periods are more frequent than expected could result in higher gas utilisation rates, it would not necessitate any need for more gas capacity.

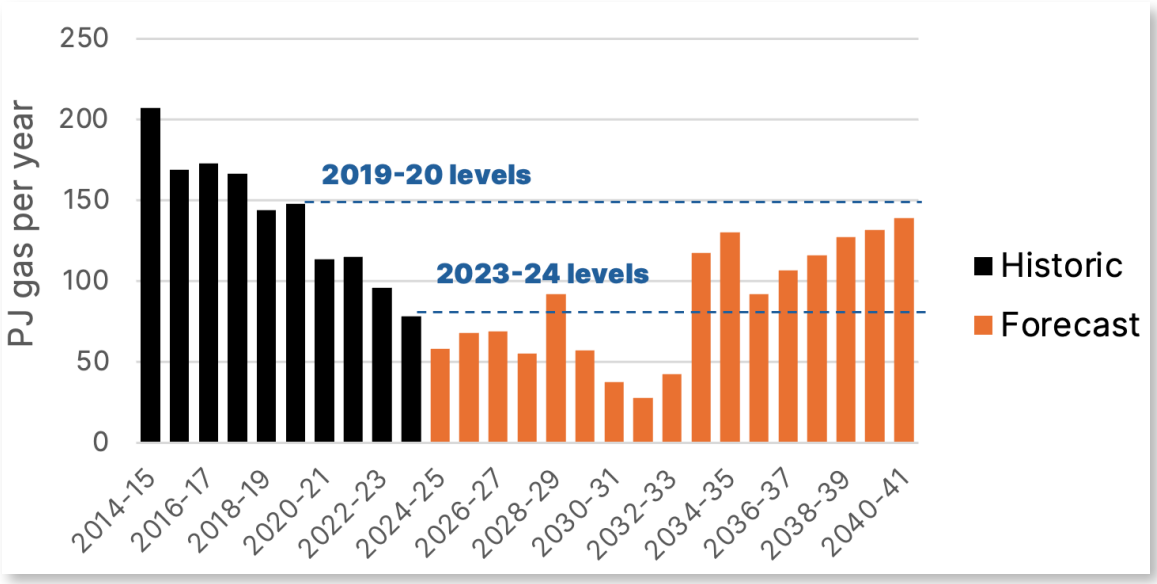
East coast gas demand is expected to decline

Some respondents have interpreted AEMO's ISP to not only signal a need for new investment in gas generation capacity, but for new investment in upstream gas supplies in Australia's east coast market.

AEMO's forecast of gas consumption requirements for GPG are shown in Figure 3 below. As expected, this broadly mirrors the generation requirements shown above in Figure 1.

Gas demand for power generation is forecast to remain below current levels (with one outlier in 2028-29) until the mid-2030s. After this point, consumption is expected to increase, though not beyond 2019-20 levels.

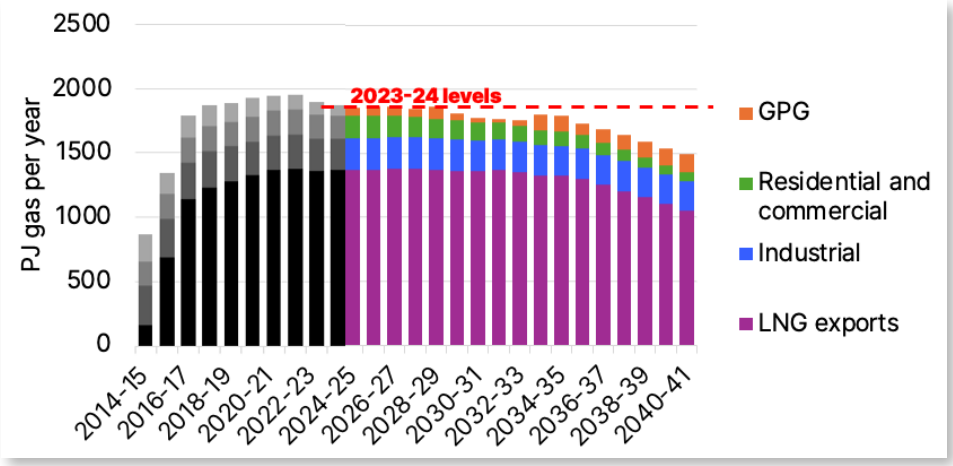
Figure 3: Forecast gas consumption for power generation, 2024 ISP



Source: AEMO (with historic years from 2014-18 added from AEMO's gas forecasting portal). Note: AEMO has not provided GPG consumption forecasts beyond 2040-41. However, as observed above, GPG is forecast to decline from the mid-2040s.

However, power generation is just one end-use of gas, accounting for only 4% of east coast market demand today. AEMO provides forecasts for other end-use sectors, as well as projected LNG exports, via its Gas Statement of Opportunities (GSOO). These are shown alongside GPG below, revealing an overall declining forecast.

Figure 4: Forecast domestic gas consumption and LNG exports, *Step Change*



Note: GPG forecasts are taken from the 2024 ISP (released in June 2024), while all other forecasts are taken from the 2024 GSOO (released in March 2024). GSOO forecasts are taken from AEMO's forecasting portal, where financial year consumption is assumed to be the midpoint of consumption in adjacent calendar years.

The table below breaks down several key features of these forecasts:

Residential and commercial demand	Residential and commercial gas consumption is forecast to decline. This is expected, given that AEMO's forecasts are informed by least-cost economic modelling, and electrification of gas use in buildings, particularly households, is largely considered cost-effective today.
Industrial demand	Industrial gas consumption is forecast to remain stable. This appears to conservative compared with alternative modelling. For example, modelling that AEMO commissioned from CSIRO and Climateworks Centre to inform the 2024 ISP found that cost-effective electrification and fuel-switching opportunities could lead to a decline in industrial gas demand.
LNG exports	LNG exports account for the vast majority of fossil gas produced in Australia. AEMO's forecasts are based on LNG industry surveys to 2035, and broadly remain stable over this period. After this, they are expected to decline due to global decarbonisation efforts. Notably, according to data from ICIS LNG Edge, most Queensland LNG producers have entered into supply contracts that expire in 2035 (though Santos's Gladstone LNG (GLNG) project has some contracts due to expire in 2030 with the option of a five-year extension). Recent IEEFA analysis also observed that long-term global LNG demand forecasts have declined substantially in recent years, with declines in mature markets and significant uncertainties around emerging market growth.
Gas power generation	Power generation is the only sector where gas demand is eventually forecast to increase. However, by the time this increase starts to occur in the 2030s, it is more than offset by reductions in other end-uses.

Despite this declining outlook, AEMO has warned that current and committed gas supplies are not adequate to meet forecast gas demand. Notably, AEMO does not consider opportunities to reduce demand, which IEEFA has found is a more cost-effective way to mitigate either annual or peak day excess gas demand events.

However, AEMO's forecasts reveal the considerable risks associated with investing in new gas supplies for the purpose of supporting power generation.

Gas demand in the east coast market appears likely to decline, though the pace of that decline is uncertain, and GPG is not the strongest driver of demand.

The gas industry faces a challenge of how to minimise the risk of over-investment. This is a material risk, given that segments of the gas industry are already grappling with significant stranded asset risks.

While AEMO has forecast a modest rise in gas demand for power generation from the mid-2030s, investors seeking to capitalise on this demand will need to navigate the risks that:

- LNG exports could decline faster than forecast by AEMO, if Santos GLNG does not extend its contracts.
- Industrial demand may decline faster than forecast by AEMO.
- GPG demand will depend on the frequency of low VRE periods, which is uncertain.
- Costs of competing technologies such as batteries continue to fall rapidly, occupying more of gas power generation's market share by the mid-2030s.

Expanding pipelines to support gas generation is not economical

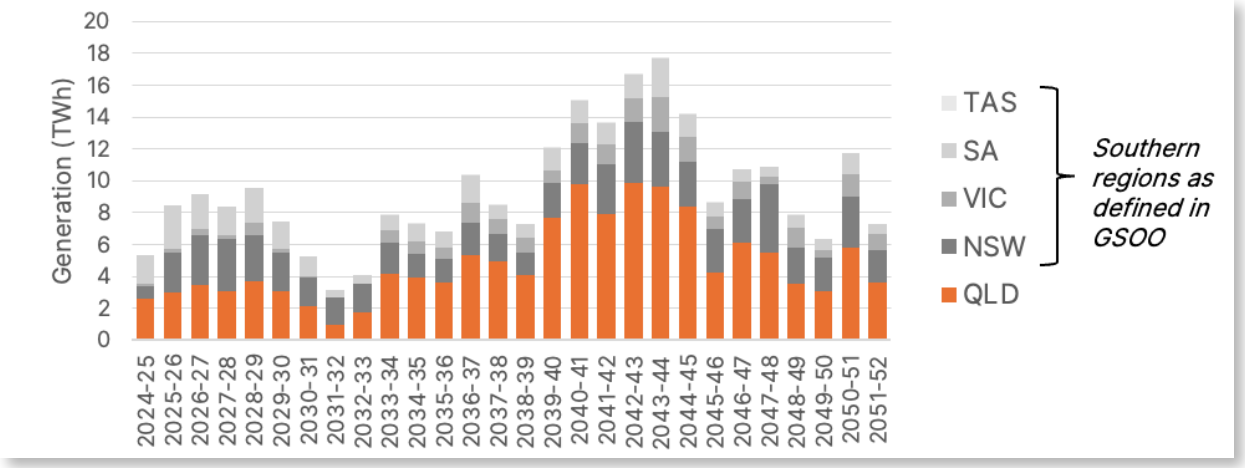
This discussion has so far focused on overall gas demand across Australia's east coast market. However, an important regional dynamic of this market must be addressed.

Increasingly, most gas production on the east coast is located in Queensland, and gas supplies in southern regions are being depleted. This creates challenges as southern regions are expected to become more reliant on Queensland gas.

As shown in Figure 5 below, just over half of the cumulative gas generation in AEMO's forecasts is expected to occur in Queensland, and should not be impacted by this dynamic.

However, meeting the needs of the other 49% could require more gas to be transported to southern regions via pipelines that are, at present, physically constrained during winter peaks in demand.

Figure 5: Gas generation by NEM region, *Step Change*



Source: Generation outlook data from the Optimal Development Pathway of AEMO's 2024 ISP.

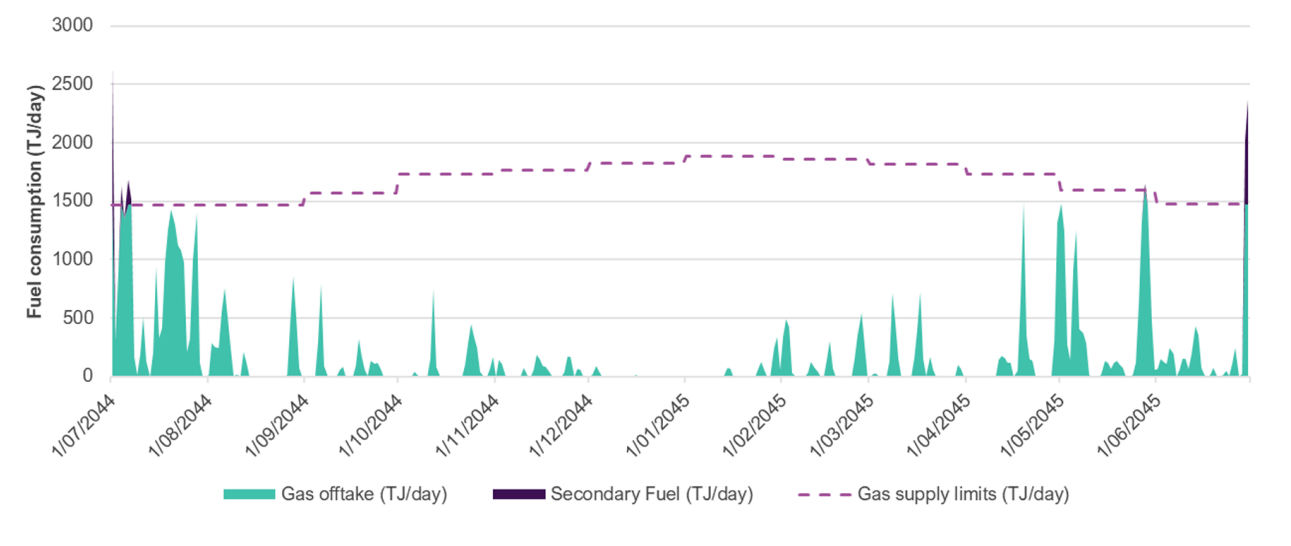
Several stakeholders including IEEFA identified a flaw in the modelling of gas generation in AEMO's Draft 2024 ISP. The modelling had assumed adequate gas would be available to gas generators at sustained low prices, without considering supply constraints.

Analysis behind Australia's Future Gas Strategy found that expanding gas supplies to serve southern demand would require "significantly more investment in exploration and development", and that new pipelines would likely involve "long lead times and high costs".

AEMO acknowledged this shortcoming in the final release of its 2024 ISP. It was addressed via an additional piece of analysis that looked at whether adequate supplies exist to deliver the gas required by generators, given the "current production and delivery limitations of the east coast gas system".

AEMO found that supplies were inadequate – but only a fraction of the time. In Figure 6, AEMO shows that in the representative year of 2044-45, gas offtake for power generation would exceed daily supply limits on only a handful of winter days, when gas demand for GPG competes with demand for gas in buildings.

Figure 6: Forecast daily gas and secondary fuel (diesel) consumption from GPG in southern NEM, Step Change, reference year 2011



Source: AEMO. Events where GPG gas offtake exceeds supply limits are annotated in red by IEEFA. Note: Equivalent charts are unavailable for other projection years.

This presents a challenge, as it would not be economical to expand the capacity of gas supplies to accommodate such infrequent peak demand capacity for GPG.

Instead, AEMO has determined that "fitting GPG with sufficient on-site storage for liquid fuels […] is the most economically efficient pathway". Gas turbines can generally run on liquid hydrocarbon fuels like diesel as well as gas, so these stores could be drawn on to supplement gas use during peak events.

Burning diesel to operate a gas turbine is not an ideal solution. Diesel is more expensive and more emissions-intensive than fossil gas. However, given the very small portion of times it will be required, and the uncertainty of just how infrequently these peak events are likely to occur, it is a far more economical and less risky alternative to building out additional pipeline capacity.

In future, it is possible that some diesel could be swapped for alternative fuels including biofuels.

Gas generation forecasts are subject to change

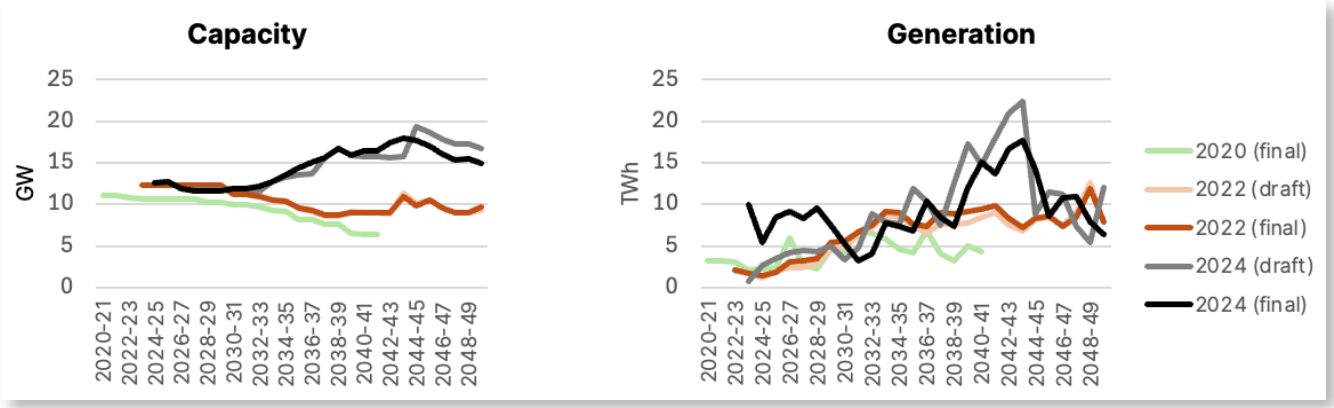
The low volumes of gas generation in AEMO's forecasts do not negate the important role that it is filling. Under a high-renewable grid, there is indeed a critical need for 'firming' technologies to support the grid at times when renewable output is low.

AEMO's 2024 ISP presents one particular view of a least-cost technology mix that meets these needs, based on a chosen set of input assumptions. However, these forecasts tend to change over time as assumptions and modelling approaches evolve.

In previous iterations of AEMO's ISP Step Change forecasts, gas generation projections varied considerably. Previous ISPs did not include the temporary resurgence in gas generation in the early 2040s that is a key feature of the 2024 ISP, and as a result, they forecast considerably lower gas capacity requirements.

In IEEFA's submission to the 2024 Draft ISP, we commented on this effect, including some of the likely changes in assumptions that sat behind it, which did not necessarily reflect more up-to-date knowledge.

Figure 7: Evolution of gas power generation forecasts by ISP release



Source: Generation outlook data from AEMO 2020, 2022 (draft / final) and 2024 (draft / final) ISPs. 2020 forecasts taken from Step Change 'least-cost' development pathway. All other forecasts taken from Step Change optimal development pathway.

This is an important reminder that the ISP does not project the level of gas needed in the NEM. Rather, it projects what is economical given a particular set of input assumptions.

Illustrating this point, AEMO explains that in 2024 it "considered alternative pathways that excluded GPG expansion. In such a future, significantly more medium duration storage and renewable energy generation was required to substitute for flexible gas, leading to higher overall electricity system costs."

In other words, some of the projected role of gas generation in the NEM could be filled by other technologies, including more renewable generation and medium-duration storage, but this wasn't determined to be economical.

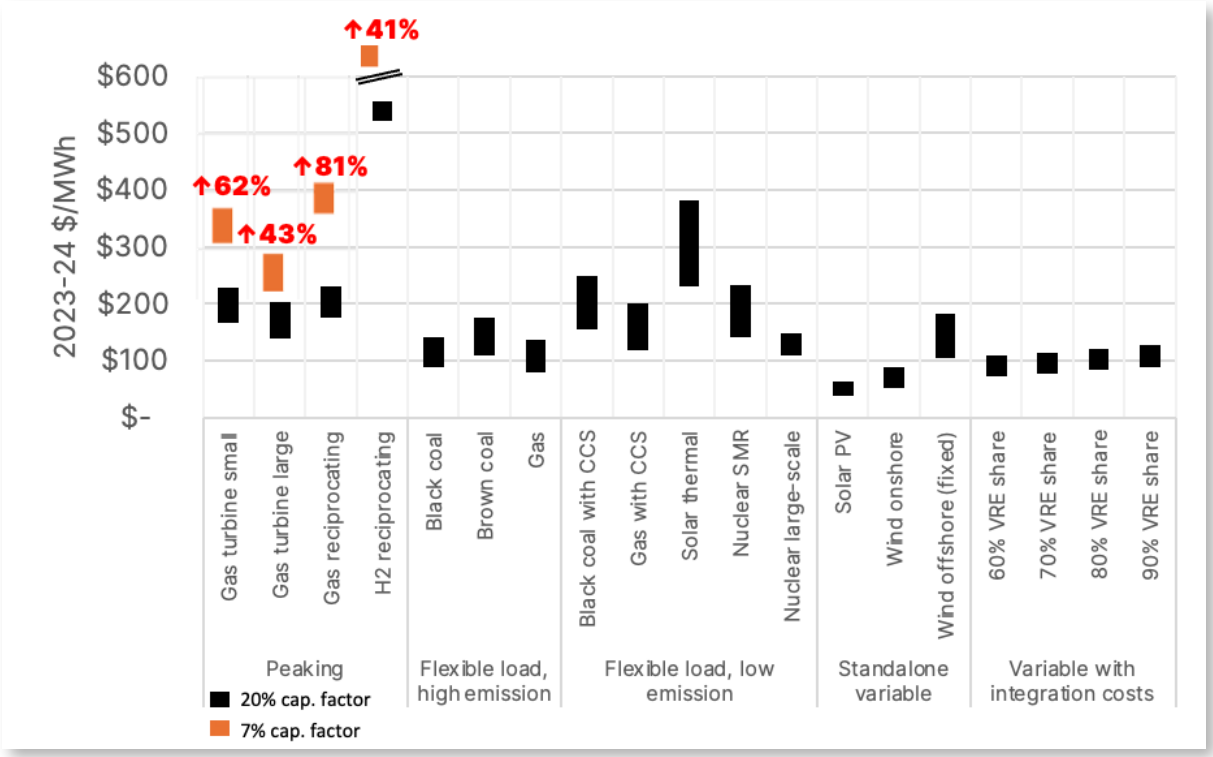
However, if the costs of competing technologies fall below AEMO's forecasts, or if unforeseen global events similar to Russia's invasion of Ukraine were to elevate gas prices above AEMO's generally low forecasts, the outlook for gas generation may well appear different in future ISPs.

Gas generators face strong competition

Peaking gas is one of the most expensive forms of generation, even if used under a high average utilisation rate ('capacity factor') of 20%.

If utilisation rates fell to 7%, as forecast by AEMO, gas generators would need to recover more of their fixed costs per unit of electricity, resulting in higher prices. This could result in a levelised cost of electricity (LCOE) that is 41%-81% above CSIRO's forecast levels by 2030.

Figure 8: Levelised cost of electricity (LCOE) by technology, 2030



Source: CSIRO 2023-24 GenCost. 7% capacity factor results calculated by manually updating input assumptions in the GenCost appendix workbook.

These low utilisation rates may challenge the profitability of gas generators. More significantly, however, they create a strong opportunity for other technologies to compete with gas.

Batteries

Batteries are one of the most significant competitors to gas generators, and their costs are rapidly declining.

In just over three years, batteries have grown from a near-zero market share in California's grid, to taking over most of gas's evening peak role. Similar trends are beginning to occur in South Australia, where batteries have provided more than 20% of peak demand on record days. Batteries are steadily chewing away at the market for gas generation.

Recent investments in large batteries in Australia include a 240 megawatt (MW) / 1 gigawatt-hour (GWh) expansion of Origin Energy's battery at Eraring, and the approval of a 500MW/1.5GWh battery in South Australia's limestone coast. New battery installations in 2024 are expected to exceed the record levels set in 2023.

S&P Global forecasts new energy storage capacity will be higher than AEMO's forecasts, and that gas capacity expansion will be much lower (3GW by 2050, compared with AEMO's 12.8GW).

Other storage technologies

Non-battery storage technologies may also compete with gas for firming services.

AEMO's ISP assumes the completion of current pumped hydro storage projects such as Snowy 2.0 and Borumba. However there is uncertainty surrounding future pumped hydro developments, and recent storage tender results in New South Wales indicate that alternative technologies can compete for long-duration storage.

Some proponents have suggested repurposing decommissioned coal mines to act as pumped hydro generators – however, IEEFA's research has found these proposals carry significant risks.

IEEFA has also identified opportunities to make better use of existing hydro resources – such as optimising the Tasmanian energy system and its interconnection with Victoria to provide firming services to the mainland grid.

Demand management

Although not fully explored in AEMO's ISP, electricity demand can be shifted away from peak times, avoiding the need for expensive firming solutions such as gas.

Demand management is emerging as a central strategy for some of Australia's largest energy businesses. Origin Energy has enrolled more than 100,000 customers to its 'Spike' program, which rewards residential customers for providing demand response services, and AGL expanded its demand flexibility programs by 127% between FY23 and FY24.

There is a particularly large untapped potential for greater flexible demand capacity to be unlocked via flexible electrification of hot water systems.

A significant advantage of demand management is that, contrary to gas generation, it reduces wholesale costs for consumers.

Alternative fuels

Some gas generators are likely to be operable with various levels of alternative fuels – including biofuels or hydrogen.

Biofuels face supply constraints, but could play a small-scale role, including as a back-up during capacity-constrained peak days.

Many new gas generators claim to be 'hydrogen-ready' – however, in some cases such plants are only compatible with low percentage blends of hydrogen alongside fossil gas.

IEEFA analysis in the United States found that due to high costs and constraints, 'hydrogen-ready' turbines would most likely rely heavily on fossil gas for the foreseeable future. This has been the experience of the 'hydrogen-ready' gas generation facility in Kurri Kurri.

Conclusion

While the ISP does forecast a steady increase in installed gas power generation capacity, it does not provide a clear, risk-free signal for greater investments in gas.

The contribution of gas towards total generation in the NEM is expected to be modest in comparison with historic levels, and tiny in comparison to the expansion of renewable generation and storage.

Although the ISP forecasts that an increase in gas demand for power generation may occur from the mid-2030s, this increase only represents a return to recent historic levels, and is likely to be offset by decreases in gas consumption in other end-use sectors.

There may, occasionally, be winter days where infrastructure limits constrain the amount of gas available to gas generators in southern regions. However, AEMO's analysis shows that the use of back-up liquid fuel reserves is likely to be a more economical option than expanding pipeline capacity. In future, alternatives such as biofuels could fulfill this small role.

Furthermore, there is a considerable range of risks and uncertainties surrounding AEMO's forecasts.

As the niche for gas power generation steadily narrows to focus on 'peaking' services, its utilisation is expected to become increasingly weather-dependent. A key driver of utilisation of gas generation is the frequency and severity of low VRE periods. However, AEMO has acknowledged that these are highly uncertain and difficult to forecast.

AEMO's gas generation forecasts have also varied considerably between different versions of the ISP, and are sensitive to input assumptions that are rapidly evolving. Of particular significance is the ongoing decline in costs for competing storage technologies, which is already impacting the role of gas in some jurisdictions. This could impact the already-fragile profitability of gas generators forced to operate at low utilisation rates.

Finally, there are also broader risks around overinvestment in new gas supplies in the east coast market, if overall demand were to fall faster than AEMO's forecasts.

Investors ought to look beyond the narrative of AEMO's ISP, and approach its gas generation forecasts with a high degree of caution. Gas generation investment opportunities may not be as significant or low-risk as they appear.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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