The role of gas in the transition to net-zero power generation – Summary

Prepared for the Australian Gas Industry Trust and Jemena | 8 November 2021

Summary

Box 1: Key messages

We find that in an electricity system increasingly transitioning to intermittent renewable generation, gas-powered generation (GPG) is the least cost way to add capacity to the predicted mix of generation and storage in 2025. This finding holds when we include a carbon price equal to either the average Australian or average European price of carbon credits in 2020/21.

Our finding is based on our estimates of the Whole of Electricity System Cost (WESC), which accounts for the characteristics of generation and storage capacity that the system needs to maintain reliability and stability. In contrast, estimates of the Levelized Cost of Electricity (LCOE), which are often used to compare the relative costs of generation and storage technologies, do not account for the extent to which each generation and storage technology contributes to reliability and stability. This means that LCOE does not account for the full cost to the system of investments.

Our estimates of WESC also indicate that the flexibility and dispatchability provided by GPG becomes more valuable to the system over time, as the system increasingly transitions to intermittent renewable generation.

The key messages of our report are the following:

- The operation of GPG has changed substantially in the NEM and WEM over the past two decades. On all the measures we consider, GPG is maintaining its role in generating to meet peak demand and as a bulk energy provider (although GPG output overall is trending downward). However, GPG is also operating increasingly flexibly around intermittent renewable generation. For instance, over recent years the trend in the NEM has been for GPG to start more often, but to operate for shorter periods of time once started.
- Requirements for flexible generation, which include gas, hydro and storage, will continue to increase as the penetration of intermittent generation increases.
- AEMO's recent forecasts of GPG have tended to significantly under-forecast GPG output. Our analysis suggests that the pattern of AEMO under-forecasting GPG output is likely to persist with the 2020 ISP forecasts. In other words, the actual need for GPG is likely to be greater than forecast in AEMO's 2020 ISP.
- Our analysis of the relative costs of different generation and storage technologies suggests that GPG will have an important ongoing role to play in the NEM. It is a mistake to think that investing in generation or storage technologies with the lowest LCOE will necessarily result in the lowest electricity system cost. The broader system benefits delivered by investing in generation or storage technologies that are flexible and dispatchable can deliver lower electricity system costs. We see this in our analysis of the NEM: we find investment in GPG delivers the lowest electricity system costs because the

flexibility and dispatchability provided by GPG are characteristics that are valuable, and becoming more valuable, in the NEM.

- While gas prices are a key driver of the cost of operating GPG, the evidence suggests that changes in gas prices are unlikely to be a key driver of dispatch of GPG.
- In electricity markets with a much bigger share of intermittent renewable generation than the NEM – such as Germany, Texas and the UK – GPG continues to play an important role in the electricity market.

The generation mix in Australia's electricity markets has changed significantly in the last decade, and is expected to continue to evolve over coming decades. Renewable generation has grown substantially, and is expected to come to dominate generation over coming decades. At the same time, the coal-fired generators that Australia's electricity markets have historically relied upon have become increasingly uneconomic.

We have been engaged by the Australian Gas Industry Trust and Jemena to assess the likely role of gas-powered generation (GPG) in Australia's electricity markets in coming decades. In doing so, we consider the role that GPG can play in providing electricity, firm capacity and system stability, and consider how GPG compares with other technologies in meeting the needs of Australia's electricity markets.

As part of this project, we have undertaken the following analysis:

- An historical analysis of the role of GPG in Australia's electricity markets.
- A critical assessment of the forecasts for declining GPG from the Australian Energy Market Operator's Integrated System Plan.
- An assessment of WESC for different generation and storage technologies available in Australia's electricity markets, and what this suggests about the value of GPG.
- Consideration of the sensitivity of GPG output to gas prices.
- A survey of the role that GPG plays in electricity markets in other jurisdictions.

This summary report provides a summary or our findings. More detail is provided in the detailed report provided to accompany this summary report.

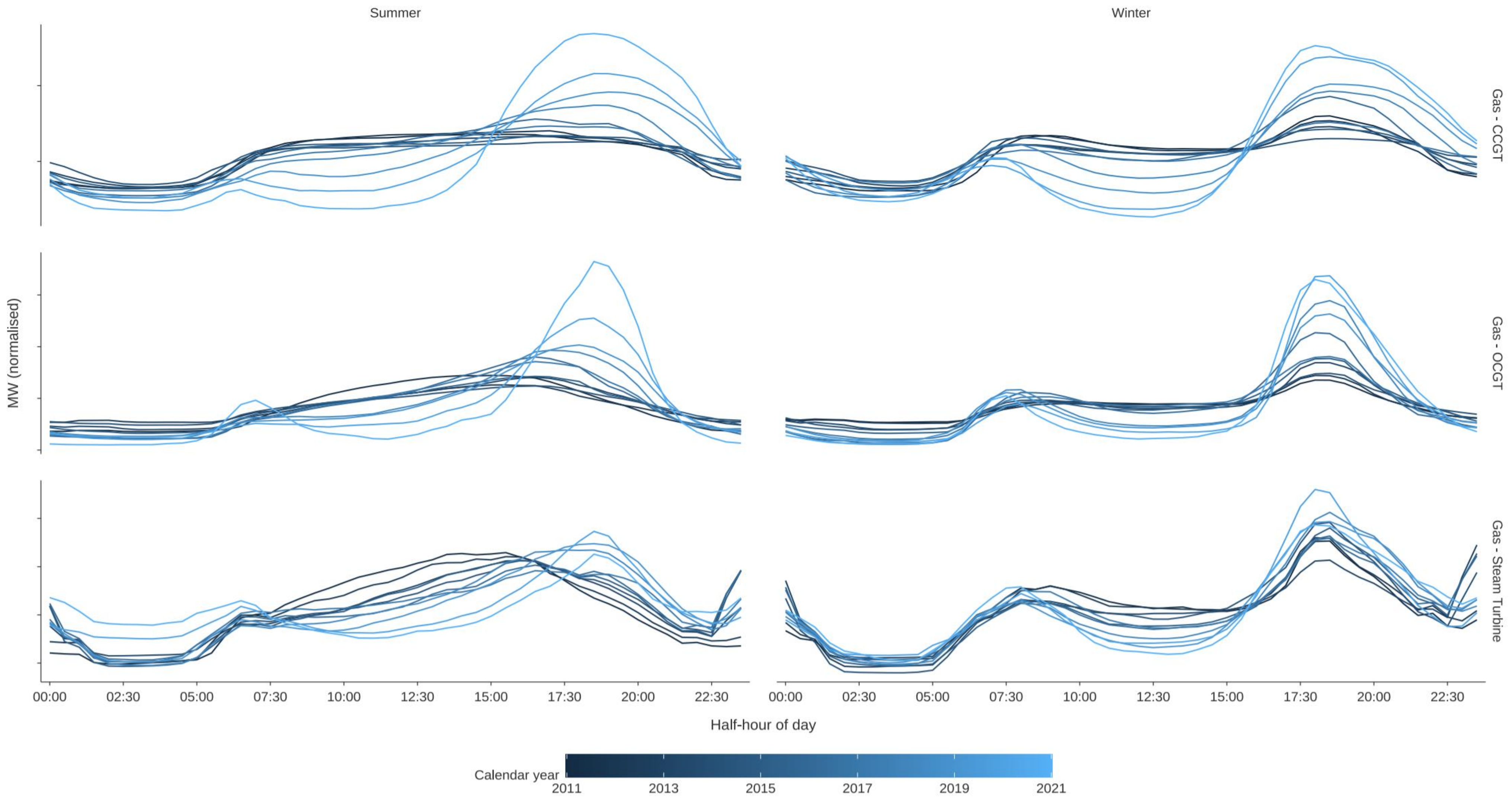
Historical analysis

Our historical analysis of the role of GPG in Australia's electricity markets shows that the operation of GPG has changed substantially in the NEM and WEM over the past two decades. On all the measures we consider, GPG is maintaining its role in generating to meet peak demand and as a bulk energy provider (although GPG output overall is trending downward), but it is also operating increasingly flexibly around intermittent renewable generation. This is reflected in some changes in the typical times that GPG operates as well as a tendency for GPG to operate more frequently, but for shorter periods of time.

This is clearly illustrated if we consider output by GPG in the NEM, by time of day, as shown in **Figure 1**. It is clear from **Figure 1** that since around 2017 GPG has increasing operated flexibly around times of renewable generation: there has been a marked decrease in the extent to which

GPG tends to operate during the day (when electricity from solar PV is available), with GPG increasingly taking on the role of operating at times when renewable generation is not available.

Figure 1: Normalised output by GPG, by time of day, 2011-2020



Source: Frontier Economics

Our historical analysis also considers three historical case studies that illustrate the important role of GPG in Australia's energy markets:

- In early January 2021 in South Australia, as wind output and solar output dropped to low levels for a number of days, GPG responded flexibly to meet demand. GPG operated for an extended period during these days – for instance, even gas peakers operated for between 5 and 10 hours a day on the days with lowest renewable generation, well in excess of the period for which batteries can typically operate.
- In late May 2021 in Queensland, following the sudden outage at the Callide C power station, fast-start gas peakers were the first to increase output, followed by increased output from CCGT gas plant and other forms of firm generation. As the outage at Callide C persisted, GPG continued to operate for the following days, weeks and months, particularly overnight when solar PV generation was not available.
- Following the retirement of major coal-fired power stations in South Australia and Victoria, GPG played an important role in increasing output to meet demand.

Critical assessment of AEMO's GPG forecasts

Reviewing AEMO's forecasting performance reveals the challenges that AEMO has faced in forecasting electricity market outcomes – AEMO's electricity market forecasts from a decade ago were not a good predictor of outcomes to 2021, and AEMO's current forecasts show a very different outlook for the electricity market.

This is important context for interpreting AEMO's forecasts of future output from GPG.

AEMO's ISP is forecasting a drop of GPG output from around 9% of total output in 2020 to around 1% in 2030. Indeed, there is a substantial and immediate drop in GPG in the first forecast year, with no obvious major changes in supply or demand conditions from the latest historical year to the first forecast year to account for this major change.

Furthermore, AEMO's recent forecasts of GPG have tended to significantly under forecast GPG output. AEMO's explanation of forecast errors relates to 'unforeseen' events such as the closure of Hazelwood Power Station and a number of power station outage events. However, unforeseen events that result in the need for greater GPG output are likely to remain a feature of the NEM. Indeed, it may be the case that the effect of unforeseen events increases:

- This could be a result of increased reliance on intermittent renewable generation.
- This could be due to increase outage rates. The forced outage rate, a measure of how often unforeseen outages occur, is trending up in coal-fired power stations, and is at recent historical highs in Victoria and NSW.

In our view, this suggests that the pattern of AEMO under-forecasting GPG output is likely to persist with the 2020 ISP forecasts. In other words, the actual need for GPG is likely to be greater than forecast in AEMO's 2020 ISP.

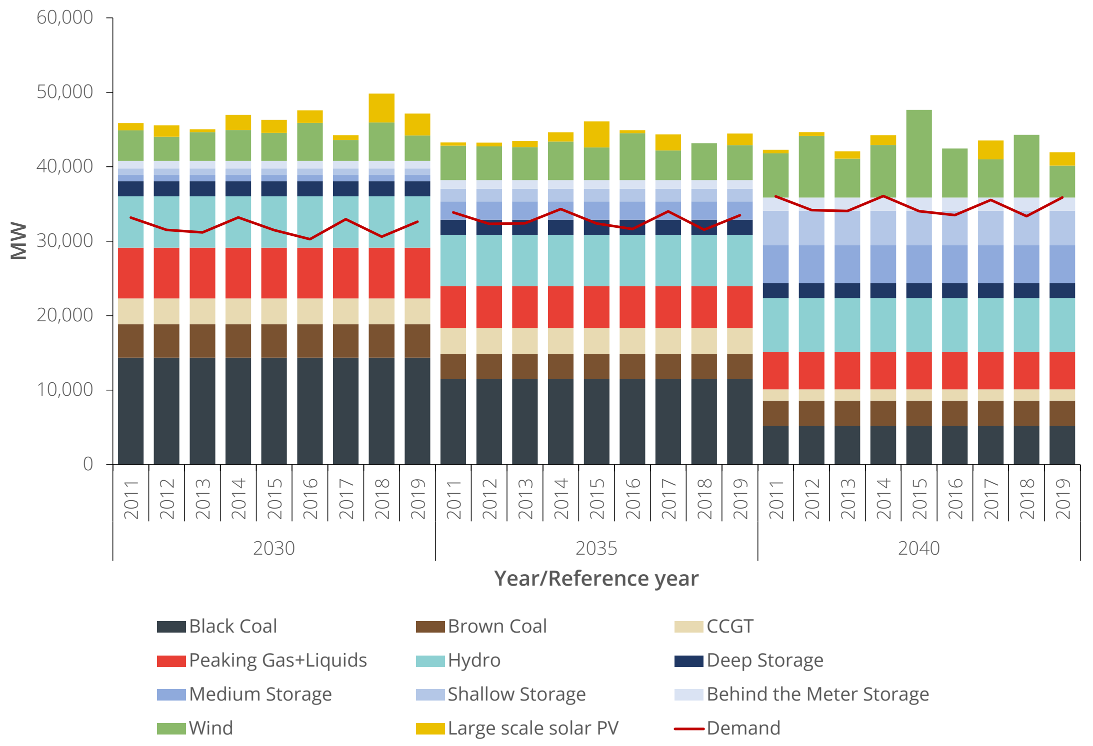
In fact, in its Gas Statement of Opportunities, AEMO forecasts that GPG output during the 2020s will be significantly higher (around 3 times higher) than it forecasts in the 2020 ISP, for reasons that are not made clear.

As the mix of generation shifts increasingly to intermittent renewable generation, the value of flexible and dispatchable generation and storage technologies to the market will increase. If we take the forecasts from AEMO's 2020 ISP as an example, we can see that the future electricity system may have far less ‘buffer’ between the available dispatchable generation and storage capacity and levels of peak demand. This is illustrated in **Figure 2** and **Figure 3**, which compare forecast coincident peak demand in the NEM with forecast available capacity at times of peak demand. Forecasts are shown for three future years – 2030, 2035 and 2040 – and for a variety of different outcomes regarding the availability of intermittent renewable generation at peak times (based on historical outcomes from 2011 to 2019). Forecasts of coincident peak demand are shown both for a 50% probability of exceedance (POE50) level – in **Figure 2** – and a 10% probability of exceedance (POE10) level – in **Figure 3**.

It is clear from **Figure 2** and **Figure 3** that, in 2030, there is forecast to be sufficient dispatchable generation and storage capacity to meet peak demand (at both POE50 and POE10 levels) with significant dispatchable capacity in reserve (despite significant retirement of coal-fired generation by then). However, as dispatchable capacity increasingly retires during the 2030s (particularly coal-fired generation) this situation changes. First, medium, shallow and behind-the-meter storage becomes increasingly important in meeting peak demand. Second, the dispatchable capacity in reserve diminishes, to the extent that even intermittent renewable generation may be necessary to meet peak demand.

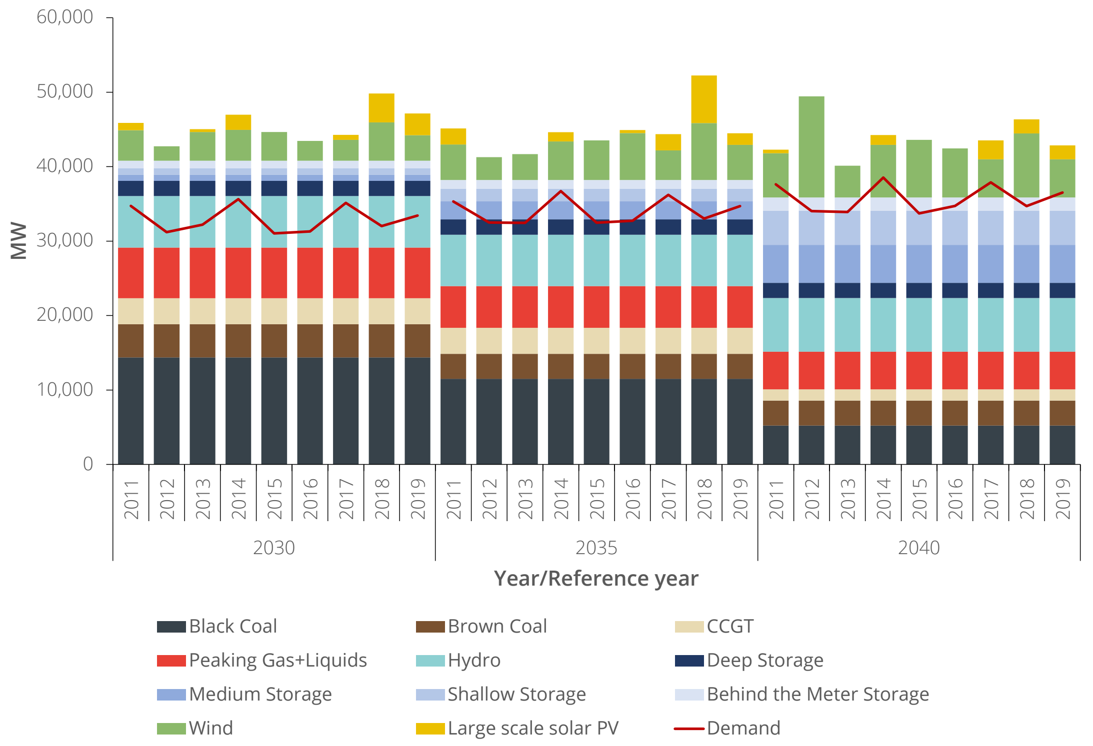
In our view, this significant shift in the balance between dispatchable generation and peak demand that is forecast in AEMO’s ISP indicates that flexible and dispatchable generation offered by GPG is going to become more valuable, not less valuable, to the NEM.

Figure 2: Coincident peak demand and generation availability, POE50 (DP1/Central)



Source: Frontier Economics analysis of ISP inputs and results

Figure 3: Coincident peak demand and generation availability, POE10 (DP1/Central)



Source: Frontier Economics analysis of ISP inputs and results

Whole of Electricity System Cost

Our analysis of the relative costs of different generation and storage technologies also suggests that GPG will have an important ongoing role to play in the NEM.

The costs of different generation and storage technologies have traditionally been compared using a measure known as the levelized cost of electricity (LCOE). However, it is clear that LCOE does not account for all of the costs and benefits to the electricity system of generation and storage technologies. In particular, the LCOE fails to account for the "when, where and how of power generation", as the IEA put it.

The Whole of Electricity System Cost (WESC) seeks to address these shortcomings of the LCOE by accounting for the impact that different generation and storage technologies have on the electricity system, and calculating the relative costs and benefits of these impacts. In doing so, it seeks to provide an alternative, more comprehensive, way of assessing the relative merits of investment in generation and storage technologies.

We calculate the WESC in the NEM for investments in five generation and storage technologies: CCGT, solar PV, wind, lithium-ion battery with 4 hours of storage and pumped-storage hydro with 6 hours of storage. We also calculate the LCOE in the NEM for investment in the same three generation technologies: CCGT, solar PV and wind.

The calculated WESC and LCOE for the generation technologies is compared in **Figure 4**, **Figure 5** and **Figure 6**, for three carbon price scenarios. Each of these figures presents the following information:

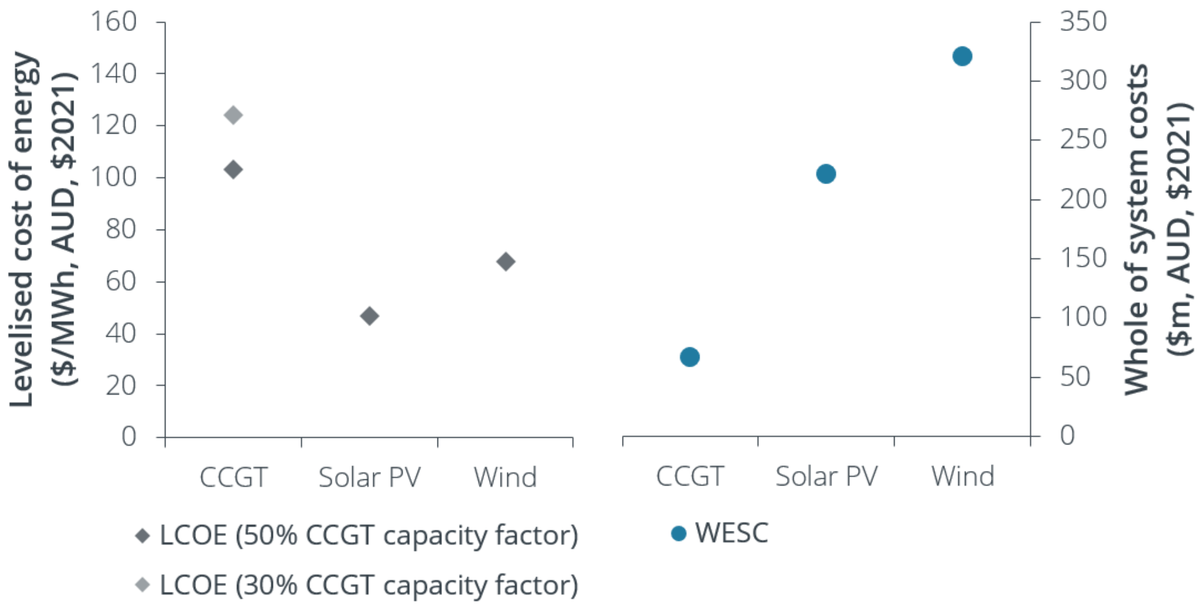
- **Estimates of LCOE**. The estimates of LCOE are shown on the left hand panel of each figure. Costs are shown as positive amounts, so a higher value for LCOE on these figures represents a technology that is more expensive. LCOE is generally presented as a curve, illustrating how LCOE varies with capacity factor. We present only point estimates of LCOE for an investment in 2025. For wind generation and solar generation these point estimates use the average capacity factor for these technologies in the NEM. For CCGT we provide two point estimates, to give an indication of the range of LCOE outcomes for CCGT: one for a capacity factor of 30% and one for a capacity factor of 50%. LCOE is reported in $/MWh.
- **Estimate of WESC**. The estimates of WESC are shown on the right hand panel of each figure. To aid comparison with LCOE, we present WESC in terms of total net cost rather than total net benefit. In other words, costs are shown as positive amounts, so a higher value for WESC on these figures represents a technology that results in higher net costs for the system as a whole. WESC is presented in terms of total net cost to the electricity market over the period 2025 to 2034, resulting from a 400 MW investment in the given technology in 2025, in $million.

It is clear from **Figure 4**, **Figure 5** and **Figure 6** that using LCOE as an indication of the lowest cost investment options presents a very different picture than using WESC as an indication of the lowest cost investment options. In particular, while CCGT has a much higher LCOE than solar PV or wind, based on our modelling of the electricity system it results in a much more favourable WESC.

The key reason that the WESC for CCGT compares very favourably to other technologies is that CCGT is flexible and dispatchable, both characteristics that are valuable, and becoming more valuable, in the NEM. For instance, the fact that investment in CCGT contributes to meeting peak demand means that other investment costs can be avoided, where this is much less true for renewable generation options. Similarly, the fact that CCGT can be dispatched when needed means that CCGT can benefit the system by avoiding the need to rely on expensive peaking plant or demand-side response. While this benefit is relatively small at the beginning of our modelling period, this benefit increases throughout the modelling period to 2035.

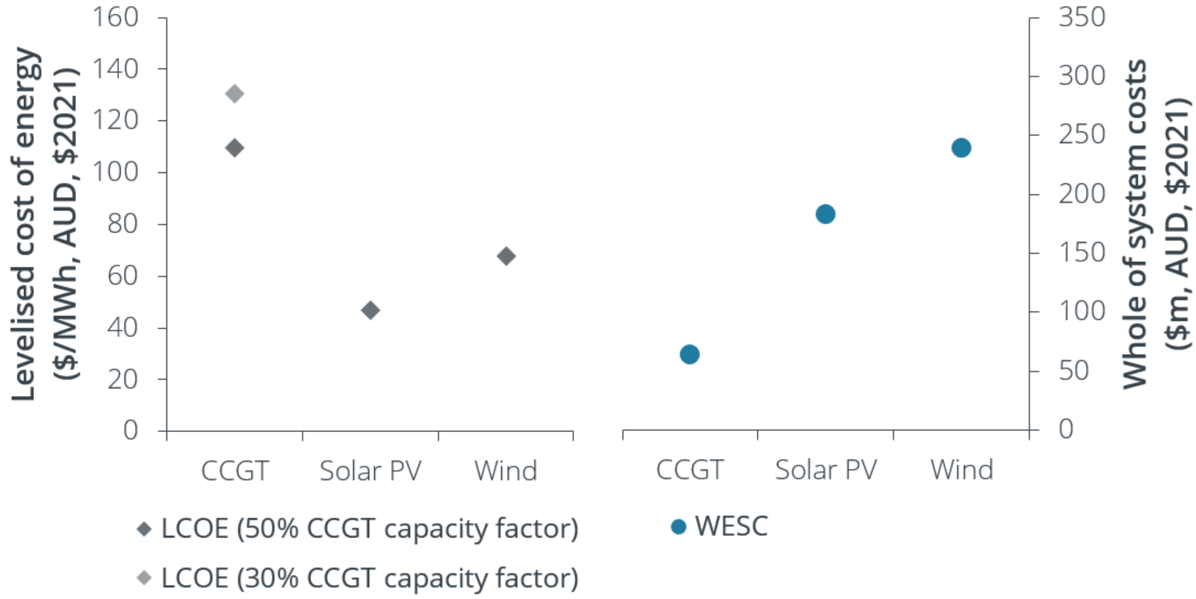
In short, it is a mistake to think that investing in generation or storage technologies with the lowest LCOE will necessarily result in a lowest electricity system cost. The broader system benefits delivered by investing in generation or storage technologies with higher LCOE may deliver lower electricity system costs, as we see for GPG in the NEM.

Figure 4: Comparison of WESC and LCOE in 2025 with no carbon price



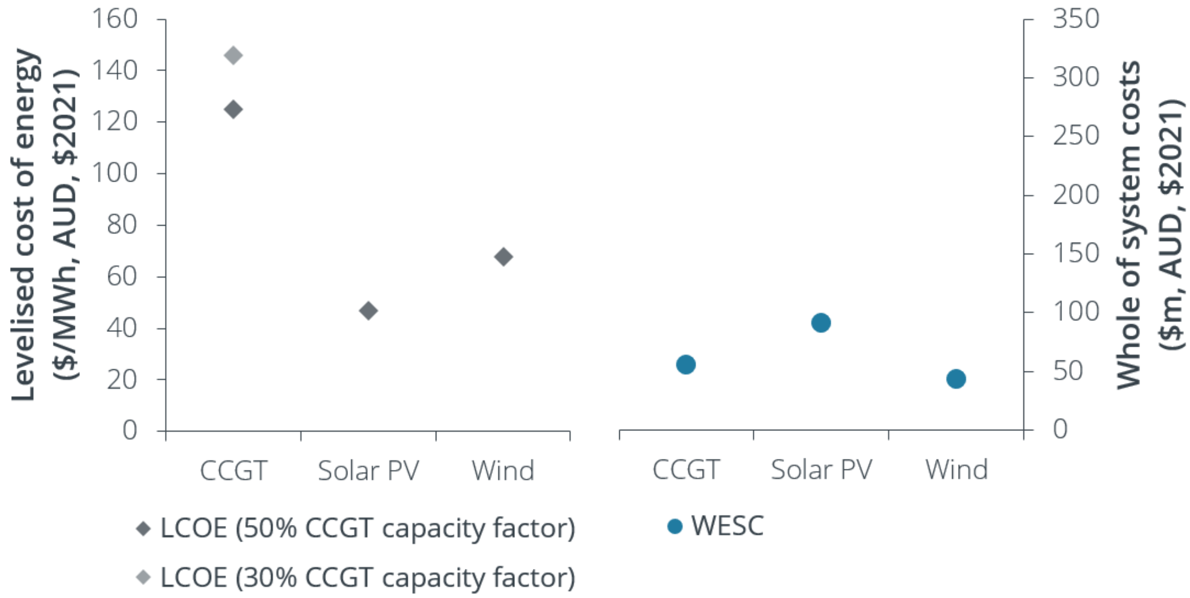
Source: Frontier Economics' analysis

Figure 5: Comparison of WESC and LCOE in 2025 with ACCU carbon price ($17.17/tonne, AUD)



Source: Frontier Economics' analysis

Figure 6: Comparison of WESC and LCOE in 2025 with EU ETS carbon price ($58.22/tonne, AUD)



Source: Frontier Economics' analysis

Sensitivity of GPG output to gas prices

As the gas market in eastern Australia has become linked to international gas markets, gas prices in eastern Australia have increased and become more volatile. GPG in the NEM will continue to be exposed to internationally-linked gas prices, with the likelihood that this will continue to result in higher and more volatile gas prices. However, the evidence suggests that this will not diminish the role that GPG will play in the NEM over coming years. In particular, while gas prices are a key driver of the cost of operating GPG, the evidence suggests that changes in gas prices are unlikely to be a key driver of dispatch of GPG.

Evidence on the relative economics of GPG suggest that gas prices would have to change very materially in order for the economics of GPG to shift sufficiently for GPG to become cheaper than competing generation technologies it is currently more expensive than, or to become more expensive than competing generation technologies it is currently cheaper than.

This is supported by an analysis of historical GPG dispatch and gas prices, which suggests that gas prices have tended not to be a key driver of dispatch of GPG.

The role of GPG in other electricity markets

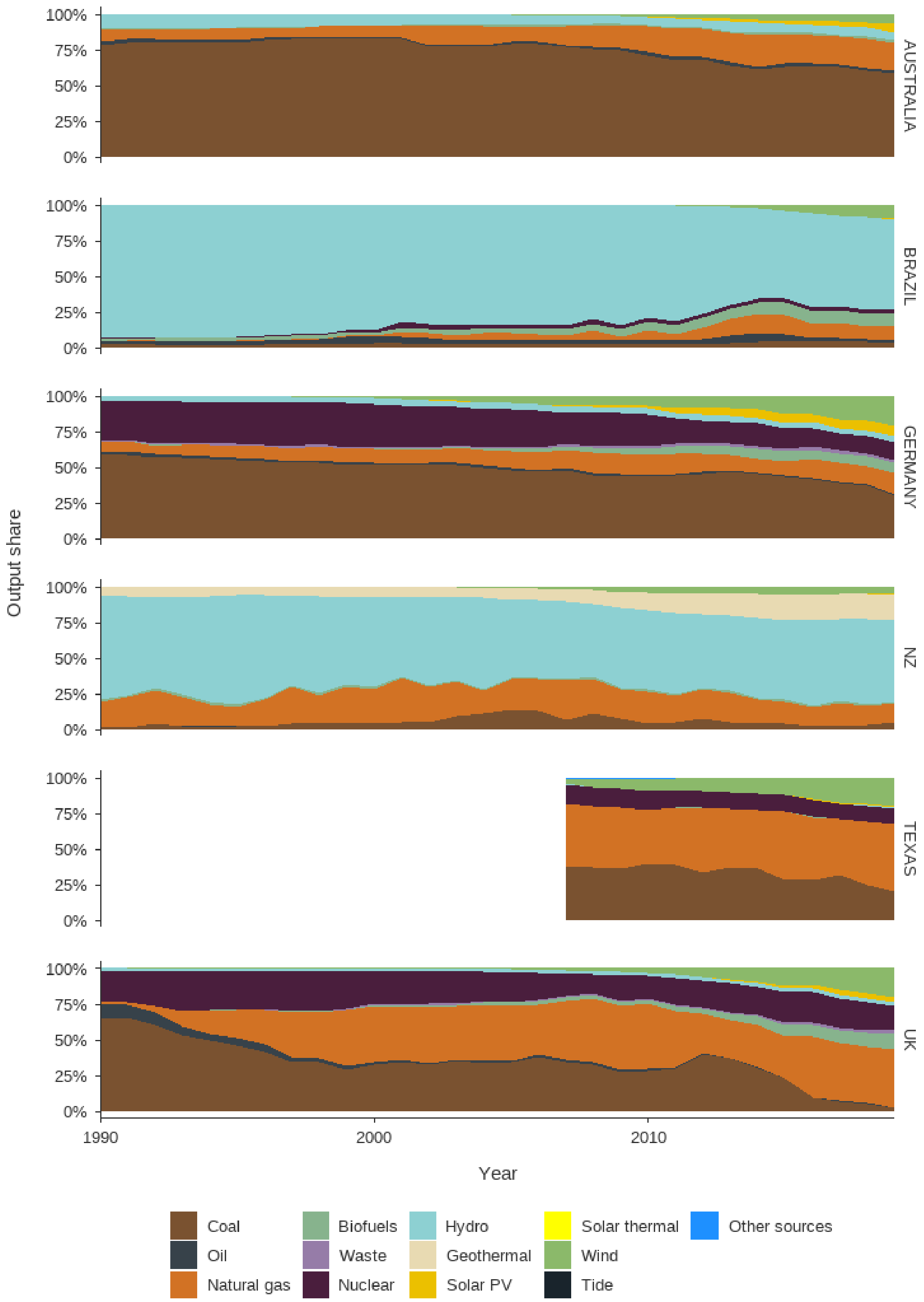
We have reviewed electricity markets in the United Kingdom, Germany, Texas, New Zealand and Brazil to investigate the role of GPG in these markets. Given that the major development in the NEM and WEM over the coming two decades is expected to be the retirement of coal-fired generation and the growth in renewables, we have chosen these jurisdictions because one or both of these trends is relatively advanced in each of these jurisdictions.

Based on this review we make the following general observations:

- In the jurisdictions that are retiring coal generation and nuclear generation – the UK, Germany, Texas – a combination of renewables and GPG are being used to replace the retired output and capacity.
- In the jurisdictions with high or increasing proportions of intermittent renewable generation, this energy is typically displacing coal generation rather than GPG.
- In none of the jurisdictions have we seen material reductions in GPG output, with the exception of New Zealand where geothermal generation is available and has increased its share of the generation mix.
- In regions dominated by hydro (New Zealand and Brazil), GPG plays a less important role in terms of annual average output in most years, but is a very important part of the energy mix during dry years.
- In each of these jurisdictions, GPG remains important to a reliable and securely functioning electricity system.

This conclusions are illustrated in **Figure 7**, which shows the changing fuel mix over time in each of these markets. **Figure 7** makes clear that GPG continues to play an important role in each of these markets, and that even in electricity markets with a much bigger share of intermittent renewable generation than the NEM – such as Germany, Texas and the UK – GPG continues to play an important role in the electricity market.

Figure 7: Summary of output shares for relevant jurisdictions



Source: Frontier Economics analysis of IEA and ERCOT data. Note Texas only includes ERCOT accounting for around 90% of Texas load

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