WA Gas Market Strategic Development

Domestic Gas Alliance

December 2021

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Executive Summary

Wood Mackenzie was engaged by the Domestic Gas Alliance (DGA) to provide an independent report on the evolving dynamics of the Western Australia (WA) domestic gas market, and specifically, the role of the domestic gas policy in an environment of a decarbonizing world. The report is intended to support ongoing policy discussions and promote a collaborative approach between gas producers, DGA members and other gas buyers as well as the WA Government.

The WA domestic gas market is facing a paradox with near-term gas demand growth likely as a pathway to reducing carbon intensity in the WA economy. This paradox is driven by gas' role in supporting the faster incorporation of renewable energy into the WA economy, but which will eventually push it towards longer-term gas demand destruction. Near-term domestic gas demand growth (between 2021 and 2030) therefore remains compatible with the WA Government's net zero emissions aspirations by 2050 (and the Australian Government's long-term net zero target). Gas will continue to play an important role in supplying WA mining and grid-power operations, although demand is expected to decline over time. Gas-fired power generation (GPG) has the flexibility to operate at variable utilisation levels and can therefore respond to fluctuations in demand (and variable renewable generation supply) across an hourly, daily, or seasonal basis. Through this grid-firming role, GPG can support the changing energy mix as renewable energy grows and displaces coal generation in the South West Interconnect System (SWIS).

The successful, scalable development of more renewable energy for both grid and remote power supply will gradually displace GPG utilization, although the pace of this displacement remains uncertain. Scenario analysis of GPG in WA indicates that the gas demand decline will be greatest over the period from 2030 to 2040.

Industrial/heat processes will continue to require gas over the longer-term, and this industrial gas demand could grow as new projects are developed. A number of large-scale projects that will require additional gas supply have been proposed and are at various stages of assessment. These include lithium hydroxide refineries, ammonia, urea and methanol projects. If these projects were to proceed fully to development, they would increase WA's domestic gas demand by more than ~690 TJ/d (~250PJ/a) by 2030 (~65% increase on 2020 gas demand). Nevertheless, these projects (together with existing industrial and mining gas demand projects) can contribute to a lower carbon future through:

- supporting the production of key export minerals that contribute to the global transition to lower carbon emissions:
    - mining, production and processing of alumina and iron ore, copper and nickel, lithium and mineral sands (and rare earth minerals). These are key commodities providing inputs into the manufacture of wind and solar power generators, batteries and other products that support future widespread electrification.
- displacing higher emissions products or imports (e.g. blue ammonia in coal fire-generation or fertiliser imports).

Even if these new projects do not proceed, WA industrial gas demand would be expected to decline at a significantly slower rate than GPG. This is due to chemical and heat processes being more complex and costly to displace directly with renewable energy. However, over the longer term, there is potential that gas will start to be displaced in industrial processes as well. For example:

- heat / steam processes that are electrified and can then utilise renewable power; and
- development of low emissions and/or potentially green hydrogen and ammonia - initially integrated within existing gas-feedstock ammonia production but eventually developing the scale for greenfield development.

The energy transition to a lower emissions economy will have an impact on the WA domestic gas market over time, but the pace and scale of this will depend on the level of investment in decarbonisation solutions and alternative technologies. All things considered, the immediate outlook for domestic gas demand in WA is likely to still see growth, particularly over the period 2025 to 2030, before entering into a demand decline thereafter.

From a gas producer perspective, gas is increasingly facing a need to be developed now or could risk remaining in the ground in the longer term or never being commercialised. The potential for material domestic gas demand growth over the period 2025 to 2030, can provide the opportunity to develop new gas supply, supported by industrial demand projects with long (at least 20 years) operational lives. This growth may at first seem counter intuitive to aspirations for net zero emissions by 2050. However, development of new gas supply contributes to the overall reduction in emissions intensity in the WA economy (reducing coal demand, supporting renewable energy growth and displacing higher emissions imports), and supports jobs associated with domestic gas industries.

Domestic Gas Commitments (DGC) from LNG export projects have delivered ~50 to 60% of the WA domestic gas supply over the last two decades. WA Domestic Gas Policy has and should continue to maintain some flexibility to ensure security of energy supply in the WA economy. The policy should encourage timely development of additional gas supply to help enable WA to be at the forefront of the energy transition – using gas to support alternative energy solutions that facilitate decarbonisation in the WA economy. To this end, domestic gas growth should be considered on a more wholistic basis, in terms of the role it can play in facilitating other potential energy solutions and technologies that help accelerate the energy transition. These energy solutions include carbon capture and storage (CCS), renewables, batteries, ammonia, hydrogen etc. as well as the production of commodities that are inputs to products that support zero emissions goals.

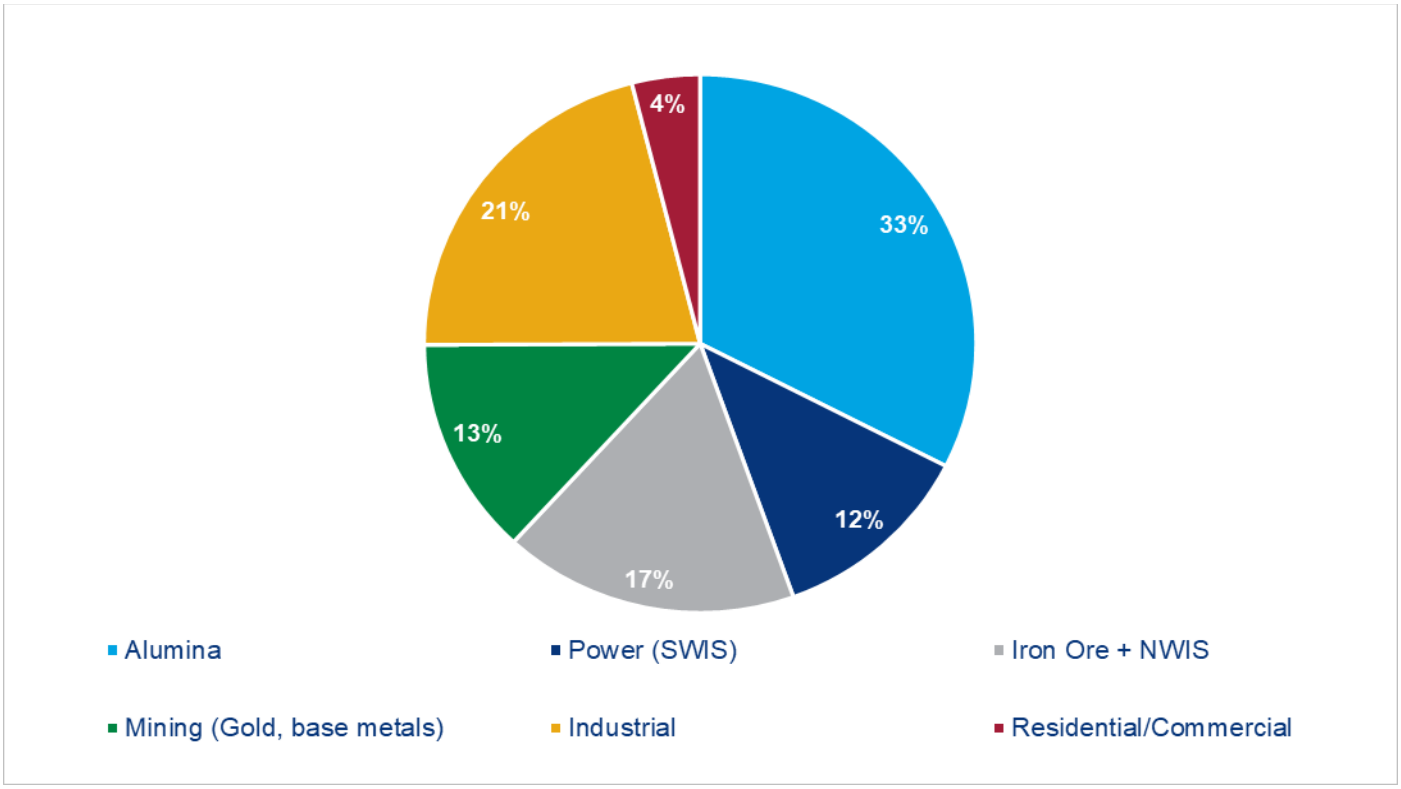
1 WA Domestic Gas Demand

1.1 Gas Demand Sectors

Domestic gas demand in Western Australia (WA) was ~1,068 TJ/d (~390 PJ/a) in 2020 – AEMO's (Australian Energy Market Operator) 2020 WA GSOO (Gas Statement of Opportunities) report. Gas is utilised primarily in six key sectors, as follows:

- Alumina sector – the alumina sector is the largest gas demand sector in WA and accounted for ~33% of WA gas demand in 2020. There are four alumina refineries in WA. Gas is used in the calcining process and to generate steam (with some co-generation producing electricity).
- Industrial sector – the industrial sector accounted for ~21% of WA gas demand in 2020. Gas is used as feedstock to produce fertilisers (ammonia and urea) and to produce heat/steam in industries producing mining chemicals, cement/bricks and mineral sands. Gas is also converted to LNG through mini LNG facilities to supply remote towns and mining operations with gas for power generation.
- Iron Ore mining sector – iron ore mining and port facilities in the Pilbara region rely on gas for power generation at remote mine sites and grid power for the Northwest Interconnect System (NWIS). The Iron Ore + NWIS sector accounted for ~17% of gas demand in 2020.
- Power sector (SWIS) – gas-fired generation (GPG) for grid-connected power supply in the Southwest Interconnect System (SWIS) accounted for ~12% of WA gas demand in 2020. Wood Mackenzie excludes co-generation gas plants from the Power sector (SWIS) demand – these plants are included in industrial and alumina sectors demand.
- Mining (gold, base metals) sector – gas primarily used for gas-fired generation at remote mining locations. The Mining sector accounted for ~13% of WA gas demand in 2020. The gold/copper and nickel are the major mining operations utilising gas to power.
- Residential/Commercial sector – is the smallest gas demand sector in WA and accounted for ~4% of gas demand in 2020.

Figure 1 WA 2020 domestic gas demand by sector (%)



Source: Wood Mackenzie and AEMO

The WA domestic gas market is unique compared to other gas markets globally, in that gas demand is heavily concentrated on mining, minerals processing and industrial operations which are widely spread geographically. It is also characterised by a relatively small number of key gas buyers - the top 10 gas buyers accounted for ~73% of WA domestic gas demand in 2020.

1.2 Domestic gas demand growth

WA domestic gas demand is forecast to grow over the next four years with a number of new gas-fuelled projects under construction. There is potential for further gas demand growth over the period from 2025 to 2030 with a number of proposed, large-scale gas demand projects at various stages of assessment. The impact of these projects (if all were to proceed to development) would be an increase in WA gas demand of more than ~690 TJ/d (~250 PJ/a) by 2030 (~65% increase on 2020 demand). Additional growth potential exists, including numerous smaller demand projects in the mining and industrial sectors that could add to this gas demand growth.

Projects under-construction are forecast to add ~54 TJ/d (~20 PJ/a) of new demand (~5% increase on 2020 WA gas demand) within the next four years. The key under-construction projects include:

- Three lithium hydroxide refinery projects are being developed which combined could add around 20 TJ/d (~7 PJ/a) of gas demand by 2025/26.
    - Kwinana Lithium Refinery (Tianqi Lithium/IGO Limited). ~50 ktpa lithium hydroxide refinery currently under construction. First production is expected in Q4 2022.
    - Kemerton Lithium Refinery (Albemarle/Mineral Resources Limited). ~50 ktpa lithium hydroxide refinery currently under construction. First production is expected in 2022.
    - Covalent Lithium Refinery (SQM/Wesfarmers). ~50 ktpa lithium hydroxide refinery. The project has received all critical approvals and is expected to start construction in 2021. First production is targeted for the second half of 2024.
- FMG's (Fortescue Metals Group) Iron Bridge magnetite project. This project will have a high electricity demand compared to other iron ore operations (haematite ore) as the beneficiation process uses magnetic separation (magnetite ore). FMG is developing a hybrid microgrid (Pilbara Energy Connect Project) incorporating solar, gas-fired generation, transmission and a Battery Energy Storage System (BESS). The Iron Bridge magnetite project is expected to commence production in late 2022. The incorporation of renewables with GPG in this operation will reduce FMG's emissions intensity compared to a gas-fired only generation solution. The project is forecast to add up to ~34 TJ/d (~12.4 PJ/a) to WA's gas demand. FMG has announced it is targeting net zero emissions for its operations by 2030 which will mean that its use of additional gas for its Iron Bridge project will likely be short term.

Advanced projects (undertaking FEED studies) could add ~147 TJ/d (~54 PJ/a) (a 14% increase on 2020 WA gas demand). These 'advanced projects' include:

- Perdaman Karratha Urea project – a 2 million tonnes/annum greenfield urea fertiliser production project which is targeting first urea production in late 2025. Perdaman has signed a conditional gas supply agreement with Woodside for ~125 TJ/d (~45.6 PJ/a). Woodside has indicated it will supply this gas from its upstream supply portfolio, though this will be primarily sourced from its Scarborough gas field development.
- CSBP Kwinana Ammonia Expansion (Wesfarmers) – a brownfield ammonia expansion which could add an estimated ~250 ktpa of plant capacity (~500 ktpa total) by 2025 if it proceeds to development. This would increase gas demand by ~22 TJ/d (~8 PJ/a).

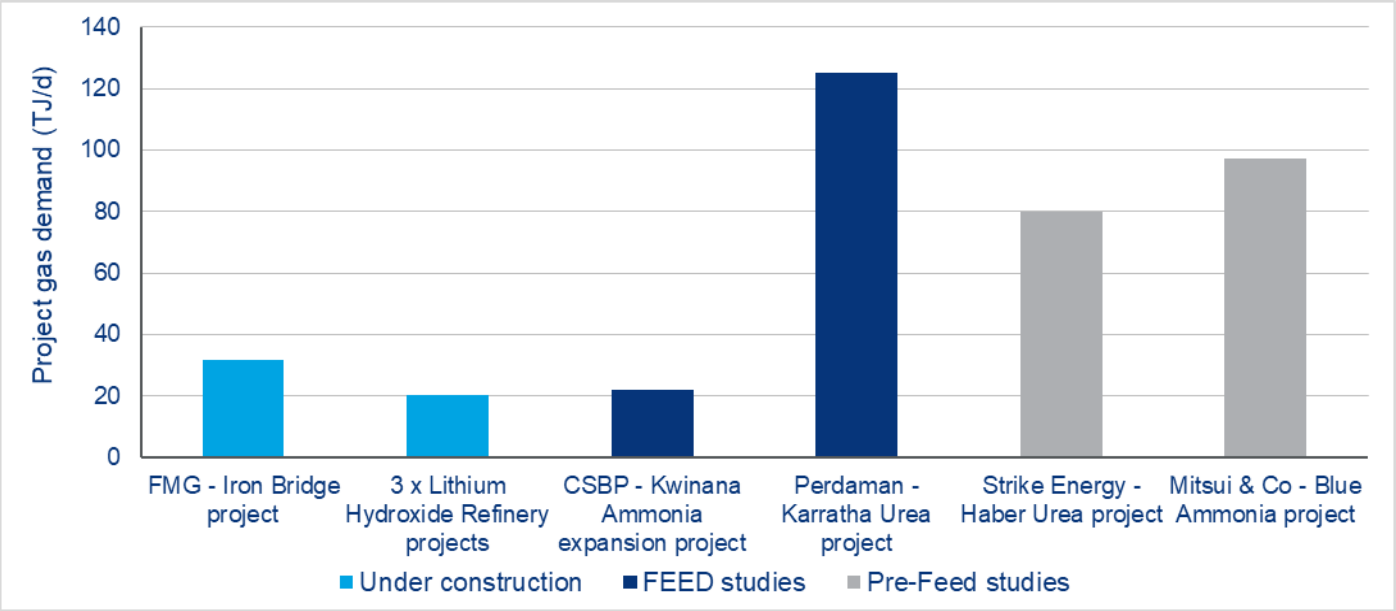
Pre-FEED projects could add a further ~488 TJ/d (~178 PJ/a) of new gas demand (~46% increase on 2020 WA gas demand).

- Project Haber Urea (Strike Energy) – 1.4 million tonnes/annum greenfield urea fertiliser production project near Geraldton. The project would have a gas demand of ~80 TJ/d (~29 PJ/a) which Strike

Energy would supply from its Perth Basin upstream supply (upside reserves from West Erregulla gas field and potential successful exploration at South Erregulla prospect to be drilled H2 2021).

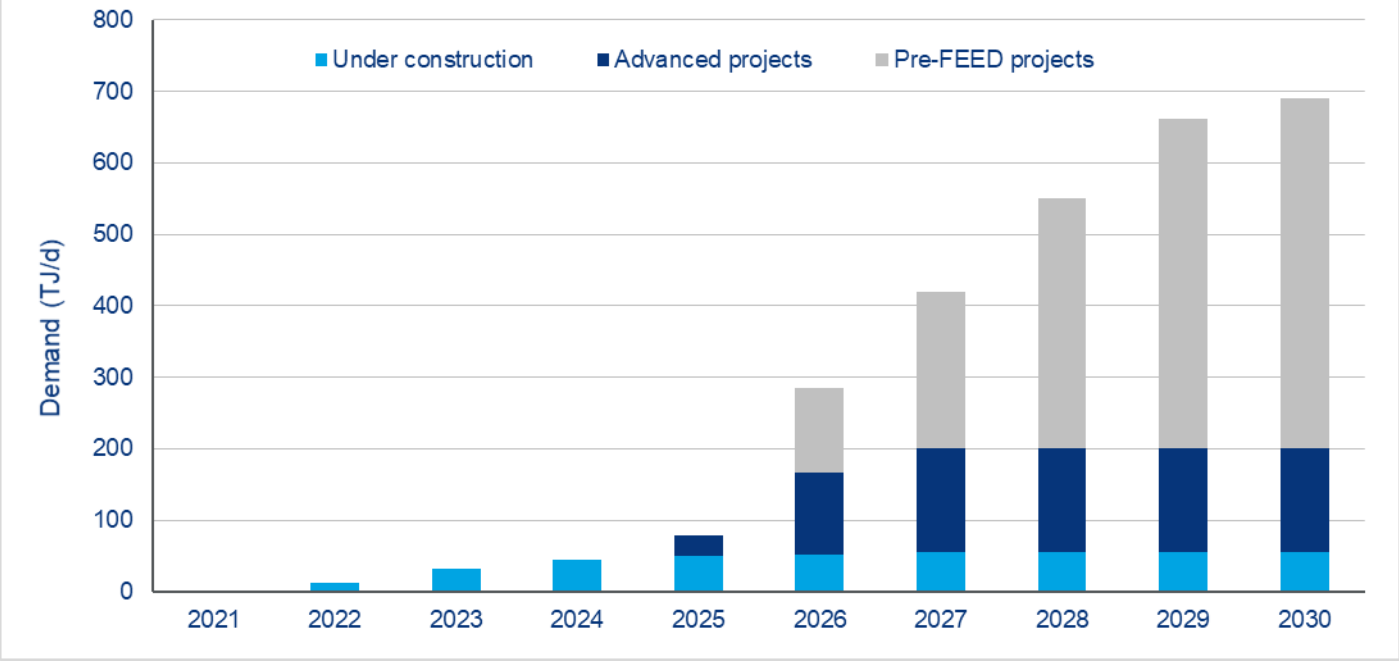
- Mitsui & Co. Blue Ammonia project - proposed ~1 million tonne/annum greenfield ammonia project with carbon capture and storage of CO_2 (CCS) to produce blue ammonia for export to Japan. Mitsui & Co. have signed MOUs with Wesfarmers and JOGMEC (Japan Oil, Gas and Metals National Corporation) to collaborate on pre-feasibility studies. The project could require up to ~96 TJ/d (~35 PJ/a) of additional gas demand which could be supplied by Mitsui & Co.'s share of Waitsia gas production from 2029.
- Other proposed projects that could add material gas demand include greenfield methanol (Coogee Chemicals / Wesfarmers) and brownfield alumina (Alcoa of Australia) projects.

Figure 2 Selection of gas demand growth projects – projects under construction, FEED and pre-FEED studies



Source: Wood Mackenzie analysis and corporate reports/announcements

Figure 3 Indicative domestic gas demand growth potential – 2021 to 2030



Source: Wood Mackenzie analysis and corporate reports/announcements

The indicative domestic gas demand profile (**Figure 3**) for these industrial/mining projects illustrates the potential for significant gas demand growth, particularly over the period 2025 to 2030. It is important to note that these types of gas projects would have long project lives of at least 20 years. All of these projects require certainty of gas reserves and production (in the form of long-term gas supply contracts) to support their development and operations over the longer-term.

Progress to development of these new demand projects would therefore require additional gas supply to be developed in the WA domestic gas market, focused on requirements for the shorter term to enable the projects to proceed. There are a number of committed gas supply projects (Gorgon Phase 2 and Waitsia Stage 2) and advanced, proposed supply development projects (Scarborough and West Erregulla Phase 1), that could meet some of this potential demand. However, to realise the full potential of the WA domestic gas market (including existing and new gas demand projects) and provide long-term energy security and reliability, more domestic gas supply would also be required to be developed (particularly over the period 2025 to 2030).

1.3 Role of domestic gas in the energy transition

The WA resources sector plays an important role in supplying commodities that are critical to supporting the transition to a lower carbon economy globally. These commodities include lithium, nickel, cobalt, mineral sands and rare earth minerals in addition to alumina and iron ore. Gas directly supports the mining, processing and export of these important commodities. Gas is also the key feedstock for the production of fertilisers (ammonia and urea) which can displace imports of higher emissions (taking into account variable feedstock sources and shipping) fertilisers from overseas.

Gas can also provide security and reliability to power supply (grid and distributed power), supporting the uptake of renewable energy and displacing higher carbon emissions coal in generation. Over the medium to longer term, this can continue to contribute to emission intensity reduction, as gas is displaced in power generation (grid and distributed power) by renewable energy (as batteries and other technologies provide the power system support). In fertiliser production, the potential exists for the staged development of lower emissions ammonia and green ammonia supply through integration with existing (gas feedstock) facilities before scaling up to greenfield, zero emissions production over the longer-term.

1.3.1 Coal retirements

In August 2019, the WA Government announced the staged retirement of the Muja Power Station's two C units. The timing of the coal unit retirements are as follows:

- Muja C Unit 5 planned for October 2022, and
- Muja C Unit 6 in October 2024.

The Muja C units are ~40 years old. In recent years, the increasing levels of residential rooftop solar power had reduced the demand for traditional coal-fired baseload power generation in the SWIS. The Muja C units had a utilisation level of ~35%, which increased the operating and maintenance costs as the units were not being employed as originally designed.

Power demand (operational consumption) in the SWIS is forecast to decline by ~9% over the decade to 2031 (AEMO – 2021 WEM ESOO report). Renewable energy is forecast to continue to grow within the SWIS (both rooftop solar and, utility scale solar and wind, supported by batteries). Minimum demand is also forecast to decline further over time. This creates more variable intra-day demand which is harder to service with coal generators (which were designed to meet essentially flat, base-load demand). This renewable energy growth will place continued operational and commercial pressure on the remaining coal-fired generators over time as their utilisation levels decline. The remaining coal-fired power stations in the SWIS are:

- Muja Power Station - D units (commissioned 1985, ~454 MW) ~36 years old;
- Collie Power Station (commissioned 1999, ~300 MW ~22 years old; and
- Bluewaters Power Station (commissioned 2009, ~416 MW) ~12 years old.

As renewable energy grows, it is inevitable that these coal-fired power stations will be retired over time, however the exact timing remains uncertain. Gas-fired power generation (GPG) has the flexibility to operate at variable utilisation levels. GPG therefore provides flexible generation to respond to variable demand throughout the day, as well as increasing or decreasing supply (through variable utilisation levels) in response to market supply/demand requirements on a weekly and / or seasonal basis. In this way, GPG flexibility can support renewables changing energy mix and coal retirements over the medium to longer-term.

However, over the medium to longer term, with incorporation of Battery Energy Storage Systems (BESS) and more geographic diversified renewable energy developments, gas generation utilisation will likely decrease, reducing gas demand into power. This is a natural progression to lower emissions for generation in the SWIS. In this way, GPG supports the SWIS reliability and security of supply as the transition to lower carbon emissions evolves.

1.3.2 Renewable energy growth

Outside of the SWIS, renewable energy is being developed to provide support to power generation in remote locations, isolated from grid power supply. The following is an example of some of the remote, renewable power installations that have been installed, are under construction or are committed:

- Agnew Hybrid Renewable Microgrid (Gold Fields Limited)
  - Agnew gold mine – 18 MW wind, 4 MW solar, 13MW / 4MWh[1] BESS and existing (16 MW) gas-fired generation. Expected to reduce CO_2 emissions (by displacing gas use in generation) by ~50 to 60%.
- Gruyere Hybrid Energy Microgrid (Gold Fields Limited / Gold Road Resources)
  - Gruyere gold mine – 12 MW solar and 4.4MW / 4.4MWh BESS integrated with 49 MW gas-fired generation
- Chichester Solar Gas Hybrid project (Alinta Energy)
  - Fortescue Metals Group's (FMG) Chichester Hub iron ore operations – 60 MW solar, transmission lines connecting the solar farm, FMG's Cloudbreak and Christmas Creek iron ore mining operations and Alinta Energy's Newman gas-fired power station and a new 35MW / 11MWh BESS. The project could displace ~100 million litres of diesel annually, previously used by FMG for its power generation needs.
- Pilbara Energy Connect project (FMG) - under-construction
  - FMG's Iron Bridge Magnetite project and Solomon Hub iron ore operations - The Pilbara Energy Connect project will incorporate a new 150 MW gas-fired generator, integrated with existing gas fired generation, transmission connection, 150 MW solar and 32MW / 13MWh BESS.
- Gudai-Darri (Kooldaideri) Solar Project (Rio Tinto) - under-construction
  - 34 MW solar plus 35MW / 12MWh BESS.
- Northern Goldfields Solar Project (TransAlta) - committed
  - BHP Nickel West operations - 27.4 MW solar at Mt Keith Nickel mine, 10.7 MW solar and 10.1 MW BESS at Leinster Nickel mine.

There are several drivers that indicate this uptake of renewable energy in the mining sector will continue and indeed accelerate. These drivers include:

1. Increasing Environmental, Social and Governance (ESG) expectation on corporations (from the public as well as shareholders). A growing number of companies have set emission reduction targets and/or including targeting net zero emissions by or before 2050 and 2030.
2. Companies seeking to improve their "social licence to operate", assist with financing of debt and/or provide a competitive differentiator/value for their products.
3. Government policy (broad alignment of Federal and State Governments net zero goal by 2050)

[1] MW - Megawatt, MWh – Megawatt hour

   a. The Australian Federal Government's net zero by 2050 goal, including 26-28% emissions reduction target by 2030.
   b. The WA State Government's net zero by 2050 aspiration.
   c. The Western Australian Government (through the EPA's Greenhouse Gas Guidance) requires proponents of major projects to articulate and publish their greenhouse gas emission reduction targets over time, demonstrating their contribution to delivering net zero emissions by 2050.
4. Technical and operational benefits – increased reliability of power supply provided by a high response battery, retirement of back-up supply including spinning reserves (reducing fuel cost and operations and maintenance costs).
5. Economic benefits of renewable energy over alternatives – particularly as costs decline and government policies change (i.e. potential changes to the Diesel Fuel Rebate or introduction of a price on carbon emissions in some form).

For many remote mining projects in WA, as well as in the SWIS, there is significant GPG capacity installed. Therefore, in comparing the economic benefits of renewable energy with existing generation facilities, it is essentially the cost of fuel displaced by the renewable energy that is the key factor to be taken into account. Where the fuel to be displaced is diesel, the cost competitiveness of renewable energy is more compelling. However, the competitiveness of renewable energy with GPG (at existing facilities) is not currently as straight forward. The cost of solar renewable energy may be broadly competitive with the cost of the gas fuel displaced but not to the level of reliability required for 24 hour-a-day mining operations. Solar renewable energy needs to be paired with a BESS to firm up this solar supply to the equivalent reliability level of GPG (and that currently cannot cover the full 24 hour-period). The additional cost of a BESS with solar currently means the existing gas generation is a significantly cheaper power supply option at present.

The cost of solar plus BESS and solar plus wind plus BESS is forecast to decline over time and become more competitive with GPG. As a result, the economic driver to displace gas-fired generation is expected to grow in the medium to longer term. Where renewable energy is added to an operation that already has existing GPG capacity installed, the impact of the renewable energy is the displacement of the gas fuel use by reducing GPG utilisation. However, there is a benefit of maintaining the GPG installed capacity, to compliment the renewable energy generation, as this enhances the overall reliability and security of power supply (GPG providing backup and "firming" supply as needed). This is particularly important in large mining, mineral processing and industrial operations that require a high level of power reliability as the cost of production interruptions can be enormous.

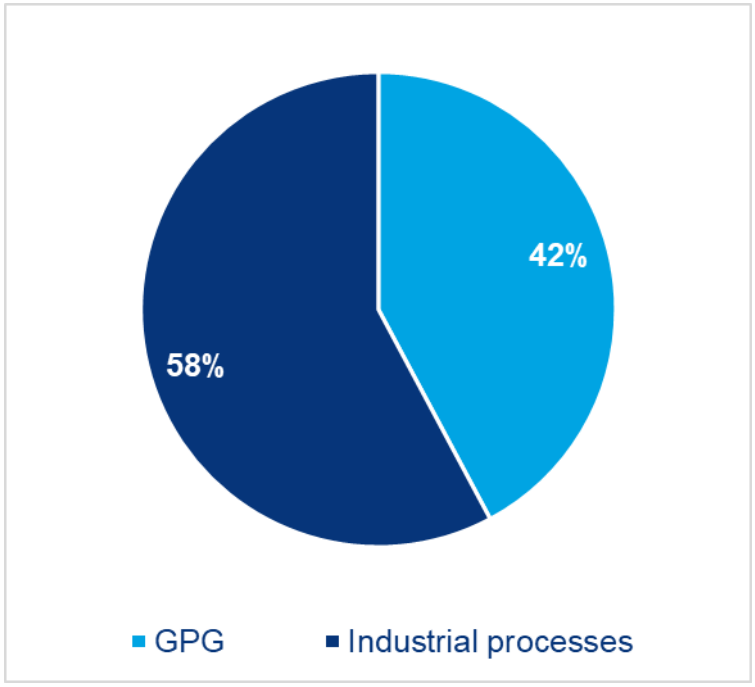
The growth of renewable energy and the resulting variability in gas demand into GPG is not without its challenges for market participants. The WA gas market has historically been characterised by relatively "flat" daily gas demand with limited seasonal variation. However, as renewable energy grows, gas demand will naturally be displaced in GPG, particularly during daylight hours (by solar energy) and intra-daily requirements for gas may be more volatile.

GPG can provide the flexibility to support renewables growth but will require greater flexibility in the broader gas supply system to meet the variable demand needs of the gas market on an hourly and daily basis. Gas supply sources (production) can provide some flexibility on a daily basis through buyer nominations under the supply contracts. But additional flexibility will be required from the pipeline transmission system and gas storage to support the demand side requirements (i.e. flexibility of gas supplied at the end-user delivery point).

Diversity of gas supply will help provide some support to the pipeline deliverability (particularly new Perth Basin gas supplies as these are located close to the gas demand centres of Perth) and help offset the forecast decline in deliverability from other supply sources (e.g. depleting Reindeer/Devil Creek production and lower than historic domestic production from the North West Shelf). It is therefore important that new gas supply is encouraged to ensure gas flexibility is enhanced and can support the renewable energy growth through WA's energy transition.

1.3.3 Gas displacement by renewables in power generation

Figure 4 WA gas use – GPG vs Industrial Processes



Source: Wood Mackenzie

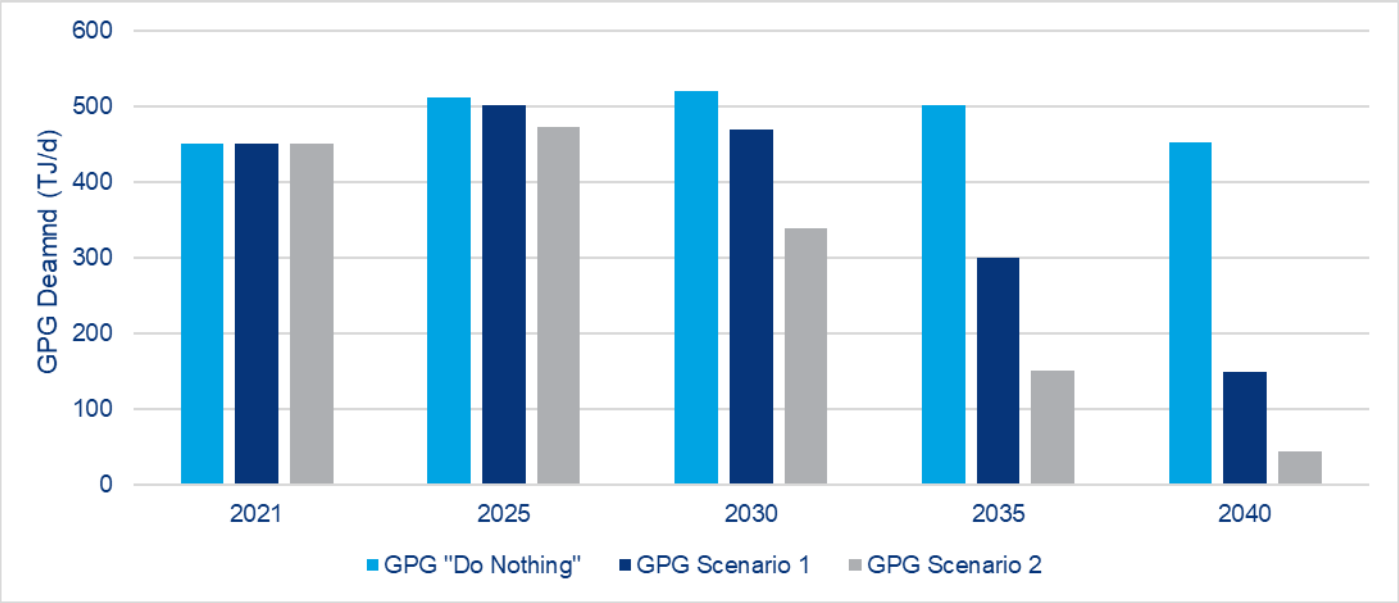
Gas demand in WA can be categorised under two broad uses – GPG and industrial/heat processes. GPG is generation within the SWIS, the NWIS and in distributed generation (remote towns and mining operations). Industrial/heat processes include gas used in feedstock to produce fertilisers (ammonia and urea), heat processes (e.g. kilns, calcining, residential/commercial heating) and steam generation (e.g. for the Bayer conversion process of bauxite to alumina). Renewable energy can directly displace gas generation in grid and remote power generation. However, the displacement of gas by renewables in feedstock, heat and stream processes is more complex, requiring additional processes and/or equipment and therefore additional costs.

In 2020, WA gas demand was 1,068 TJ/d (~390 PJ). Of this, ~450 TJ/d (42%) was used in GPG and ~617 TJ/d (58%) was used in industrial/heat processes.

The level and pace of renewable energy development in WA has important implications for gas demand and the drive for lower emissions. Wood Mackenzie forecasts renewable energy's share of the WA energy mix to increase over time, although the timing and scale of the impact this has on gas demand remains uncertain. To illustrate the potential impact on gas demand in WA, Wood Mackenzie has analysed the WA gas demand for GPG under three scenarios:

1. GPG "Do Nothing" – Our "Do Nothing" scenario forecasts GPG demand based on the existing operations configurations. i.e assumes no new renewable energy displacement of GPG.
2. GPG Scenario 1 – this scenario assumes the uptake of renewable energy will be modest over the next decade as GPG remains more cost competitive compared to firm supply renewables (hybrid solar and/or wind plus BESS). However, the pace of renewables uptake accelerates from 2030 and ultimately results in 77% displacement of gas into GPG by renewable energy by 2040.
3. GPG Scenario 2 – this scenario assumes more rapid uptake of renewable energy in WA in the second half of this decade and through the next decade. The scenario assumes that GPG demand will almost be completely displaced by 2040 (90% displacement of gas in GPG). This scenario likely requires other technologies (green hydrogen / ammonia) in addition to renewables / BESS to support this low level of GPG demand by 2040.

Figure 5 WA GPG gas demand scenarios



Source: Wood Mackenzie

The GPG “Do Nothing” scenario suggests gas demand to be broadly maintained at existing levels over the next two decades. However, with Governments (Australian Federal and WA State), Corporate and societal drives to reduce carbon emissions, this scenario is unlikely. It is more likely that increased renewable energy investment will see greater displacement of gas in GPG, with only the pace of change being the key uncertainty. Under both Scenario 1 and 2, the biggest impact on gas demand is expected to occur next decade (2030’s). This 2030’s impact on gas is due to:

- firm supply renewables + BESS are currently not competitive with existing GPG (although costs are forecast to reduce over time)
- managing the challenges of deeper displacement of renewables requires greater support from BESS and/or other technologies
- higher carbon emissions coal generation is more likely to be retired earlier than flexible use GPG.

1.3.4 Gas use in industrial processes

In contrast to GPG, displacement of gas by renewables in the industrial sector is more complex and costly. Industrial processes that use gas for feedstock or chemical processes (e.g. ammonia, alumina and lithium hydroxide processes) cannot easily substitute the gas in their existing operations and would require major operational redesign or greenfield development to substitute gas with renewables, hydrogen or other technologies. Industrial processes that currently use gas for heat and steam processes, may be able to electrify processes, incorporating renewable power and thereby reducing their emissions intensity. However, this requires new heat process equipment to be incorporated into an existing operation, incurring capital expenditure to change out the heat process equipment. This presents an economic challenge for this transition to lower emissions for these operations.

Some of these changes will be possible as the existing equipment reaches the end of its operating life or requires major overhaul, providing the opportunity to limit the cost impact of this change-over. Likewise, greenfield developments can be configured to be electrified from start-up and incorporate renewable power. But these changes are likely to take time and therefore the transition to lower or zero emissions for the industrial sector will take longer.

The utilisation of blue or green hydrogen does present an opportunity to move to lower emissions operations for feedstock industrial processes currently using gas (e.g. ammonia production). Whilst technically feasible to produce green ammonia, the current cost is significantly higher than the existing production utilising gas as the feedstock.

Yara Pilbara Fertilisers and Engie are co-developing one of the world's first industrial-scale renewable hydrogen production operations. The project will comprise the development, construction and operation of a renewable hydrogen plant at Yara Pilbara's existing ammonia plant. The aim of the initial project development is to prove the potential commercial and operational viability of renewable hydrogen production. Yara and Engie have outlined a multi-phase roadmap to help reduce costs and build scale over time.

The phased development allows the production of renewable hydrogen to be scaled up by initially integrating with Yara's existing ammonia plant and then to a level that a new ammonia plant can be built. This phased approach helps reduce the risks and costs compared to a greenfield renewable ammonia facility. It also provides the potential for a more rapid pathway to reducing Yara's ammonia production emissions intensity.

A multi-phased approach could be incorporated by other industrial operations seeking to provide a pathway to lower emissions intensity of their operations as well as build or expand new production capacity.

Industrial projects in WA are expected to continue operations over the longer term, as the demand for their end products remains robust. The gas demand is characterised by relatively large volumes and low variability over the long-term (substitution or displacement of gas in these industrial projects is challenging and will only likely occur through time). As a result, gas supply will be required to support these industries over the longer term. New industrial projects tend to bring relatively "lumpy" new tranches of gas demand, rather than incremental gas growth. As a result, new industrial projects generally need to be associated with new gas supply projects, as both require the supporting gas contract over a longer time period (~10 to 20 years) to support the development / investment.

1.4 Conclusions for WA Domestic Gas Demand

In the short to medium term (2021 to 2027), domestic gas demand in WA is expected to grow, driven by new and expanding mining and industrial projects. Further gas demand growth to 2030 could occur with additional industrial gas developments flagged above (proposed but not yet committed). However, gas demand into power is forecast to decline from ~2025 onwards as renewable energy displaces gas use in GPG.

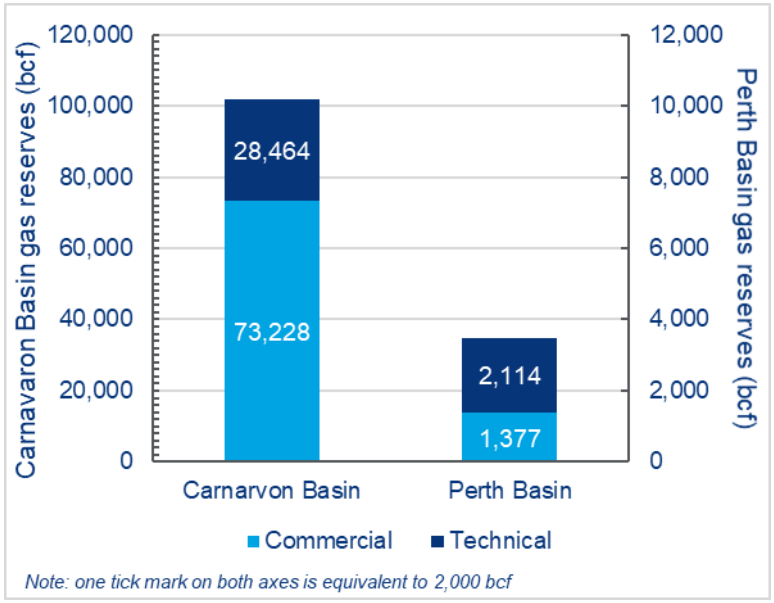
Continued policy support for WA's gas industry (producers and consumers) will help facilitate decarbonisation in the WA economy and therefore remains compatible with the Australian Government and WA Government's net zero emissions goal / aspirations by 2050. This is achieved through:

- supporting renewable energy uptake, that displaces higher emitting fuels in the power sector;
- supporting the industrial / mining sectors that produce the key commodities that are inputs to the manufacture of zero-emissions electrification;
- creating new industrial developments (that use gas) that displace higher emission imported products (e.g. fertilisers); and
- helping to commercialise and de-risk green hydrogen / ammonia production through the phased investment and incorporation of renewable energy within existing facilities. This provides the potential for the efficiencies required to make zero-emission operations, cost competitive.

2 WA Domestic Gas Supply

2.1 Gas reserves and supply

Figure 6 WA Gas reserves (Carnarvon and Perth basins only)



Source: Wood Mackenzie

The Carnarvon Basin is the key basin for gas supply and reserves for the WA domestic gas market. The Perth Basin, whilst significantly smaller gas resource, has shown considerable potential in recent years with the Waitsia, Beharra Springs Deep and West Erregulla gas discoveries. Wood Mackenzie has excluded the Browse, Bonaparte and Canning basins from the analysis as these are not currently connected to the WA gas market. The discovered gas resources relevant to the WA gas market are:

- Carnarvon Basin has ~100 tcf of discovered gas resources.
- The Perth Basin currently has an estimated ~3.5 tcf of discovered gas resources.

Wood Mackenzie's classification of reserves includes:

- **Commercial reserves** – recoverable volumes that are in production, under development or likely to be developed in the near future. These are broadly equivalent to company reported 2P reserves.
- **Technical reserves** – technically recoverable resource that is currently not commercial. These are discovered 2P[2] reserves and 2C[3] resources that do not have a near-term development plan identified.

Commercial reserves in the Carnarvon Basin have largely been developed or are expected to be developed for production through the LNG export facilities – North West Shelf, Pluto, Gorgon and Wheatstone LNG. These projects also have domestic gas supply commitments under agreements/arrangements with the WA Government (Domestic Gas Policy).

We have divided WA gas reserves and additional contingent resources into three groups:

- **LNG Projects – DGC** (Domestic Gas Commitment). These are domestic gas reserves committed to the domestic gas market from the LNG projects and associated tolling supply arrangements under the WA Domestic Gas Policy. These agreements are listed in ***Table 1***. Note: Wood Mackenzie refers to DGC in this report to more broadly represent both the reserves and production committed to the domestic market as part of the LNG exporters agreements / arrangements with the WA Government.
- **Carnarvon Basin 'Domestic only' projects.** These are domestic gas developments in the Carnarvon Basin that supply exclusively to the domestic gas market. The projects include gas processed through the Varanus Island, Macedon and Devil Creek gas processing facilities.

[2] 2P reserves – proven plus probable reserves

[3] 2C resource – contingent resources, discovered and technically recoverable but not currently considered commercially recoverable

- **Perth Basin Domestic projects**. These predominantly reflect reserves and resources from the Waitsia, Beharra Springs Deep and West Erregulla discoveries in the Perth Basin. We have subtracted the reserves that will be exported under the Waitsia-NWS LNG tolling agreement as well as the corresponding Waitsia JV DGC. For example, Waitsia Stage 2 will export its entire production from 2024 to 2028 (therefore these reserves are not available to the domestic gas market) before reverting to full domestic gas supply from 2029 onwards.

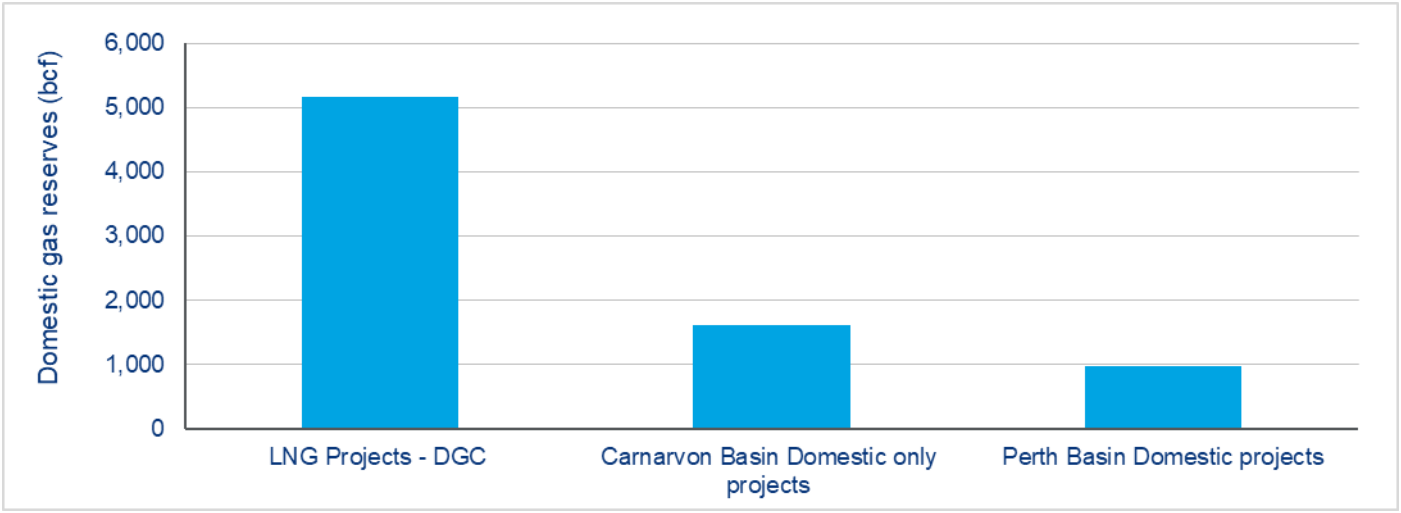
Table 1 Summary of the WA domestic gas agreements/arrangements (LNG Projects - DGC)

Project / Processing Plant	DGC Initial volume (PJ)	Status / First gas	Plant capacity (or committed volume (TJ/d)	Remaining DGC volume 1/1/2021 (PJ)	Comments
Pluto 1 - Domgas	Pluto 1 (450)	Online	**25**	**441**	Pluto 1 arrangement volumes
Pluto 1- LNG trucking		Online	**15**		
Additional NWS DGC (Woodside)		2025	**25**		2025 to 2029 45.6 PJ attributed to Pluto 1 Arrangement volume
Wheatstone DGC	Wheatstone (1,600)	Online	**200**	**1,505**	Assume 200TJ/d capacity
Gorgon Phase 1 DGC	Gorgon (2,000)	Online	**180**	**1,779**	300TJ/d Phase 1 & 2
Gorgon Phase 2 DGC		2022	**120**		
NWS DGC (additional)	NWS additional (660)	Online	**90**	**584 (est.)**	630TJ/d domestic plant capacity
Pluto Acceleration (NWS)	Pluto Accel. (25)	Q1 2022	**17**	**25**	2022-2025 processed through NWS facilities
Waitsia DGC – Xyris plant	Waitsia (58)	Online	**30**	**60**	2021-2028 ~20TJ/d
Scarborough DGC	Pluto 2 (1,300)	FID / H1 2026	**225**	**1,300 (WM est.)**	155 to 180TJ/d domgas commitment

Source: Wood Mackenzie, AEMO WA Gas Bulletin Board and WA Government (Department of Jobs, Tourism, Science and Innovation) and Company reports

Total reserves and resources that are currently dedicated to the WA domestic market are estimated at ~8 tcf (~8,450 PJ). This includes an estimate of Scarborough DGC volumes (assumed 7 to 8 Mtpa LNG output). LNG Project DGC resource accounts for ~65% of this total.

Figure 7 WA domestic gas projects - reserves



Source: Wood Mackenzie

The processing capacity associated with each domestic gas supply facility is outlined in **Table 2**, **Table 3** and **Table 4** . Also included is the 2021 year-to-date (YTD) plant utilisation for the facilities.

Table 2 Summary of the LNG Project - DGC domestic gas facilities, capacity and 2021 YTD utilisation

Processing Plant	Fields	Processing Capacity (TJ/d)	Status	2021 Utilisation
North West Shelf	Various	630[4] (90TJ/d DGC)	online	4% (26%)
Pluto 1	Pluto / Pyxis	25 (plus 15TJ/d LNG trucking)	online	78%
Gorgon	Gorgon / Io Jantz	180 (300 TJ/d from 2022)	online	91%
Wheatstone	Wheatstone / Julimar	205 (200 TJ/d DGC)	online	85% (87%)
Pluto 2	Scarborough	225	FID	N/A

Source: Wood Mackenzie, AEMO WA Gas Bulletin Board and WA Government (Department of Jobs, Tourism, Science and Innovation) and Company reports

The North West Shelf JV (NWS JV) delivered on its original DGC commitment in 2015. The JV entered into a new DGC agreement with the WA Government in 2015 to enable additional LNG exports. This Amendment Agreement reserved ~660 PJ of gas to be produced at an average estimated 90 TJ/d.

The NWS has a domestic gas processing capacity of ~630 TJ/d though is entering into a period of production decline. This will gradually reduce LNG export production and limit the effective production available to the domestic gas plant. A number of large volume, historic domestic gas contracts expired in 2020 which resulted in a significant step down in its domestic gas production. The utilisation of the North West Shelf (based on the Amendment DGC agreement of ~90 TJ/d) was ~26% in 2021 year to date (YTD). Wood Mackenzie understands that there have been some production issues that have contributed to this reduced domestic gas supply. However, in contrast to the other LNG domgas facilities, the North West Shelf has significant spare processing capacity and, subject to upstream production availability, can produce above its nominal DGC commitment during periods if required.

Table 3 Summary of the WA Carnarvon Basin domestic-only gas facilities, capacity and 2021YTD utilisation

Processing Plant	Fields	Processing Capacity (TJ/d)	Status	2021 YTD Utilisation
Varanus Island	John Brookes, Halyard-Spar, Spartan	390	online	70%
Devil Creek	Reindeer	220	online	65%
Macedon	Macedon	220	online	89%

Source: Wood Mackenzie

Devil Creek utilisation fell in 2021 due to upstream supply issues. This resulted in a reserves downgrade by the operator of the facility (Santos).

The Xyris (expansion) and Beharra Springs projects have only recently restarted gas production (in 2020) with the tie-in of new gas production wells. The projects are expected to reach their full production output in 2021.

[4] Whilst the North West Shelf has installed domestic processing capacity of 630 TJ/d, it is unlikely that the Joint Venture will produce up to this level as it faces declining upstream production capacity and will likely seek to maintain LNG output. Wood Mackenzie expects that the Joint Venture will maintain domestic gas production at ~ 90TJ/d.

Table 4 Summary of the Perth Basin domestic gas facilities, capacity and 2021 YTD utilisation

Processing Plant	Fields	Processing Capacity (TJ/d)	Status	2021 YTD Utilisation
Xyris (expansion)	Waitsia	30	online	84%
Beharra Springs	Beharra Springs Deep	20	online	52%
Waitsia	Waitsia	250	Under construction	N/A
West Erregulla	West Erregulla Phase 1	87	Pre-FID	N/A

Source: Wood Mackenzie

Gas processing plant utilisation can be impacted by a number of factors including:

- Upstream production availability and supply (including reserves);
- Processing facility planned and unplanned maintenance;
- Supply contracts – terms and flexibility (ACQ[5], Take-or-pay, swing, contract expiries and re-contracting);
- Equity contracting positions (both the level contracted and the timing of expiry and start of contracts);
- Gas producers portfolio sales versus project specific supply;
- Market supply/demand dynamics (interested/available buyers); and
- Buyer nominations.

These factors will result in a lower sales volume on average over a year compared to the installed processing plant capacity (plant utilisation).

The LNG projects will provide material, long-dated (~20 years) domestic gas supply volumes through their respective DGC's. The domestic-only projects gas supply outlook, however, is more uncertain. These projects are at different levels of production maturity and depletion of their reserves. The Santos-operated facilities (Varanus Island, Macedon and Devil Creek) require additional gas fields to be developed in order to backfill and prolong domestic gas production to the market. Santos has recently installed inlet compression at Varanus Island and is developing the Spartan gas field to provide enhanced gas production from Varanus Island. However, in February 2021, it announced a reserves downgrade (due to early water breakthrough) of their Reindeer gas field (Devil Creek production). This is expected to result in the field ceasing production as early as 2024 (Wood Mackenzie indicative forecast). Overall, domestic-only gas production in the Carnarvon Basin is expected to decline rapidly in the later part of this decade, unless additional gas fields are developed.

The Perth Basin has shown promising signs through gas exploration in recent years. Discoveries at Waitsia, Beharra Springs Deep, West Erregulla, Waylering and Lockyer Deep have provided encouragement to the market of a potentially material gas producing province. But the near term development of this gas resource for the domestic gas market is still uncertain from a timeline perspective.

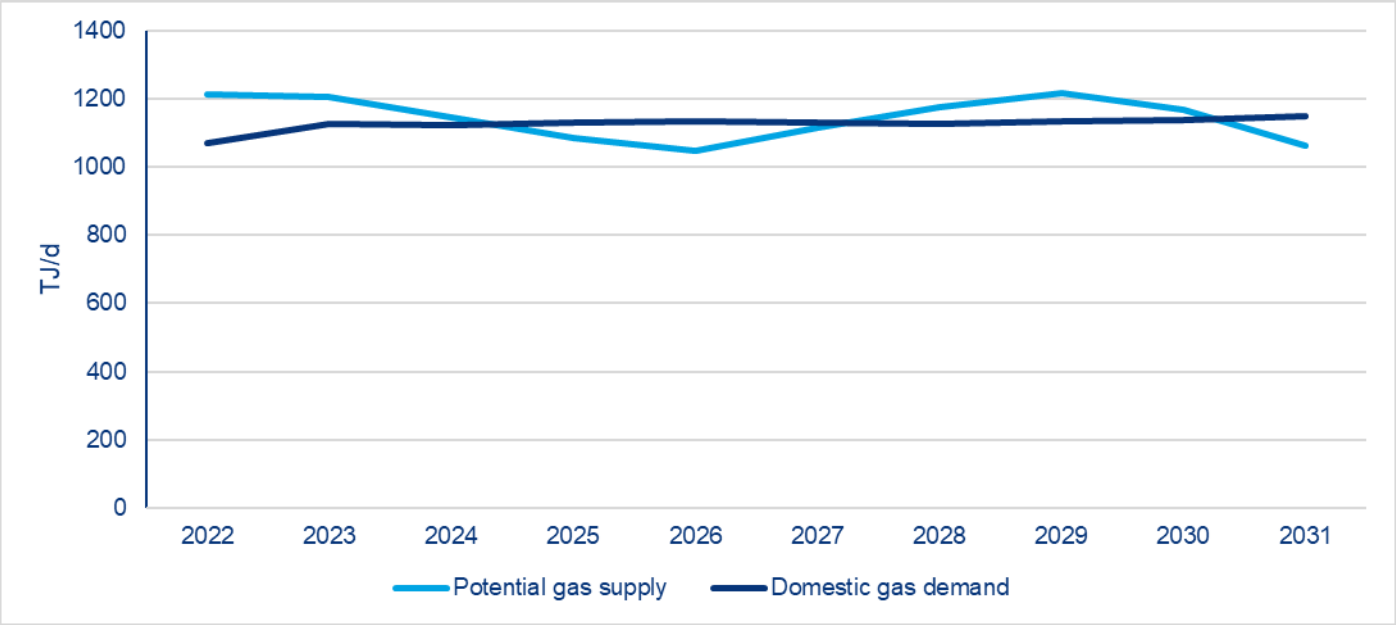
The Waitsia Phase 2 gas project is being developed for LNG export through to the end of 2028 (before remaining volumes then being diverted fully to the domestic gas market). Smaller gas supply additions are flowing into the domestic gas market from Waitsia Phase 1 and Beharra Springs Deep. West Erregulla Phase 1 development has slipped from initial timing plans. Waylering and Lockyer Deep will require further appraisal drilling, testing and/or development studies to be undertaken before these progress.

AEMO's 2021 WA GSOO report forecasts a finely balanced domestic gas market out to 2031, but highlights the risk of a potential gas supply shortfall of 51PJ between 2025 and 2027 (illustrated in **Figure 8)**. The WA GSOO base demand forecast is for average annual gas demand growth of ~0.8% over the period to 2031. The AEMO 2021 WA GSOO highlights the need for additional gas supply to be developed. This additional gas supply is required, not only to fill the potential supply gap in the middle of the decade, but to also provide

[5] ACQ – Annual Contract Quantity

greater redundancy for supply in the gas market to cope with supply interruptions, and support potential new demand developments (as highlighted in Section 1).

Figure 8 AEMO 2021 WA GSOO domestic gas supply demand balance 2022 to 2031



Source: AEMO 2021 GSOO

Increasingly, the development of new gas resources in WA is intrinsically tied to associated downstream project developments. For example:

- Scarborough/Pluto 2 DGC with the Perdaman proposed Karratha Urea project;
- Scarborough/Pluto 2 DGC with the Woodside proposed Kwinana H2Perth project; and
- West Erregulla Phase 2/South Erregulla with Strike Energy's proposed Haber Urea project.

New industrial projects require certainty of gas supply to underpin their development. This certainty comes in the form of a long-term gas contract (~10 to 20 years) at a competitive gas price to ensure the viability of the project development. Similarly, gas producers are also supportive of long-term contracts that help underpin the financing of their supply projects, at a gas price that reflects the cost and risks associated with exploring, developing and producing the resource.

2.2 The Future of Gas in WA

The WA Government's Domestic Gas Policy objective is to secure the state's long-term energy needs by ensuring that gas considered for LNG export includes and reserves a portion for local use and economic development. LNG developers must comply with the policy as a condition of project approval.

Whilst there are four LNG projects currently producing, additional domestic gas agreements have been struck in recent years as a result of extended LNG production beyond initial agreements (e.g. North West Shelf variation agreement) and to incorporate the tolling of gas for LNG exports through the North West Shelf (Waitsia LNG export tolling and Pluto Acceleration tolling). Woodside has also made an additional agreement to supply domestic gas from its equity supply in the North West Shelf that will contribute to its Pluto 1 domestic gas arrangement.

Each agreement /arrangement between LNG exporters and the WA Government differs slightly but all include the following three key elements:

1. Reservation – to reserve a domestic gas portion equivalent to 15% of LNG production,

2. Infrastructure – to develop and maintain access to domestic gas supply infrastructure,
3. Marketing – to show diligence and good faith in marketing gas to WA consumers.

Each agreement/arrangement is project specific and was entered into at different points in time. The terms of each may therefore have slight differences, as the policy (and market) has evolved over the intervening period.

DGC installed processing capacity and production history (from 2016 to present) is illustrated in **Figure 9**.

Figure 9 WA LNG Projects – DGC production (Gorgon, NWS, Wheatstone and Pluto)

Source: Wood Mackenzie; AEMO Gas Bulletin Board

Gorgon, Wheatstone, and Pluto LNG's domestic gas facilities have all produced up to their installed capacities at times. However, the production history shows a high degree of variability. As outlined previously, there are multiple factors contributing to this variable output.

Each project's domestic processing capacity was agreed with the WA Government at project inception, together with its respective DGC reserve volumes. Daily production expectations to meet DGC arrangements broadly align with each facility's production capacity, therefore any daily volumes not produced can only be made up at the end of the agreement and will remain in the ground in the interim period. Production capacity cannot be sustainably exceeded (without expansions or debottlenecking) - effectively extending the time in

which the DGC will be in vigour. It is generally very difficult for LNG and DGC producers to sustainably "catch up" on shortfall production.

The North West Shelf is different to the other LNG projects as it is not constrained by its domestic gas capacity. This is due to having processing capacity installed to meet its initial DGC which far exceeds its current DGC commitment. However, as the project has entered into a period of production decline, its ability to produce higher volumes is ultimately constrained by its upstream supply capacity. Gas tolling and third-party processing does however provide an opportunity for additional domestic gas production through the North West Shelf.

LNG-associated domestic market agreements/arrangements or DGC are an important contributor to the WA domestic gas market. The DGCs have delivered ~50 to 60% of total WA gas supply over the last two decades. The Gorgon and Wheatstone LNG projects are in their sustainable production phases and are expected to contribute domestic gas volumes at their current rates for many years ahead (at least out to ~2040). The North West Shelf LNG Project is entering into the latter stages of its equity resource production. Whilst the North West Shelf will continue to produce from its own equity gas reserves for the next decade or more, it will do so at a lower rate than it has produced in the recent past. This has opened up the opportunity for tolling arrangements with third parties. Two agreements have recently been struck with Woodside (Pluto Acceleration) and the Waitsia JV for this purpose. The potential development of the Scarborough gas field and the associated Pluto 2 LNG train and domestic gas facility will provide an additional source of domestic gas supply to the market (forecast to begin in 2026).

DGC gas supply is expected to continue to supply in the order of 50 to 60% of the WA domestic gas market, at least over the remainder of this decade.

2.3 Supporting new gas supply for the domestic market

WA domestic gas demand is forecast to grow through this decade (2021 to 2030). As outlined in Section 1, the mining, mineral processing and industrial sectors in WA are producing commodities and products that are important for the global energy transition. It is important that WA can continue to contribute to this development and do so whilst reducing its own emissions intensity, and ultimately as a pathway to net zero emissions by 2050 (consistent with the Australian and WA Governments goal / aspirations).

To this end, additional domestic gas supply will be required to support this demand growth. The key areas for potential development of supply are in the Perth Basin and discovered but undeveloped gas resources in the Carnarvon Basin.

Offshore Carnarvon Basin gas discoveries face various impediments to their economic development including increasingly smaller field sizes, greater distance from shore and/or accessible infrastructure, as well as trickier gas compositions (lower associated liquids content, CO_2 and N_2 content and other impurities such as H_2S or mercury). These factors are likely to add to the cost of any new developments.

The Reindeer gas field (supplying gas processed through the Devil Creek facility – owned and operated by Santos) is forecast to cease production as early as 2024. Ullage at the Devil Creek processing plant therefore presents an opportunity to more optimally develop new gas supply – either Santos-owned or third-party gas to be processed through the facility. However, this is not always straightforward, as the upstream gas supply needs to be compatible with the installed processing facility's technical specifications. Whilst additional processing equipment can be installed, this adds to the cost of developments and can ultimately challenge commerciality. That said, utilising existing facilities, where these have spare capacity, should be prioritised over building greenfield facilities. This can also support earlier development timings compared to greenfield developments.

The majority of the gas developed in the Perth Basin and through existing infrastructure in the Carnarvon Basin should focus on meeting any new domestic gas demand.

With the forecast growth in renewable energy potentially seeing domestic gas demand decline in the period 2030 to 2040, gas may increasingly face a need to be developed now or could risk remaining in the ground in the longer term or never be commercialised. New industrial projects can provide the longer-term gas demand certainty to support new domestic gas supply developments, resulting in a win-win outcome for both supplier and consumer.

2.4 Implications for the WA Gas Market

The energy transition to a lower emissions-economy will have a fundamental impact on the WA gas market over time. The domestic gas market is currently showing growth in demand, and there are likely other gas-using projects in the pipeline not identified in this report which could support further gas supply. This growth may at first seem counter intuitive to aspirations for net zero emissions by 2050.

Over time, the role of gas will change, seeing declining demand into GPG as renewable energy and batteries and other technologies take a more prominent role. Gas not utilised now could risk remaining in the ground. Development of new gas supplies (and the economic benefits these bring) should therefore be encouraged, particularly if to increase the utilisation of already installed processing facilities that now have spare capacity (e.g. through third-party tolling). Development of new gas supplies is required in the near term to support both new industrial gas projects, as well as the existing domestic demand. This additional gas supply is also required as existing gas fields deplete and to support the flexibility in the gas deliverability system (as renewable energy grows and gas provides the flexible power generation to support this growth).

The mining, mineral processing and industrial sectors in WA are producing commodities and products that are important for the global energy transition. Domestic gas can support continuing operations from industrial / mining projects, as well as new developments and do so whilst reducing the emissions intensity over time.

Acronyms

Accel.	Acceleration
ACQ	Annual contract quantity
AEMO	Australian Energy Markets Operator
BESS	Battery Energy Storage System
bcf	Billion cubic feet
CCS	Carbon capture and storage
CSBP	Subsidiary of Wesfarmers Chemicals Energy and Fertilisers division
DGA	Domestic Gas Alliance (members include: Alcoa of Australia, Coogee Chemicals, CSBP, Wesfarmers Chemicals, Energy and Fertilisers and Yara)
DGC	Domestic Gas Commitment
DMA	Domestic Market Agreements / Arrangements
e.g.	For example
EPA	Environmental Protection Authority
ESG	Environmental, Social and Governance
ESOO	AEMO's Electricity Statement of Opportunities
Est.	Estimate
FEED	Front-end Engineering and Design
FID	Final Investment Decision
FMG	Fortescue Metals Group
GJ	Gigajoule
GPG	Gas-fired power generation
GSOO	AEMO's Gas Statement of Opportunities - supply and demand report
HOA	Heads of Agreement
H1, H2	First half of the calendar year, second half of the calendar year
Incl.	Including
JOGMEC	Japan Oil, Gas and Metals National Corporation
JTSI	Department of Jobs, Tourism, Science and Innovation
JV	Joint venture
km	Kilometre
LNG	Liquefied natural gas
MOU	Memorandum of Understanding
Mt	Million tonnes
Mtpa	Million tonnes per annum
MW	Megawatt
MWh	Megawatt hour

NWIS	Northwest Interconnect System – the electricity grid in the Pilbara region of WA
NWS	North West Shelf project
PJ	Petajoules
PJ/a	Petajoules per annum
Q1, Q2, Q3, Q4	First quarter, second quarter, third quarter, fourth quarter (calendar year)
SWIS	Southwest Interconnect System – the electricity grid in the southwestern part of WA
tcf	Trillion cubic feet
TJ	Terajoules
TJ/a	Terajoules per annum
WA	Western Australia
WEM	Wholesale Electricity Market
WM	Wood Mackenzie
YTD	Year to date

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