AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

2019 Western Australia Gas Statement of Opportunities

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Important notice

PURPOSE

The purpose of this publication is to provide information about the natural gas industry in Western Australia.

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VERSION CONTROL

Version	Release date	Changes
1.0	13/12/2019	

Executive summary

The 2019 Western Australia (WA) Gas Statement of Opportunities (GSOO) presents AEMO's assessment of WA's domestic gas market for the 10-year outlook period 2020 to 2029. The WA GSOO presents forecasts of WA's domestic gas demand and potential gas supply for the low, base and high scenarios[1], and an overview of gas infrastructure and emerging issues affecting the gas industry, to Gas Market Participants (GMPs) and stakeholders.

Key findings

- In the base scenario, potential gas supply[2] exceeds forecast domestic gas demand over the outlook period, though development of prospective sources is required to maintain supply adequacy.
  - Supply capacity is expected to expand by 126.5 terajoules (TJ)/day by 2021, with the commencement of the Xyris expansion in 2020 and second tranche of Gorgon in 2021.
  - WA domestic gas supply is expected to be underpinned by projects currently under development ("prospective supply"), including Browse, Scarborough, and West Erregulla.
  - Overall, potential gas supply is forecast to decline at an average annual rate of 1.5% between 2020 and 2029, in line with reserve depletion at existing production facilities.
- Gas demand is forecast to grow at an average annual rate of 1.2% in the base scenario, largely due to growth in the mining and minerals processing sectors. This includes six committed projects[3] that are expected to add 60 TJ/day to domestic demand by 2023.
  - Strong global demand for battery-related commodities, including lithium, cobalt, and nickel, is expected to drive gas demand growth in the mining sector. Mining sector gas demand is forecast to grow at an average annual rate of 1.1% over the outlook period.
  - The staged retirement of two units at the coal-fired Muja C power station (unit 5 from October 2022 and unit 6 from October 2024)[4] will be offset by increasing small and large-scale renewable generation capacity that is expected to commence in 2020. However, the retirement is likely to increase gas demand for electricity generation in the South West interconnected system (SWIS) over the outlook period.
- In the high scenario, prospective demand projects[5] could consume up to an additional 168 TJ/day by 2025, increasing WA's gas demand by around 17% to 1,332 TJ/day. However, potential gas supply in the high scenario is forecast to be sufficient to meet this additional demand for the majority of the outlook period.

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[1] In this executive summary, all references to forecasts are to the base scenario, unless otherwise specified.

[2] AEMO forecasts the potential availability of supply to the WA domestic market ("potential gas supply") as gas that could be economically offered to the domestic market given forecast prices and production costs, capped by the availability of processing capacity and gas reserves. The model does not project how much gas *will* be produced, but how much *could* be produced if there was demand at the forecast price, and distinguishes between existing, committed, and prospective projects by triggering prospective projects when the domestic gas price or Asian LNG price exceeds production costs.

[3] Committed projects are included in all three demand scenarios.

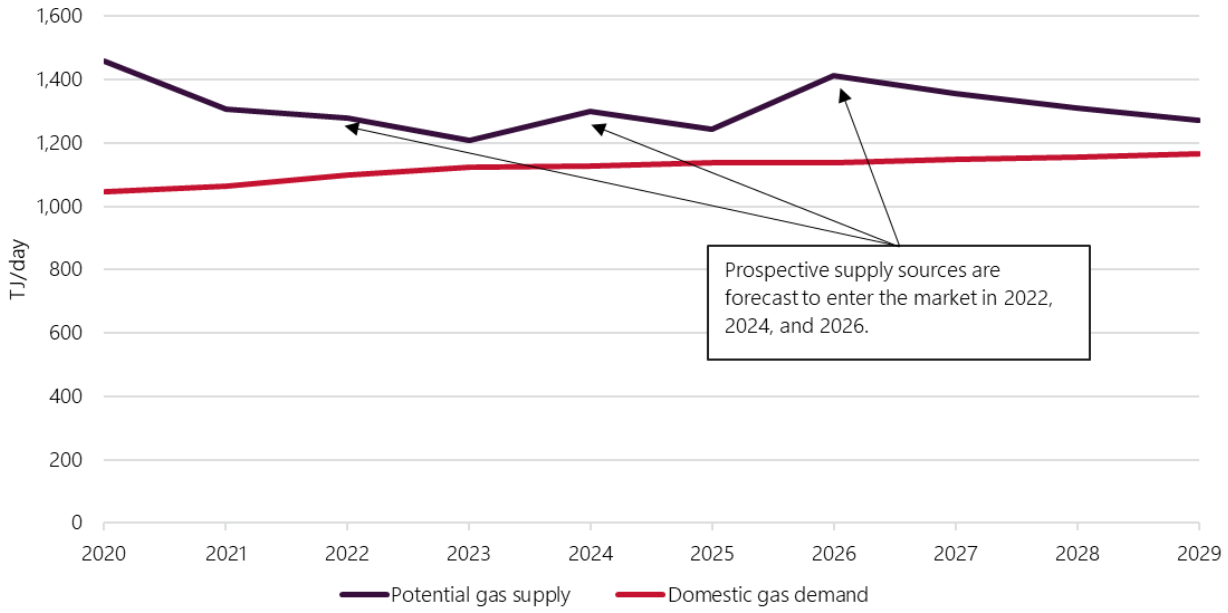
[4] WA Government: "Muja Power Station in Collie to be scaled back from 2022", media statement, 5 August 2019, at https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/08/Muja-Power-Station-in-Collie-to-be-scaled-back-from-2022.aspx.

[5] Prospective gas demand projects are only included in the high scenario and must meet set criteria. These include projects that may switch from diesel to gas electricity generation.

Potential gas supply is expected to exceed forecast gas demand over the outlook period

Potential gas supply is expected to exceed forecast gas demand over the outlook period, as shown in Figure 1 and Table 1.

Figure 1 Base scenario WA gas market balance (TJ/day), 2020 to 2029



Potential gas supply is forecast to decline at an average annual rate of 1.5% over the outlook period, in line with reserve depletion at existing production facilities. Prospective supply sources are expected to be available and economically viable[6] to enter the market in 2022, 2024 and 2026, partly offsetting the decline in potential gas supply from existing production facilities.

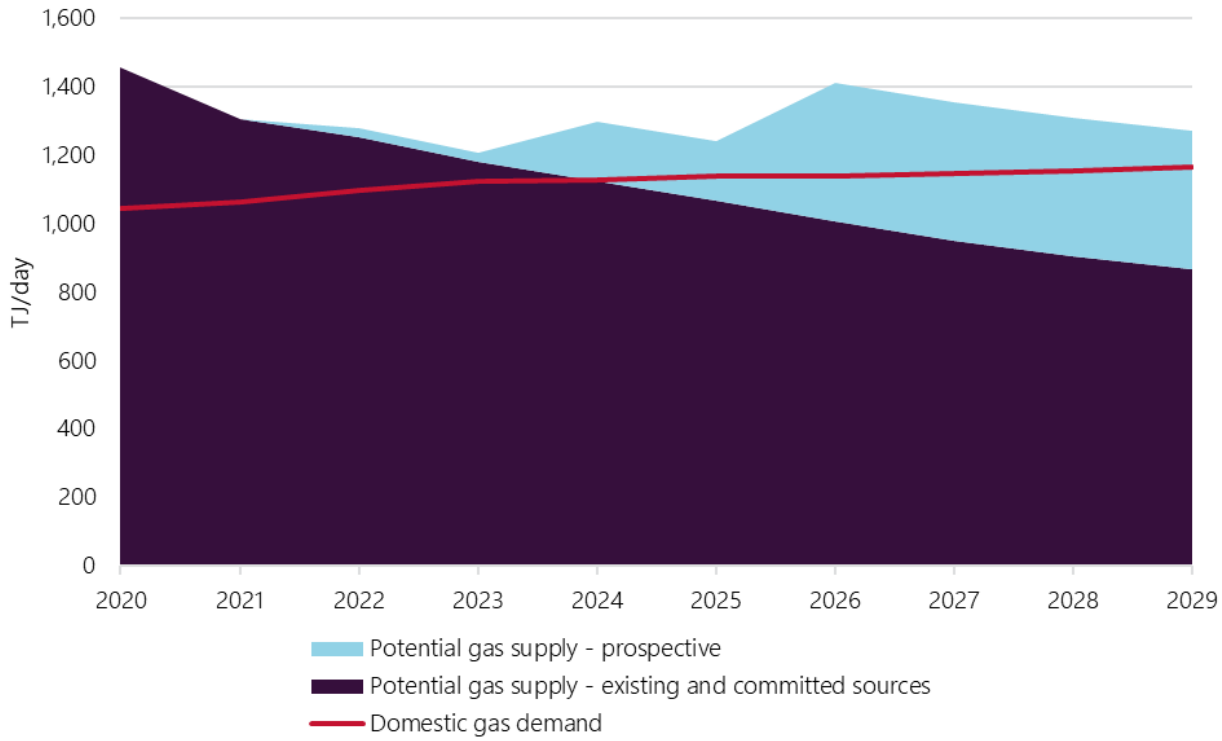
Table 1 Base scenario WA potential gas supply and demand forecasts (TJ/day), 2020 to 2029

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Potential supply	1,458	1,307	1,280	1,207	1,299	1,243	1,411	1,357	1,311	1,272	-1.5	-2.8
Demand	1,046	1,065	1,098	1,124	1,128	1,139	1,138	1,148	1,154	1,165	1.9	1.2

The development of prospective gas supply sources is required to maintain supply adequacy over the outlook period, as shown in Figure 2. In contrast to the base scenario, if prospective supply sources are not developed, AEMO forecasts a supply deficit of 4 TJ/day in 2024, with the deficit increasing over the outlook period to 299 TJ/day in 2029.

[6] AEMO's potential gas supply model triggers new domestic-only projects if the forecast WA domestic gas price exceeds the long-run cost (LRC) of production, while LNG-linked projects commence if the forecast Asian LNG price is higher than their LRC. Where appropriate, prospective supply sources are assumed to backfill existing domestic gas production facilities.

Figure 2 Potential supply compared to gas demand under the base scenario, 2020 to 2029



Prospective gas supply sources are necessary to offset falling output from existing gas production facilities

In 2019, two new gas supply sources added 245 TJ/day of gas supply capacity to the WA domestic gas market. The Wheatstone production facility (205 TJ/day) commenced in March 2019, while Pluto began directly injecting up to 25 TJ/day into the domestic pipeline in December 2018 and started its domestic liquefied natural gas (LNG) truck-loading facility (15 TJ/day) in April 2019.

An additional 126.5 TJ/day of gas supply capacity is expected to become available by 2021 from two committed projects:

1. An expansion of the Xyris production facility from 11.5 TJ/day to 20 TJ/day in 2020.
2. The second tranche from the Gorgon domestic gas plant (118 TJ/day) in 2021.

From 2022, prospective supply sources could add up to 405 TJ/day to potential gas supply if they are built. The West Erregulla domestic gas-only project is expected to commence in 2022 at a capacity of 25 TJ/day. Scarborough (150 TJ/day from 2024) is proposed to be developed through an expansion at Pluto, while Browse (230 TJ/day from 2026) is expected to be connected to the existing Karratha Gas Plant, where spare LNG capacity may become available as early as 2021[7].

The potential gas supply forecasts are shown in Table 2. In summary:

- AEMO forecasts potential gas supply from existing gas production facilities to decline over the outlook period, in line with reserve depletion assumptions.

[7] In accordance with WA's domestic gas policy, LNG projects must reserve and actively market 15% of LNG production for the domestic market. See https://www.jtsi.wa.gov.au/economic-development/economy/domestic-gas-policy. AEMO has estimated the expected domestic market obligation quantities for these projects.

- Potential gas supply volumes are the same in all three scenarios (low, base, and high[8]) in 2020 and 2021, reflecting the availability of only existing and committed gas production facilities.
- In the low scenario, LNG and domestic gas prices are sufficient to trigger one prospective supply project, but potential gas supply still declines at an average annual rate of 5.2% between 2020 and 2029.
- The base and high scenarios are similar because the same prospective supply sources are triggered in both scenarios, but at slightly different levels[9].

Table 2 Potential gas supply forecasts (TJ/day), 2020 to 2029

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Low	1,458	1,307	1,280	1,209	1,155	1,102	1,047	991	942	902	-5.7	-5.2
Base	1,458	1,307	1,280	1,207	1,299	1,243	1,411	1,357	1,311	1,272	-2.8	-1.5
High	1,458	1,307	1,328	1,255	1,346	1,277	1,447	1,395	1,350	1,314	-2.0	-1.1

AEMO notes that there is a large volume of undeveloped gas that could supply the WA domestic market during the outlook period, but this volume is currently too speculative to include in the potential supply forecasts. These sources include Clio-Acme, Equus[10], and Corvus. AEMO will continue to monitor these projects and may include them in future WA GSOOs.

Committed and prospective gas-consuming major projects could increase WA's domestic gas demand by more than 20% by 2025

WA's domestic gas demand is forecast to increase at an average annual rate of 1.2% over the outlook period, from 1,046 TJ/day in 2020 to 1,165 TJ/day in 2029. Forecast growth in domestic demand, as shown in Table 3, is underpinned by:

- Four[11] resources projects that are either committed or currently under construction, which are expected to add 62 TJ/day to gas demand by 2023 in all three scenarios.
- Strong global demand for battery-related commodities, including lithium, cobalt, and nickel, is expected to drive general mining sector gas demand growth at an average annual rate of 1.1% over the outlook period.
- On average over the outlook period, gas demand from gas-powered generation (GPG) in the SWIS[12] is expected to grow at an average annual rate of 1.2% in the base scenario, from 112 TJ/day in 2020 to 125 TJ/day in 2029. Between 2020 and 2021, gas demand from GPG is expected to decrease by 5.3%. This is primarily due to the displacement of generation caused by an additional 528 MW of intermittent

[8] Assumptions about domestic gas and Asian LNG prices vary between scenarios.

[9] In the high scenario, prices are expected to be high enough to encourage expansion of one prospective supply project.

[10] Equus was included in prospective supply forecasts in the 2018 WA GSOO but has been removed from the prospective supply forecasts for the 2019 WA GSOO due to project delays and uncertainty about the development path.

[11] Includes two projects that have taken final investment decision since the 2018 WA GSOO was published. Of the nine projects included in the 2018 WA GSOO, five have been completed, three retained for the 2019 WA GSOO, and one removed as it will use diesel instead of gas. See page 22 of the 2018 WA GSOO for the full list of projects, at https://aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/WA_GSOO/2018/2018-WA-GSOO.pdf.

[12] Some SWIS GPG (e.g. Alinta's Pinjarra cogeneration) is classified as minerals processing, mining, or industrial and is excluded from SWIS GPG gas demand. For a full description of how AEMO classifies facilities, see Appendix A5.

utility-scale renewable energy capacity[13] and an expected 1,504 MW of behind the meter photovoltaics (PV) by June 2021. From 2024, the retirement of the Muja 5 and 6 coal fired units, combined with increasing generation variability[14] due to the continued uptake of large-scale and behind-the-meter PV, is expected to require greater utilisation of GPG in the SWIS. As a result, gas demand for GPG is forecast to grow by around 15% between 2024 and 2029 in the base scenario.

- The addition of 10 prospective demand projects in the high scenario totalling 168 TJ/day of gas demand by 2025.

As an improvement to gas demand forecasting, AEMO has included two projects that are expected to reduce gas demand by around 2.5 TJ/day by 2021 in all three gas demand scenarios, partially offsetting the expected growth. There are currently several additional projects[15] that may reduce gas demand but have not yet taken final investment decision. AEMO will continue to monitor these projects and will include them in future WA GSOOs if they become committed.

Table 3 Domestic gas demand forecasts (TJ/day), 2020 to 2029

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Low	1,033	1,050	1,079	1,103	1,105	1,092	1,092	1,098	1,102	1,108	1.7	0.8
Base	1,046	1,065	1,098	1,124	1,128	1,139	1,138	1,148	1,154	1,165	1.9	1.2
High	1,081	1,128	1,157	1,187	1,256	1,332	1,327	1,338	1,344	1,355	3.8	2.5

[13] Including Yandin wind farm (214 MW), Warradarge wind farm (184 MW), Merredin solar farm (100 MW), and an upgrade to the Greenough solar farm (30 MW).

[14] The difference between minimum and peak demand in the SWIS is widening with increasing uptake of behind the meter PV and large-scale solar. This, combined with increased intermittent wind generation, requires generation (usually GPG) that is capable of rapidly increasing output ("ramping") over a short period of time to meet evening peak demand.

[15] These include ATCO's hydrogen microgrid, Yara Pilbara's feasibility study into using hydrogen to produce ammonia, and the Murchison Renewable Hydrogen Project.

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1. Year in review

This chapter provides a snapshot of events in the Western Australia (WA) gas market since the 2018 WA Gas Statement of Opportunities (GSOO) publication[16]. References for this chapter are provided in Appendix A1.

1.1 Supply

- Two projects started supplying the domestic gas market in the first half of 2019:
  - Wheatstone, with a total capacity of 205 terajoules (TJ)/day.
  - Pluto, including 25 TJ/day of domestic pipeline gas and up to 15 TJ/day from the domestic liquefied natural gas (LNG) trucking facility.
- Santos Limited (Santos) discovered Corvus, a gas reservoir in the Carnarvon basin.
- Woodside Energy (Woodside) announced delays to tolling arrangement negotiations for the Browse Project. Woodside is targeting a final investment decision (FID) in the first half of 2021.
- Woodside took FID on the Pyxis Hub project, which will develop the Pyxis gas field as well as drilling additional wells at Pluto North and Xena as backfill to the Pluto LNG facility.
- Mitsui E&P Australia (Mitsui) and Beach Energy's Waitsia Gas Project (connected to the Xyris plant) will double its capacity to 20 TJ/day by late 2020, supported by a gas sales contract with Alinta Energy. Mitsui is seeking environmental approvals from the Environmental Protection Authority (EPA) for Waitsia Stage 2 (up to 250 TJ/day).
- Strike Energy and Warrego Energy made a gas discovery in the Perth basin (West Erregulla) in August 2019. Drilling has confirmed the size of the resource is 1,257 petajoules (PJ)[17].
- Santos and Carnarvon Petroleum confirmed further discoveries of gas in the Dorado oil and gas field.
- Design and construction activities for the Hazer Commercial Demonstration Project commenced in July 2019, with operations expected to commence from January 2021.
- The Department of Primary Industries and Regional Development published the 'Western Australian Renewable Hydrogen Strategy' in July 2019, to focus on establishing industries that support the production and handling of 'green' hydrogen in WA.
- Beach Energy discovered gas in the Perth Basin at the Beharra Springs Deep-1 well.
- Drilling is underway on the Waukarlycarly well project in the South West Canning Basin. Geoscience Australia estimates there are recoverable shale gas resources of 390 trillion cubic feet (tcf) with additional potential for tight gas resources of 48.5 tcf.

[16] Including some activities that occurred late in 2018.

[17] Calculated by AEMO. The size of the resource reported by Strike Energy is 1,185 billion cubic feet.

1.2 Infrastructure

- The State Government announced plans for a world-first micro-scale LNG plant with a capacity of 10 tonnes per day, as part of an LNG Futures Facility in Kwinana.
- Woodside took FID on a 3.3 km pipeline connecting the Pluto Compressor Station to the Karratha Gas Plant (KGP) (referred to as the Pluto-KGP interconnector).

1.3 Demand

- Fortescue Metals Group (FMG) approved the second stage of the 22 million tonnes per annum (mtpa) Iron Bridge magnetite project[18] and the 30 mtpa Eliwana project[19].
- AngloGold Ashanti and Independence Group approved an expansion of the Tropicana gold mine, which is expected to be commissioned in mid-2020. Additional power requirements will be met by increasing the gas-fuelled power station capacity to 50 megawatts (MW).
- Woodside and Chevron Australia entered into a long-term gas supply agreement with the Worsley Alumina Joint Venture for the supply of approximately 40 PJ and 60 PJ of natural gas, respectively.
- Gold Fields Group (Gold Fields) is developing a hybrid renewable energy microgrid at its Agnew Gold Mine in the northern Goldfields. The microgrid will have a total installed capacity of 54 MW upon completion in 2020.
- Alinta Energy will develop a solar gas hybrid project to power FMG's Chichester mining hub. Construction is expected to commence in late 2019 and be completed in mid-2021.
- The lithium industry is experiencing a short-term dip in market conditions. As a result:
  - Neometals decided to delay further evaluation of a proposed lithium refinery operation in Kalgoorlie.
  - Albemarle Corporation decided to reduce the Kemerton lithium processing plant[20] from 75,000 tonnes per annum (tpa) (stage 3-5) to 50,000 tpa (stage 1 and 2). Stage 1 and 2 of the construction of the processing plant is anticipated to be commissioned in 2021.
  - The Talison lithium mine expansion in Greenbushes has temporarily been placed on hold.
  - The Wodgina lithium project completed construction of a spodumene concentrate plant and an infrastructure upgrade including a new 81 km gas pipeline, and a 64 MW gas-fired power station. The project, however, will be placed on care and maintenance by December 2019.
  - Tianqi Lithium Australia Pty Ltd has put construction of stage 2 of the Kwinana lithium hydroxide plant on hold. Stage 1 construction of the plant achieved practical completion in October 2019.
- Covalent Lithium Pty Ltd (Covalent Lithium) has received Ministerial approval to develop a mine, concentrator, and refinery for the Mt Holland Lithium project, with an FID expected in early 2020.
- Kalium Lakes Ltd took FID on 3 October 2019 for the Beyondie sulphate of potash project. Production will commence in late 2020.
- Rio Tinto Ltd (Rio Tinto) has approved an investment in the Western Turner Syncline Phase 2 mine. Rio Tinto will continue to assess renewable energy solutions. Construction will commence early 2020, subject to regulatory approvals.

[18] The Iron Bridge Project Stage 2 requires up to 225 MW of power. FMG will source power from the Solomon Power Station and new generation and transmission sources.

[19] FMG is considering four options for power supply. The Eliwana Project is estimated to require 122,640 megawatt hours (MWh) of electricity per annum. Two of the options include construction of a new gas-fired power station at Eliwana with a nominal capacity of 25 MW and a new underground gas pipeline to connect to either the Goldfields Gas Pipeline or Fortescue River Gas Pipeline.

[20] At full capacity, 2,300 kg/hr of natural gas will be combusted for the production of steam in five boilers (one for each of the five processing trains).

1.4 Regulatory

- Goldfields Gas Transmission Pty Ltd and ATCO Gas Australia Pty Ltd (ATCO) submitted their revised access arrangements for the Goldfields Gas Pipeline and Mid-West and South-West Gas Distribution Systems respectively, for the period 2020 to 2024, to the Economic Regulation Authority (ERA). The ERA did not approve ATCO's proposed changes to the access agreement and published a revised agreement. A final decision on the Goldfields Gas Pipeline access agreement is still pending.
- The State Government submitted legislation to Parliament to allow the KGP to continue to process gas for a further 25-year term.
- The State Government will introduce a new royalty arrangement as soon as practicable to encourage downstream processing and manufacturing of lithium in WA.

2. Gas demand

In the base scenario, AEMO forecasts domestic gas demand to grow at an average annual rate of 1.2%. This growth is underpinned by the mining sector and new major projects, including six committed projects that are expected to add 60 TJ/day to domestic demand by 2023. Following a short-term dip in demand for battery-related commodities, including lithium, cobalt, and nickel, strong global demand in the medium term is expected to drive gas demand growth in the mining sector as gas is used for electricity generation for these projects.

2.1 Historical WA domestic gas demand

2.1.1 Overview, historical characteristics, and comparisons

The WA gas market has been shaped by its unique combination of geographic isolation and very large gas resources suitable for LNG development that are remote from large population centres.

In the 1980s, WA Government policy promoted the development of gas fields in the North West Shelf (NWS). The state-owned utility, the State Energy Commission of Western Australia, signed a large gas supply contract and constructed the Dampier to Bunbury Natural Gas Pipeline[21].

The WA domestic gas market is characterised by:

- Bilateral, confidential, long-term take-or-pay gas sales contracts.
- Residential, commercial, and small industrial consumers comprising a small proportion of total demand.
- A small number of transmission pipelines, interconnectors, and limited surplus pipeline capacity.
- Small volumes of short-term and spot gas sales.
- Limited transparency into the state of the market, such as the availability of new supply or potential buyers[22].

In contrast, the east coast market, which includes New South Wales, Queensland, South Australia, Victoria, and Tasmania, is characterised by:

- Smaller gas reserves which are predominantly located onshore.
- Active short-term gas hubs which provide greater price discovery and trading flexibility.
- Over 200 PJ of gas storage capacity[23].

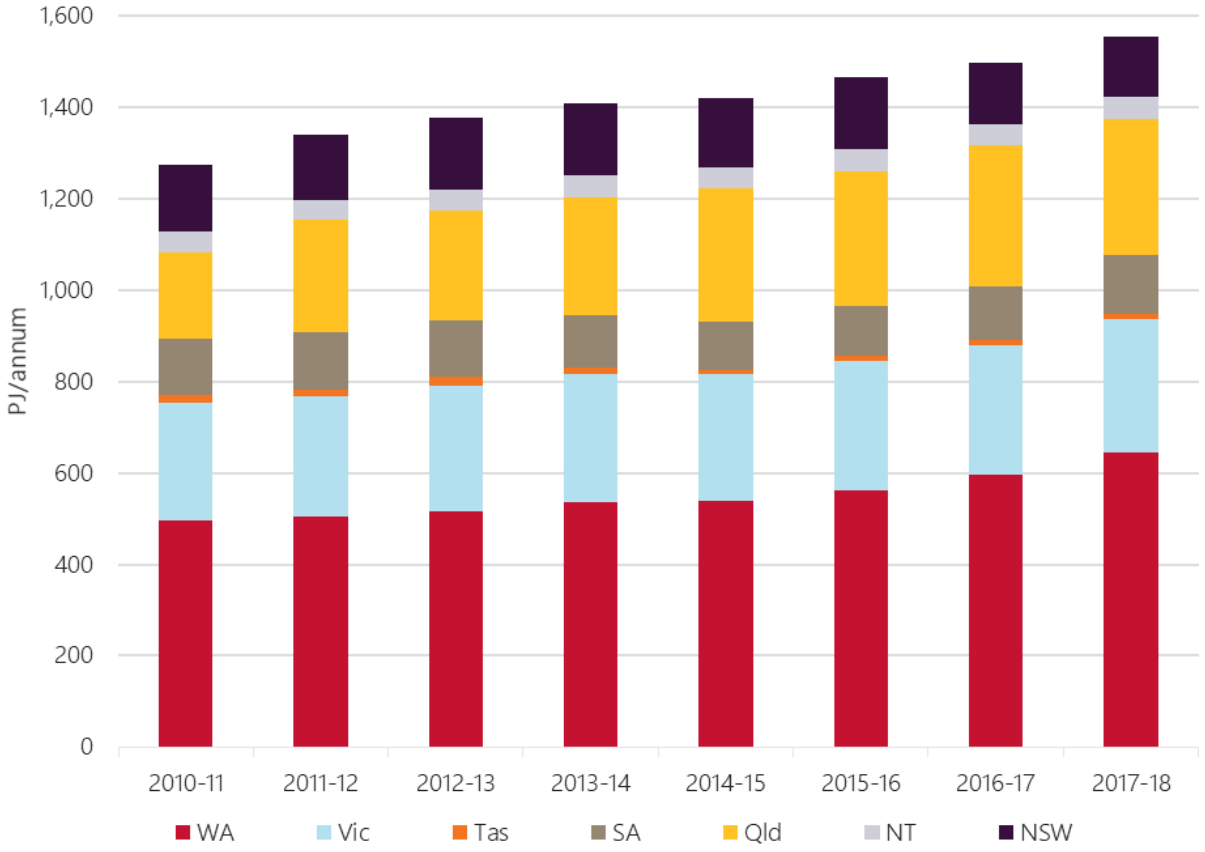
[21] Later renamed the Dampier Bunbury Pipeline.

[22] Adapted from Wood Mackenzie. *Western Australia Gas Market Study*, Final Report, 26 March 2010, Attachment 1, North West Shelf Project Application to the ACCC for exclusionary provisions and associated cartel provisions: Application for Authorisation, at http://registers.accc.gov.au/content/index.phtml/itemId/922104/fromItemId/401858/display/application.

[23] Core Energy Group. *Gas Storage Facilities Eastern and South Eastern Australia*, p. 9, at: https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2015/Core--Gas-Storage-Facilities.pdf.

WA has the highest natural gas consumption of all Australian states, despite its relatively small population. WA consumed 644 PJ of gas in 2017-18, approximately 41% of Australia's total gas consumption (shown in Figure 3)[24].

Figure 3 Gas consumption by state (PJ/annum), 2010-11 to 2017-18

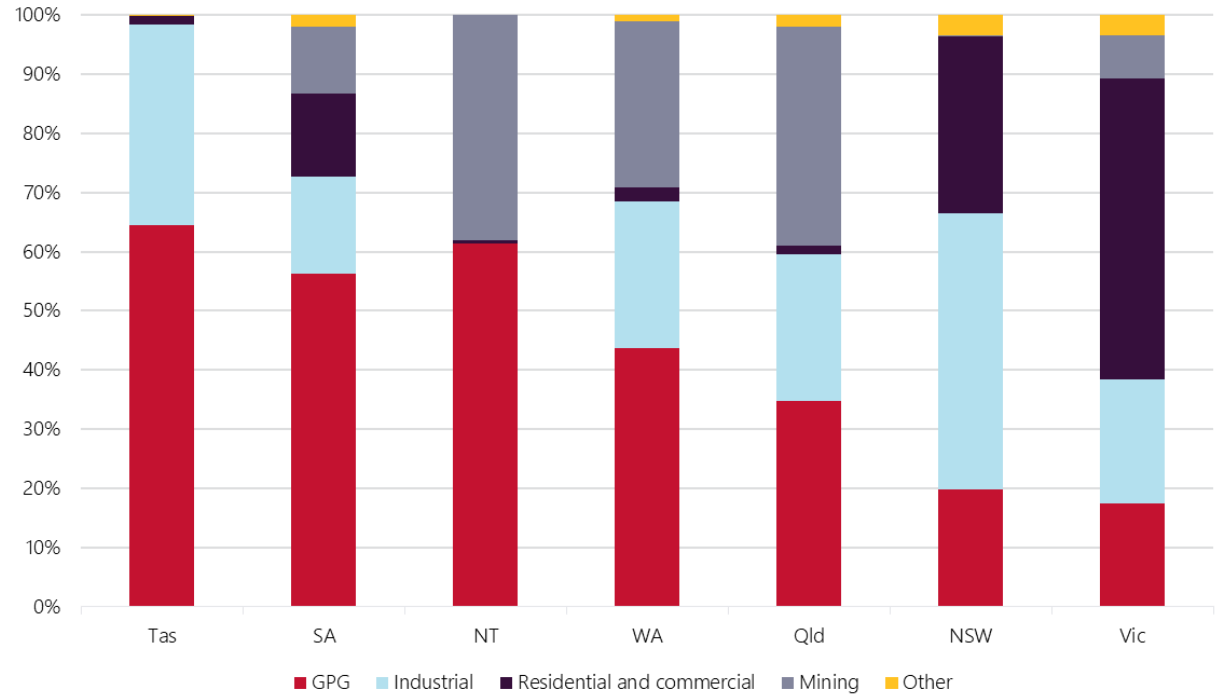


Source: Department of Environment and Energy.

Figure 4 presents a comparison of gas consumption by category across Australian states and the Northern Territory. Notably, WA has a relatively low proportion of residential and commercial gas consumption compared to South Australia (14%), New South Wales (30%), and Victoria (51%).

[24] The data used for Figure 3 and Figure 4 is sourced from the Department of Environment and Energy. *Australian Energy Update 2019 – Australian Energy Statistics (AES)*, September 2019, at https://www.energy.gov.au/publications/australian-energy-update-2019. The AES data includes gas used in petroleum extraction and processing, pipeline shipping and transmission, compression, gas storage, and marine applications. These classifications differ from those used in the WA GSOO report, which only considers gas consumed from the pipeline transmission system.

Figure 4 Major category gas consumption by state (% share of total), 2017-18



Source: Department of Environment and Energy.

Consumption of WA gas in 2017-18 was from:

- Gas-powered generation (GPG) – 44%[25].
- Mining – 28%.
- Industrial and minerals processing sector – 25%.
- Residential and commercial – 2%.
- Other – 1%.

2.1.2 Large customers supplied through the transmission network

Large customers[26] are supplied directly through the transmission network (such as the Dampier Bunbury Pipeline [DBP] and the Goldfields Gas Pipeline). Some smaller remote customers are supplied by domestic LNG facilities, which convert natural gas to LNG that is then transported by road.

Large customers include:

- Mine sites such as iron ore, gold, and nickel mines.
- Mineral processing facilities such as alumina refineries and nickel smelters.
- Electricity generation from GPG, mainly located in the North West Interconnected System (NWIS) and the South West interconnected system (SWIS).
- Industrial large users like brickworks, cement manufacturers, and chemicals plants.
- Producers of domestic LNG, compressed natural gas, and liquefied petroleum gas (LPG).
- Petroleum processing facilities.

[25] Including generation for mining and minerals processing.

[26] Gas customers using 10 TJ/day or more.

Based on WA Gas Bulletin Board (GBB)[27] data, in 2018-19, large customers[28] accounted for 86% of gas used in WA, the majority of which was consumed in the minerals processing (32% of large customer use), mining (27%), and electricity generation (27%) sectors.

2.1.3 Customers supplied through the distribution network

Customers supplied through the retail distribution network account for 7% of WA's total domestic gas consumption. The total number of residential and non-residential customers supplied through the distribution network, and customer transfers between retailers between the 2014-15 and 2018-19 financial years are shown in Table 4.

The annual growth in customer numbers has fallen across this period, which may be attributed to the slowing of both population growth and dwelling completions. Average usage per connection has fallen due to increasingly efficient gas appliances, smaller household sizes, and increasing competitive substitutes from alternative energy sources such as electricity[29].

Customer churn has increased, from 5% in 2014-15 to 16% in 2018-19. Before 2013, Alinta was the only residential and small business retailer. The distribution gas market has since expanded to include Kleenheat, Origin, AGL, and Engie (as Simply Energy), which has progressively led to growth in customer churn to similar levels observed in the competitive eastern states market[30].

Table 4 Residential and non-residential retail customer numbers, 2014-15 to 2018-19

Financial year	Total number of customers		Existing customer transfers	
	Number	Growth	Number	Churn[A]
2014-15	717,439	N/A	37,196	5%
2015-16	738,835	3%	54,103	7%
2016-17	752,454	2%	95,845	13%
2017-18	761,734	1%	112,089	15%
2018-19	771,415	1%	119,884	16%

A. Calculated by dividing the number of customers changing retailer by the total number of customers for a given financial year.

The annual market share of retailers servicing the non-residential distribution market (which represents customers connected to the distribution networks that use more than 1 TJ per year) has seen some movement. Alinta's customer share has decreased by 31% since the 2014-15 financial year, but it remains the largest provider by number of customers. Perth Energy's share of the market almost doubled between 2017-18 and 2018-19.

2.2 Domestic gas demand forecasts

2.2.1 Forecasting scenarios

The annual domestic gas demand forecasts are provided by calendar year (average TJ/day) over the outlook period (2020 to 2029) and split into three scenarios – low, base, and high. These scenarios reflect varying

[27] The WA GBB is a public website (at https://gbbwa.aemo.com.au) that publishes forecast and historical data on the domestic production, transmission, storage, and usage of natural gas in WA.

[28] Excludes gas consumed by petroleum processing, which is not reported to the GBB as it is used 'behind the fence'.

[29] ATCO. *2020-24 Plan: Access Arrangement Information for ATCO's Mid-West and South-West Gas Distribution System*, 31 August 2018, p. 57-8, at https://yourgas.com.au/wp-content/uploads/2018/09/ATCO-2020-2024-Plan-1.pdf?utm_source=plan_downloads&utm_medium=2020-24_Plan_page.

[30] A comparison of churn rates between states across the 2018-19 financial year is available at: https://www.aemo.com.au/-/media/Files/Gas/Retail_Markets_and_Metering/Data/2019/Gas-Monthly-Retail-Transfer-Statistics---July-2019.pdf.

views on the economic outlook, population growth, commodity production, and gas prices. The high gas demand scenario includes prospective demand projects[31].

Scenario assumptions specific to GPG gas demand are dependent on the electricity demand forecasts presented in the 2019 Wholesale Electricity Market (WEM) Electricity Statement of Opportunities (ESOO)[32], as well as the expected generation mix in the SWIS over the outlook period.

Further information about the methodology and assumptions underpinning the GPG and gas demand scenarios are outlined in Appendix A3.2.1.

2.2.2 Gas demand forecasts by scenario

AEMO forecasts domestic gas demand to grow at an average annual rate of 1.2% in the base scenario, underpinned by general demand growth in the mining sector and new major projects.

Specifically, all scenarios assume that the following committed mining and mineral processing projects will contribute approximately 62 TJ/day of gas demand over the outlook period:

- BHP's South Flank project, due to commence operation in 2021[33].
- Rio Tinto's Koodaideri iron ore project, with first production planned for late 2021[34].
- Albemarle Corporation's Kemerton lithium processing plant, near Bunbury, scheduled to commence in 2021[35].
- FMG's Iron Bridge magnetite processing project (stage 2), due to commence in mid-2022[36].

Partially offsetting the above projects, all scenarios assume that the following two committed projects will reduce existing gas demand by approximately 2.5 TJ/day over the outlook period:

- Gold Field's Agnew Gold Mine renewable energy microgrid, expected to be completed in 2020[37]. Renewable power generation from the project is anticipated to reduce existing gas demand by approximately 0.5 TJ/day.
- Hazer Group's biogas to hydrogen and graphite project, expected to reduce existing gas consumption by approximately 2 TJ/day, beginning in 2020[38].

In all scenarios, non-SWIS GPG (including towns like Port Hedland, Karratha, Carnarvon, and Exmouth, but excluding mining GPG) represents roughly 20% of total GPG usage (3-4% of total domestic gas demand). However, limited growth has been identified in this area since electricity consumption in these towns is expected to remain relatively stable. Further discussion on the projected outlooks for individual gas use sectors is provided in Section 2.2.3.

The gas demand forecasts under the low, base, and high scenarios are presented in Figure 5 and Table 5.

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[31] Prospective gas demand projects may be developed over the outlook period, or may switch from diesel to gas. To be included in the high scenario, they must meet set criteria, as defined in Appendix A3.2.1.

[32] For further information about the electricity forecasts, see https://aemo.com.au/Electricity/Wholesale-Electricity-Market-WEM/Planning-and-forecasting/WEM-Electricity-Statement-of-Opportunities.

[33] Government of Western Australia. "Minister Johnston launches accommodation village in the Pilbara", Media statement, 6 August 2019, at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/08/Minister%20Johnston%20launches%20accommodation%20village%20in%20the%20Pilbara.aspx.

[34] Rio Tinto. "Interim Results 2019", 1 August 2019, at: https://www.riotinto.com/documents/190801_Rio_Tinto_2019_half_year_results.pdf.

[35] Australian Mining. "Metso awarded major Albemarle contract at Kemerton lithium plant", 19 April 2019, at: https://www.australianmining.com.au/news/metso-awarded-major-albemarle-contract-at-kemerton-lithium-plant/.

[36] Fortescue Metals Group Limited. "US$2.6 billion Iron Bridge Magnetite Project approved", Announcement, 2 April 2019, at: https://www.fmgl.com.au/docs/default-source/announcements/iron-bridge-project-approval.pdf?sfvrsn=8cdff6a3_4.

[37] Australian Renewable Energy Agency, "Gold Fields gold mine to be powered with wind, solar, and battery", 19 June 2019, at: https://arena.gov.au/news/gold-fields-gold-mine-to-be-powered-with-wind-solar-and-battery/.

[38] Australian Renewable Energy Agency. "World-first project to turn biogas from sewage into hydrogen and graphite", Media Release, 2 September 2019, at: https://arena.gov.au/assets/2019/09/ARENA-Media-Release_Hazer-WA-Hydrogen-Production-Facility-from-Wastewaster-Biogas-020919.pdf.

Figure 5 Domestic gas demand forecasts (TJ/day), 2020 to 2029

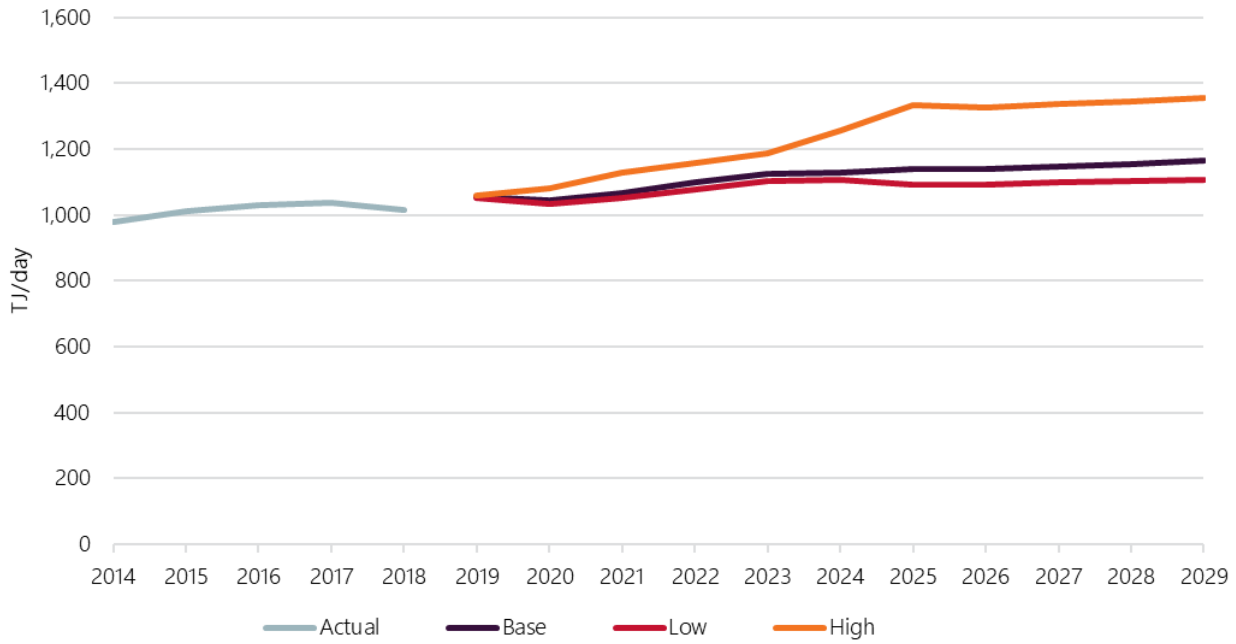


Table 5 Domestic gas demand forecasts (TJ/day), 2020 to 2029

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Low	1,033	1,050	1,079	1,103	1,105	1,092	1,092	1,098	1,102	1,108	1.7	0.8
Base	1,046	1,065	1,098	1,124	1,128	1,139	1,138	1,148	1,154	1,165	1.9	1.2
High	1,081	1,128	1,157	1,187	1,256	1,332	1,327	1,338	1,344	1,355	3.8	2.5

Varying assumptions about gas demand growth between scenarios are:

- In the **low** scenario, minerals processing, mining and industrial gas consumption is lower compared to the base and high scenarios, due to differing commodity outlooks. Forecast increases in gas prices from 2024[39] also see a significant reduction in GPG in this scenario, as coal becomes more cost-competitive.
- In the **base** scenario, growth in overall demand is partially offset by a decline in SWIS GPG gas demand between 2021 and 2024, due to the commencement of renewable generation capacity currently under construction. This continued uptake of large-scale renewables and behind the meter PV is displacing GPG in the short-term in the SWIS. The retirement of the Muja C facilities by the end of 2024 will result in about 15% higher gas demand for SWIS GPG by 2029.
- In the **high** scenario, demand is forecast to increase by approximately 168 TJ/day by 2025 with the commencement of 10 prospective projects[40], including a large petrochemicals project. The inclusion of

[39] RBP applied high scenario gas price forecasts to the low scenario GPG forecasts, and the low scenario gas price forecasts to the high scenario GPG forecasts. For further information, see Appendix A3.2.1.

[40] Prospective gas demand projects must meet set criteria, and are only included in the high scenario. They may either be developed over the outlook period or switch from diesel to gas.

prospective projects is the key factor contributing to higher gas use in the high scenario compared with the base scenario.

Compared to the 2018 WA GSOO, AEMO now forecasts higher average annual growth across the forecast horizon, particularly in the first half of the outlook period. Growth outlooks in the mining and industrial sectors remain similar to the 2018 WA GSOO. Higher gas demand forecasts are partially due to increased projected growth opportunities in minerals processing, a stronger outlook for lithium and nickel over the medium to long term, and assumed higher economic growth, with gross state product (GSP) forecast to grow at an average annual rate of 3.4% in the base scenario compared to 2.6% forecast in the 2018 WA GSOO[41].

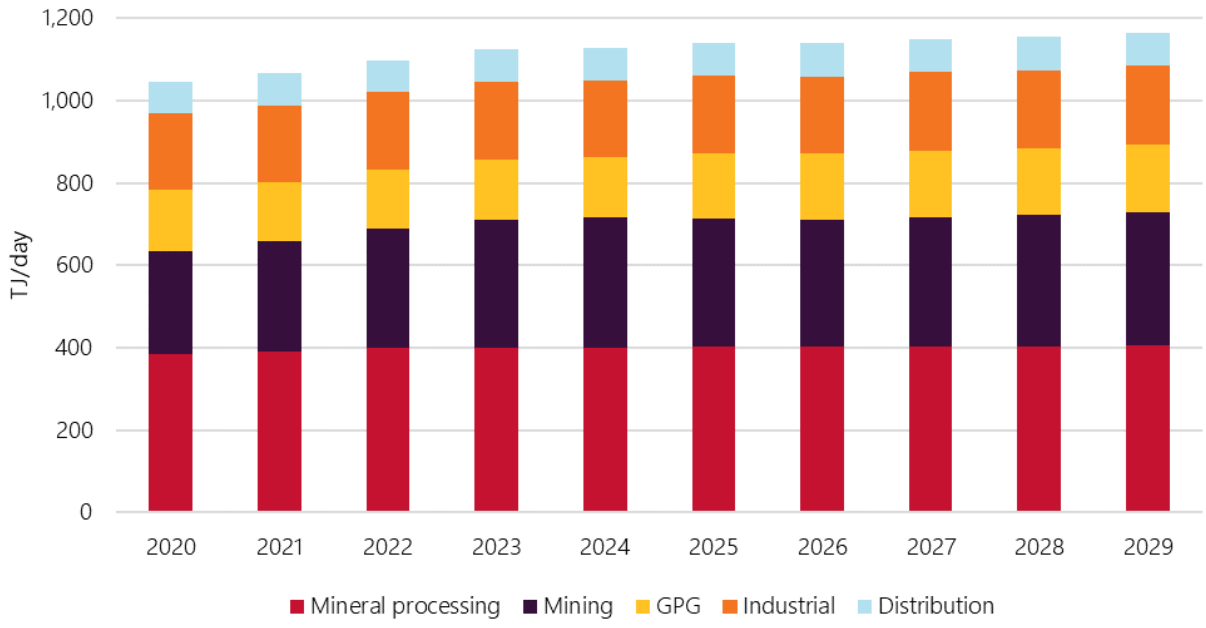
2.2.3 Gas demand forecasts by usage category

The gas demand forecasts are disaggregated by the following usage categories[42]:

- Mineral processing.
- Mining.
- GPG (SWIS and non-SWIS).
- Industrial (major users such as ammonia, fertiliser, and LPG production).
- Distribution.

This breakdown for the base scenario is shown in Figure 6 and Table 6.

Figure 6 Domestic gas demand forecasts by category (TJ/day), base scenario, 2020 to 2029



[41] Further detail on the economic outlook can be found in Appendix A3.1.1.

[42] The usage categories are defined in a manner that reflects the different sets of external and internal influences for each category for forecasting purposes. To see the complete breakdown of how gas consumers were categorised, refer to Appendix A5. The mining and minerals processing sectors include GPG that are located at remote mine sites or minerals processing facilities. Note: these categories differ from the categories in Figure 4.

Table 6 Forecast annual gas demand by sector (TJ/day), base scenario, 2020 to 2029

Sector	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average growth pa (%)	10-year average growth pa (%)
Mineral processing	384	392	399	400	401	402	402	403	403	405	1.1	0.6
Mining	250	266	290	312	315	312	309	314	320	324	5.9	2.9
GPG	149	144	144	145	148	159	160	162	162	165	-0.2	1.1
Industrial	186	186	187	188	186	187	188	190	189	190	0.0	0.2
Distribution	77	78	78	79	79	79	80	80	80	81	0.6	0.6

In summary:

- Strong global demand for battery-related commodities, including lithium, cobalt, and nickel, is expected to drive mining sector gas demand growth at an average annual rate of 2.9% over the outlook period.
- The five-yearly projected growth in minerals processing has increased slightly from the 2018 WA GSOO forecasts, from 0.5% to 1.1%, as a result of projected higher production of mineral commodities (primarily alumina). By 2021, 8.3 TJ/day is expected to be added by major projects.
- GPG is forecast to grow at an average annual rate of 1.1%, underpinned by the following trends[43]:
  - Between 2020 and 2021, gas demand from SWIS GPG is expected to decrease by 5.3%, primarily due to an additional 528 MW of intermittent renewable energy capacity[44] that is expected to connect to the SWIS by October 2020 and displace existing generation.
  - From 2024, the retirement of Muja C, combined with increasing ramping requirements due to uptake of large-scale and behind the meter PV, is expected to require greater SWIS GPG utilisation[45]. As a result, gas demand for SWIS GPG grows by a total of 15% between 2024 and 2029 in the base scenario.
  - Non-SWIS GPG is expected to grow slightly at an average annual rate of around 1%.
- Distribution demand is forecast to increase at an average annual rate of 0.6% over the outlook period. While the number of residential connections in the distribution network is forecast to grow, this is offset by falling average use per connection over the outlook period. However, forecast growth in commercial consumption is expected to lead to overall growth in demand in the distribution sector.
- Minimal annual growth (0.2% on average) is forecast in the industrial sector across the outlook period and new projects in this sector are limited to one prospective project, which has been included in the high scenario only. Overall, gas consumption forecasts for the industrial sector have increased from the 2018 WA GSOO forecasts, largely due to improvements in gas usage categorisations[46].

[43] Detailed SWIS GPG results were sourced from Robinson Bowmaker Paul (RBP). See Appendix A3.2.1 for further information about the GPG forecasts.

[44] Including Yandin wind farm (214 MW), Warradarge wind farm (184 MW), Merredin solar farm (100 MW), and an upgrade to the Greenough solar farm (30 MW).

[45] AEMO notes that increased ramping requirements as a result of renewable energy generation (both large-scale and behind the meter) are likely to cause issues managing pipeline capacity. For further information, see https://www.dbp.net.au/wp-content/uploads/2019/05/AGIG-DBP-Draft-Plan-2021-2025_Web.pdf.

[46] See Appendix A5 for the full list of facilities AEMO has classified as industrial consumption.

2.2.4 Gas demand forecasts by area

In line with previous WA GSOO reports, gas demand has been disaggregated into two areas, SWIS and non-SWIS[47], as shown in Table 7.

Consistent with the 2018 WA GSOO, the forecast growth in gas demand outside the SWIS exceeds the expected growth in the SWIS. Non-SWIS growth is projected to be stronger than the 2018 WA GSOO forecast, predominantly due to stronger projected mining growth, which tends to be located outside of the SWIS.

Forecast gas demand within the SWIS has reduced in comparison to the 2018 WA GSOO forecasts. However, the overall trends are similar. An increase in gas demand from minerals processing is projected between 2020 and 2022, which is partially offset by a forecast reduction in GPG demand between 2020 and 2024 associated with increased renewable generation capacity in the SWIS. GPG demand is forecast to return to growth in the second half of the outlook period following the retirement of Muja C power station combined with ramping requirements (see Section 2.2.3).

Table 7 Forecast annual gas demand by area (TJ/day), base scenario, 2020 to 2029

Area	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average growth pa (%)	10-year average growth pa (%)
Non-SWIS	395	417	442	465	468	465	464	470	477	482	4.3	2.2
SWIS	651	649	656	659	661	673	674	678	678	684	0.4	0.5

2.2.5 Gas demand forecasts by region

Regional disaggregation of gas demand forecasts was introduced in the 2018 WA GSOO as an outcome of the WA GSOO five-yearly review. This modelling approach provided further insights into forecast gas usage trends, and has been retained for the 2019 WA GSOO and for future WA GSOOs. WA domestic gas forecasts have been split into three regions based on the geographic zones defined in the GSI Rules[48]:

- East (includes the GBB zones Goldfields and Kalgoorlie).
- North (includes the GBB zones Karratha, Dampier, Pilbara, and Telfer).
- Metro/South West (includes the GBB zones Mid-West, Parmelia, Metro, and South West)[49].

Figure 7 and Table 8 present the expected domestic gas demand forecasts by region for the base scenario.

[47] The SWIS includes the electricity networks operated by Western Power that extend from Albany to Kalbarri and to Kalgoorlie in the east. The non-SWIS area includes all towns and mine sites outside of the SWIS (see Appendix A3.2.1 for further information).

[48] Available at: https://www.erawa.com.au/rule-change-panel/gas-services-information-rules.

[49] Note that this is not identical to the SWIS area presented above for SWIS/non-SWIS demand forecasts.

Figure 7 Domestic gas demand forecasts by region (TJ/day), base scenario, 2020 to 2029

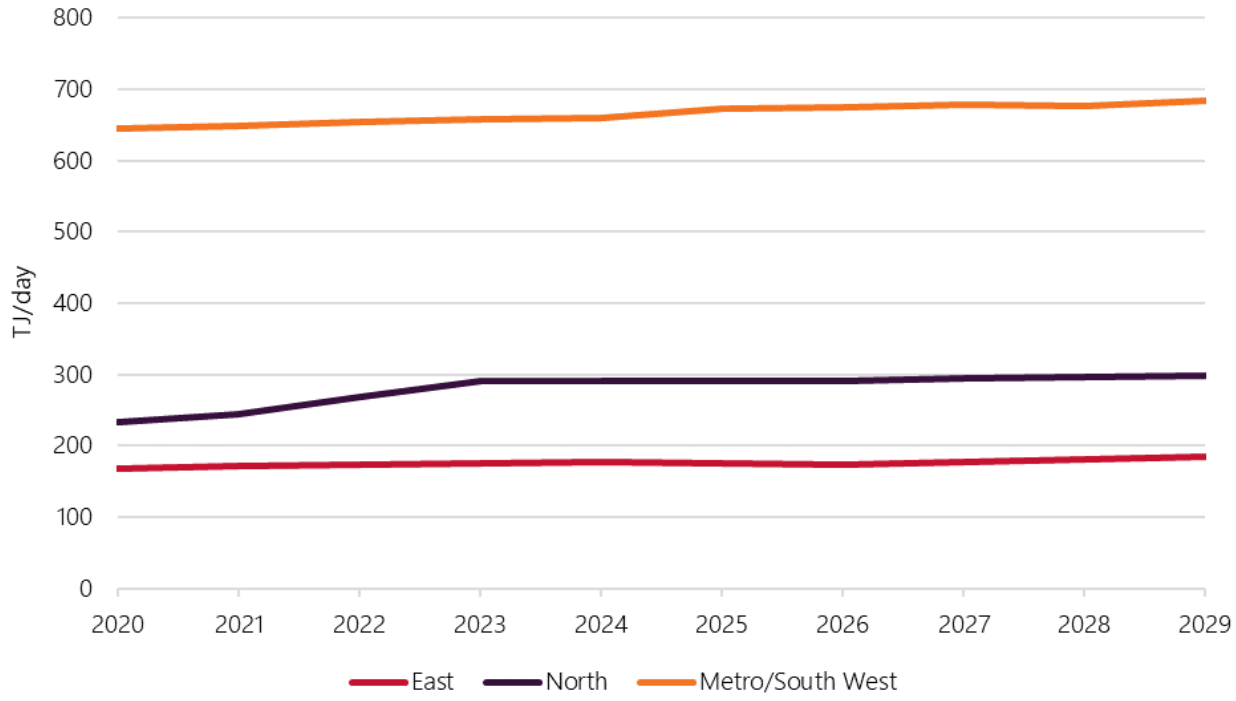


Table 8 Forecast annual gas demand by region (TJ/day), base scenario, 2020 to 2029

Region	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average growth pa (%)	10-year average growth pa (%)
East	168	172	174	176	178	176	174	177	181	184	1.5	1.0
North	233	245	268	290	291	290	290	294	296	299	5.7	2.8
Metro/ South West	645	648	655	658	660	673	674	678	677	683	0.6	0.6

Of the three regions, the strongest growth is forecast to occur in the North region, particularly during the first half of the outlook period (5.7% average annual growth). This is predominantly due to new gas consuming projects in the mining sector, which are expected to add 57 TJ/day to gas consumption from 2023. From 2024, growth in this region is expected to decrease, as indicated by the reduction in average annual growth rate to a 10-year annual average of 2.8%.

Growth in both mining and new projects is forecast in the Metro/South West region, but at a smaller scale than in the North. New projects are estimated to contribute an additional 2.8 TJ/day demand by the end of the outlook period. This is partially offset by the forecast reduction in demand from SWIS GPG associated with the entry of renewable generation, as discussed in Sections 2.2.2 and 2.2.3.

In the East, forecast falling gas demand resulting from reduced GPG consumption, combined with the Agnew renewables project, is offset by an increase in other mining consumption, leading to a relatively stable 10-year average annual growth rate of 1%.

2.3 Historical peak WA domestic demand days

AEMO analysed historical WA gas demand using GBB data for the period 1 August 2018 to 14 August 2019[50]. The peak gas use day[51] over this period was 19 March 2019 with consumption of 1,269 TJ.

The 20 largest gas usage days for each year since the GBB commenced, and the seasons in which they were recorded, are shown in Table 9. High consumption days are more likely to be associated with cooler days, with these exceptions:

- In 2013, data collection on the GBB commenced in August (the end of winter), missing the autumn season and most of summer.
- In 2016, an unusually warm summer led to periods of higher electricity demand and GPG consumption with high autumn demand as well.
- In 2019, high consumption days were recorded in autumn due to cooler than usual weather and relatively high GPG consumption due to high electricity load.

The major drivers of high demand days included weather-related factors and outages of non-gas electricity generation facilities.

Table 9 20 largest gas usage days (total WA), number of days each year falling in each season, 2013 to 2019

Number of peak gas usage days in:	2013 (1 August to year end)	2014	2015	2016	2017	2018	2019 (year start to 14 August 2019)
Winter	1	19	15	4	15	18	13
Spring	14	1	-	5	3	-	1
Summer[A]	5	-	5	4	-	-	1
Autumn	-	-	-	7	2	2	5

A. January, February, and December of the same calendar year.
Source: AEMO and MJA.

Gas consumption data is grouped into the three categories defined in Section 2.2.5. The seasonal distribution of 20 high gas consumption days for the last year for the period 14 August 2018 to 14 August 2019 across three zones are estimated as shown in Table 10.

Table 10 20 largest gas usage days by geographic region, number of days each year falling in each season, 2018 and 2019

Number of peak gas usage days in:	Metro/South West	North	East
Winter	15	1	12
Spring	2	0	0
Summer	0	6	2
Autumn	3	13	6

[50] MJA completed this analysis for the period 1 August 2013 to 14 August 2018.

[51] Excluding gas demand used in gas shipping and compression but including injections to storage facilities.

The analysis of high consumption days by zone showed that:

- The majority of the high usage days in Metro/South West occurred in winter, with a 67.8 TJ difference between the highest gas use day and the twentieth highest, driven predominantly by changes to consumption from GPG coincident with high gas demand at mine sites (alumina production). In contrast, there is a much smaller variation of 17.2 TJ in the North zone and 9.8 TJ/day in the East zone, reflecting relatively stable gas use from mine sites.
- Increased industrial activity and GPG during the working week in the Metro/South West region resulted in a notably higher demand for gas when compared to weekends and public holidays.

2.4 Reconciliation of previous WA GSOO domestic gas demand forecasts and actual average gas use data

AEMO reconciled previous WA GSOO domestic gas demand forecasts against actual average gas use data sourced from the GBB. Improvements to forecasting methodology, access to formal information request (FIR) data and improvement of gas use (GBB) data have contributed to improving the accuracy of the forecasts over time. The deviation between the forecast (base scenario) and actual gas use is shown in Table 11.

Table 11 Reconciliation of previous WA GSOO domestic gas demand forecasts (% deviance of forecast from actual), 2017 to 2019

	2017 actual	2018 actual	2019 actual[A]
December 2016 GSOO forecast deviance (%)	+3.6	+2.8	-1.2
December 2017 GSOO forecast deviance (%)		+1.0	-1.9
December 2018 GSOO forecast deviance (%)			0.8

A. Based on average daily gas use to 14 August 2019.
Source: AEMO and MJA.

For 2019 (to 14 August 2019), actual gas demand is 9 TJ/day (0.8%) higher than forecast in the 2018 WA GSOO.

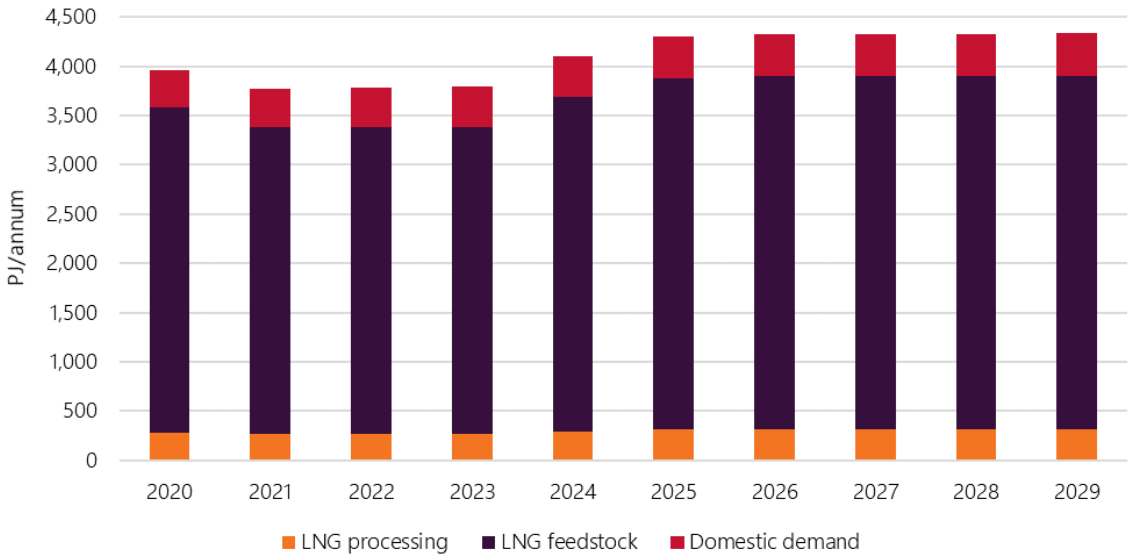
2.5 Total gas demand forecasts

Total gas demand is the aggregate of the following forecasts, based on the assumptions outlined in Appendix A3.2.2:

- Domestic gas demand.
- LNG export feedstock.
- Gas used for LNG processing.

The base scenario forecast for total gas demand for the outlook period is shown in Figure 8. Total gas demand forecasts for the low, base, and high scenarios are provided in Appendix A4.

Figure 8 Total gas demand forecasts (PJ/annum), base scenario, 2020 to 2029



Projected increases in total gas demand are driven by:

- Potential backfill for the NWS and Prelude projects.
- Expansions of existing projects (primarily in the high scenario).

The low total gas demand scenario illustrates a decline in production for the NWS project from 2024, as spare processing capacity emerges due to reserves depletion. The low scenario assumes no backfill projects coming online for the NWS, and no new stand-alone projects.

The base scenario incorporates the following assumptions in addition to the low scenario:

- An expansion to Pluto (second train), supported by Scarborough gas, to commence in 2024.
- The following backfill for the NWS:
  - Pluto (via the Pluto-KGP interconnector) and the Equus project, both commencing in 2024.
  - Browse from 2026.

With these assumptions, the base scenario projects total gas demand to increase by around 521 PJ between 2023 and 2026 and then remain stable for the rest of the outlook period. This flattening in the latter half of the outlook period corresponds with the commencement of NWS backfill projects, which are projected to maintain NWS at full capacity.

The easing of production growth in the latter half of the outlook period is not reflected in the high scenario, as this scenario assumes the commencement of prospective LNG expansions at Wheatstone, Ichthys, and Gorgon in 2026, 2027, and 2028 respectively.

The average annual growth rate for LNG feedstock over the outlook period is 1%. Domestic gas demand is estimated to comprise 10% of total gas demand in 2020; this proportion is not expected to change significantly over the outlook period.

AEMO notes that assumptions about backfill for the NWS are critical to both the domestic gas supply and total gas demand forecasts. For AEMO's assumptions about the NWS for the potential gas supply modelling, see Section 3.3.3.

3. Gas supply

Overall, potential gas supply is forecast to decline at an annual average rate of 1.5% (28 TJ/day) between 2020 and 2029 in line with reserve depletion at existing production facilities. Prospective supply sources could add up to 405 TJ/day of supply to the domestic market if they are developed.

3.1 Profile of upstream and gas production

3.1.1 Reserves and resources

Gas has been categorised into either reserves or resources based on the level of commercial and technical uncertainty associated with extraction[52]. These terms are broadly defined below:

- Reserves are quantities of gas that are anticipated to be commercially recoverable from known accumulations. Proved and probable (2P) reserves are considered the best estimate of commercially recoverable reserves[53].
- Contingent (2C) resources are considered less commercially viable than reserves. These can be considered roughly the equivalent of reserves with one or more commercial or technical uncertainties impacting the likelihood of development. 2C resources are considered the best estimate of sub-commercial resources[54].

Third-party estimates of WA's total conventional and unconventional[55] gas resources are summarised in Table 12[56]. Compared to 2018, conventional gas 2P reserves and 2C resources have decreased.

In addition to conventional gas, WA's resources of unconventional gas (shale and tight gas), mostly located in the Canning and Perth basins, are estimated to be substantial. Given the amount of conventional gas resources remaining, and the relatively high cost of developing unconventional gas, there has been no commercial production of unconventional gas in WA. Under current government policy, an announcement on the use of hydraulic fracture stimulation techniques[57] in WA indicates future unconventional gas production will be limited.

[52] These uncertainties could include securing finance, obtaining government approvals, negotiating contracts, or overcoming geological challenges. The terms resources and reserves are not interchangeable: reserves constitute a subset of resources.

[53] The 2P reserves categorisation indicates there is a reasonable probability that 50% or more of the gas is recoverable and economically profitable. Proved reserves (1P) indicate that this probability is higher than 90%. Gas producers generally sign gas supply sales contracts based on 1P reserves.

[54] The resources are estimated to exist in prospective areas but have not been proven by drilling.

[55] 'Conventional' refers to formations that are relatively straightforward to extract, and 'unconventional' refers to formations that are much more difficult to extract, in some cases requiring specialised techniques. Both conventional and unconventional gas formations may contribute to reserves and resources, depending on the economic viability of extraction.

[56] Department of Jobs, Tourism, Science and Innovation (DJTSI). *WA LNG Industry Profile*, Sept/Oct 2018, p. 5, at https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/wa-lng-profile-0918.pdf?sfvrsn=ea0d721c_6, and DJTSI, 2018. *WA LNG Industry Profile*, August 2019, p. 5, at https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/wa-lng-profile-0919.pdf?sfvrsn=93c7701c_4.

[57] WA Government, "Hydraulic fracturing remains banned on 98 per cent of WA", media statement, 6 September 2019, at https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/09/Hydraulic-fracturing-remains-banned-on-98-per-cent-of-WA.aspx.

Table 12 WA conventional and unconventional gas resources and reserves (PJ)[A], as at August 2019

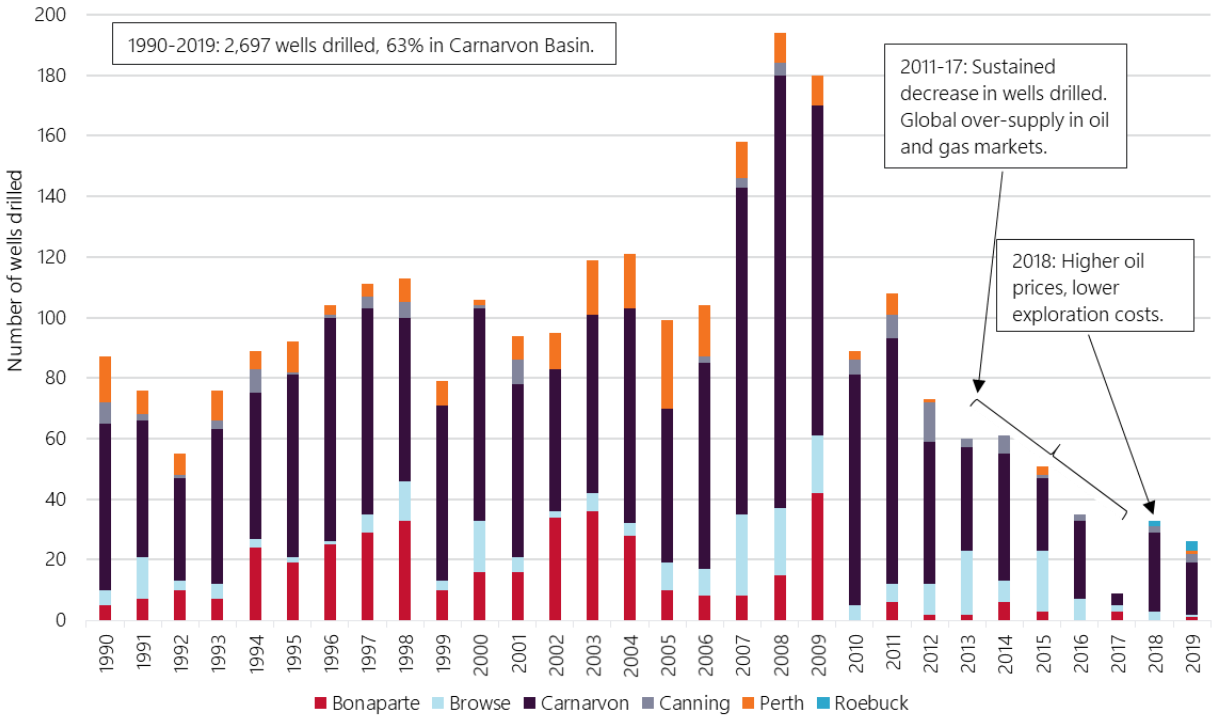
Attribute	2018	2019
Conventional 2P gas reserves	72,186	69,430
Conventional 2C gas resources	80,454	72,080
Unconventional: Estimated shale gas resources, range low to high[B]	96,460-204,580	96,460-204,580
Unconventional: Estimated tight gas resources[C]	91,160	91,160

A. Sum of resources and reserves converted from tcf to PJ. 2C resources reported are over and above the 2P reserves reported.
B. Based on WA Department of Mines, Industry Regulation and Safety's (DMIRS) current, best estimates of risked, recoverable resources.
C. Gas-initially-in-place, referring to the total amount of gas contained in each basin, including volumes that are deemed sub-economic, and which may never be recovered.

3.1.2 Exploration

Gas supply to the WA domestic market is largely dependent on the sustained development of gas reserves. Reserves associated with domestic gas production exhibit a natural decline. The number of exploration and development wells drilled remains subdued, with only 26 wells drilled over the January 2019 to August 2019 period. However, this compares favourably to 2017 when only nine wells were drilled, representing the lowest number of wells drilled since 1990, as shown in Figure 9.

Figure 9 Exploration and development wells drilled (number), 1990 to 2019 (year to date)



Source: Compiled using information from the Western Australian Petroleum Information Management System, at https://wapims.dmp.wa.gov.au/WAPIMS/Search/Wells (viewed 12 September 2019) and the National Offshore Petroleum Information Management System, at: https://nopims.dmp.wa.gov.au/Nopims/Search/Wells (viewed 12 September 2019).

Of the wells drilled this year, five were for exploratory purposes, with the majority of the remaining wells drilled for development purposes, consistent with the trend observed in 2018.

3.1.3 Production by facility

There are nine gas production facilities that supply the WA domestic market, with a total capacity of about 1,850 TJ/day, as shown in Table 13[58]. The KGP maintains the largest capacity at 630 TJ/day.

Over the year to Q2 2019, average gas production from the Xyris, Gorgon, and Macedon facilities has fallen. For the Pluto facility, output in Q2 2019 decreased as a result of maintenance undertaken during this period[59]. A relatively stable level of production has been observed from the remaining facilities.

Table 13 Domestic gas production facility average production and utilisation, Q3 2018 to Q2 2019

Facility	Nameplate capacity (TJ/day)	Average production (TJ/day)				Average capacity utilisation[A] (2018-19 financial year) (%)
		Q3 2018	Q4 2018	Q1 2019	Q2 2019	
Beharra Springs	18.5	11	13	12	12	61
Devil Creek	220	76	92	84	89	39
Gorgon	182	169	178	172	152	92
KGP	630	366	382	356	404	60
Macedon	213	177	176	171	153	77
Pluto	25	-	2	3	0	8
Varanus Island	345	124	124	119	129	36
Wheatstone	205	-	-	40	95	22
Xyris	11.5	8	7	3	4	47
Total	**1,850**	**932**	**975**	**959**	**1,037**	**53**

A. Utilisation was calculated using nameplate capacity and average production over the preceding four quarters.
Source: WA GBB and EnergyQuest.

Pluto (25 TJ/day) and Wheatstone (205 TJ/day) gas production facilities commissioned in Q4 2018 and Q1 2019 respectively, resulting in an increase of around 14% in WA's total domestic gas production capacity.

Further information about WA gas infrastructure, including details of multi-user gas storage facilities, gas transmission pipelines, spot and short-term gas trading mechanisms, and LNG export production facilities, can be found in Appendix A6.

3.2 Potential gas supply model assumptions

AEMO forecasts the potential availability of gas supply to the WA domestic market, or "potential gas supply", as supply that could be economically offered to the domestic market given forecast prices and production costs, subject to the availability of processing capacity and gas reserves.

The model does not project how much gas *will* be produced, but how much *could* be produced if there was demand at the forecast price, and distinguishes between existing, committed, and prospective projects by triggering prospective projects when the forecast price (domestic gas price or Asian LNG price) exceeds production costs.

[58] Red Gully and Dongara have not operated since Q3 2017, so are excluded.

[59] Woodside Energy, "Second Quarter 2019 Results", 18 July 2019, at https://www.woodside.com.au/investors/reports-publications.

For further information about the methodology and model features see Appendix A3.3.

3.2.1 Forecasting scenarios

AEMO developed the potential gas supply forecasts for three scenarios for the outlook period 2020 to 2029: low, base, and high. A summary of the key assumptions for the three scenarios is presented in Table 14.

Table 14 Key assumptions for low, base and high potential gas supply modelling scenarios

Inputs	Low scenario	Base scenario	High scenario
Domestic gas demand forecasts	Low	Base	High
Costs of production[A]: • Short-run costs for existing projects • Long-run costs (LRC) for prospective projects	Base	Base	Base
Reserves and gas sales[B]: • Gas reserves connected or expected to be connected • Maximum contracted quantity	Base	Base	Base
For domestic gas-only prospective projects to be triggered: • Domestic gas price forecasts[C]	Low	Base	High
For LNG-linked prospective projects to be triggered: • Oil price forecasts (US$/barrel)[D] • Asian LNG price forecasts[E] • Exchange rate forecasts (A$/US$)[F]	Low	Base	High
For LNG-linked projects: • Domestic market obligation (DMO) quantities (15% of gas resources)[G]	Base	Base	Base

A. AEMO estimates based on EnergyQuest, Wood Mackenzie, and public information. Note that the changes to the Petroleum Resource Rent Tax introduced from 1 July 2019 have not been incorporated. See Section 6.1.2 for further information.
B. Sourced from 2019 FIR data (see Chapter 5 for details) for existing domestic gas production facilities; public domain for others.
C. Forecasts sourced from Wood Mackenzie.
D. Forecasts sourced from the International Energy Outlook 2019 developed by the United States Energy Information Administration. See https://www.eia.gov/outlooks/ieo/.
E. AEMO forecasts based on the LNG pricing slope to oil price forecasts.
F. Forecasts sourced from Deloitte.
G. Existing DMO quantities were sourced from the WA Department of Jobs, Science, Tourism and Innovation (DJTSI). See https://www.jtsi.wa.gov.au/economic-development/economy/domestic-gas-policy/implementation-of-domestic-gas-policy. Prospective projects' DMO quantities were calculated by AEMO. See Section 3.3.2 for further information.

3.2.2 Key modelling assumptions

WA has a Domestic Gas Policy[60] that aims to secure the state's long-term energy needs by ensuring that LNG export project developers make gas available to the WA domestic market. The policy seeks to reserve the equivalent of 15% of WA LNG exports for WA consumers.

The full DMO quantity associated with an LNG-linked supply source is assumed to be available to the domestic gas market as gas reserves and infrastructure are developed over the outlook period.

[60] DJTSI. *WA Domestic Gas Policy*, at https://www.jtsi.wa.gov.au/economic-development/economy/domestic-gas-policy.

In addition, for modelling existing and committed production capacity:

- Beharra Springs, Devil Creek, Gorgon (tranche one), Macedon, Varanus Island, and Wheatstone were modelled as existing production facilities[61].
- Modelling assumed maximum potential gas supply from domestic gas-only production facilities is subject to remaining gas reserves.
- The second tranche from Gorgon (118 TJ/day) was modelled as being available from 2021.
- Pluto was modelled as an existing facility at 40 TJ/day, the sum of the LNG truck-loading facility (15 TJ/day) and direct pipeline injection (25 TJ/day) capacities.
- The KGP is assumed to produce at the greater of its contracted rate or the DMO volume of 90 TJ/day until the end of the outlook period.
- Xyris was assumed to expand to 20 TJ/day from 2020 and remain at that capacity for the rest of the outlook period.

Three prospective supply sources were identified and included in the modelling – West Erregulla, Scarborough, and Browse. The earliest that each of these prospective sources will be available to supply the market has been based on information from the project proponent and expected availability of reserves and infrastructure. Section 3.3.2 provides more information about these three prospective supply sources.

3.3 Prospective supply sources assessment

3.3.1 Assessment criteria

AEMO's assessment of prospective supply sources reflects information from external consultants[62] and DJTSI, and information in the public domain. AEMO used both physical and commercial characteristics when assessing prospective supply sources, as shown in Table 15.

Table 15 Criteria for assessing prospective gas supply sources

Physical characteristics	Commercial characteristics
• Reserves location • Water depth • Reserves volume • Reservoir characteristics (for example, dry or technically challenging) • DMO for sources that are primarily being developed to supply the global LNG market	• Ownership structure (joint venture or sole owner) • Proponent or operator experience • Primary development driver (global LNG market or domestic gas market) • Likely development path (for example, tie-back to an existing facility, or new production facility) • Estimated development costs, based on the likely development path, and including long-run (capital) and short-run (operating) costs • Commercial arrangements (for example, any tolling requirements) • Gas sales contracts (for example, offtake option, sale and purchase agreement)

AEMO assessed 21 candidate new supply sources, and excluded 18 of these as prospective supply sources for the purposes of modelling potential gas supply, for at least one of the following reasons:

- Insufficient testing of the field had been completed to evaluate the size and characteristics of the resource.
- The development timeframe was likely to extend beyond the end of the outlook period.
- Developing the resource was uneconomic under current and expected near-term LNG and domestic market conditions.
- The project proponent or operator had not selected a preferred development option.

[61] Red Gully and Dongara were excluded from the modelling because they are no longer operating.

[62] AEMO sourced information from EnergyQuest and Wood Mackenzie on candidate prospective supply sources.

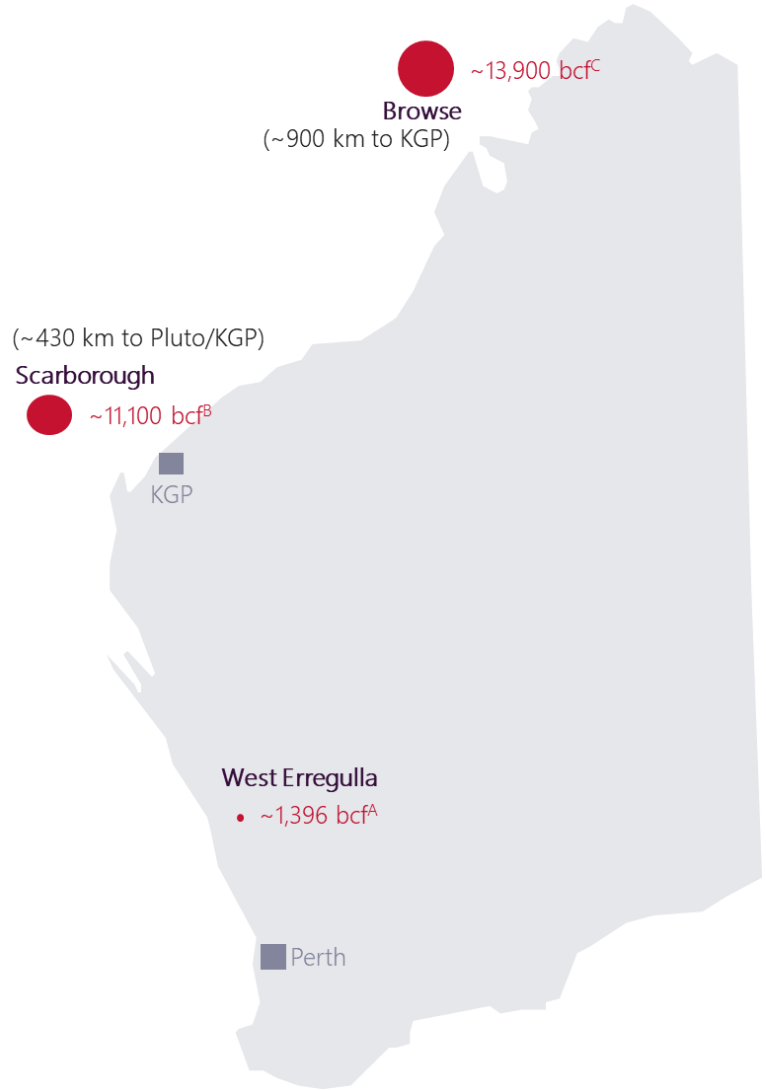
AEMO will continue to monitor these fields as potential future prospective supply sources.

The remaining three candidates (Browse, Scarborough, and West Erregulla) were identified as prospective supply sources and included in the potential gas supply model to determine whether they were likely to be developed over the outlook period (see Section 3.4 for the potential gas supply forecasts).

3.3.2 Modelled prospective supply sources

There are substantial undeveloped gas reserves located in WA that could provide domestic gas in the future, either through new or existing production facilities. Key information about the three prospective sources included in the potential gas supply modelling is summarised in Figure 10 and Table 16.

Figure 10 Prospective gas supply sources infographic



Note: Map is indicative and not to scale.
A. Estimate of 2P reserves. The field's 2C resources estimate is 1,185 bcf. See Strike Energy, *West Erregulla Resource Statement*, 11 November 2019, at http://www.strikeenergy.com.au/wp-content/uploads/2019/11/20191111_West-Erregulla-Resource-Statement.pdf.
B. Estimate of 2C resources. See Woodside, *Scarborough resource volume increased by 52%*, 8 November 2019, at https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/scarborough-resource-volume-increased-by-52.pdf?sfvrsn=32aa96f7_2.
C. Estimate of 2C resources. See Woodside, *Browse to North West Shelf*, accessed 12 November 2019, at https://www.woodside.com.au/our-business/burrup-hub/browse-to-north-west-shelf.

Table 16 Prospective gas supply sources included in the potential gas supply model

Source	Project type	Operator	Earliest available from	Volume available (TJ/day)[A,B]
West Erregulla	Domestic gas-only	Strike Energy	2022[C]	25 – 75
Scarborough	LNG-linked	Woodside	2024[D]	150
Browse	LNG-linked	Woodside	2026 and 2027[E]	230

A. For Browse, AEMO calculated approximate DMO volumes as 15% of the 2C resources as shown in Figure 10 and assumed a 20-year project life.
B. Scarborough's DMO has been calculated based on Woodside's equity share of 112.5 TJ/day. See Woodside, *Investor Briefing Day 2019*, 19 November 2019, at https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/investor-briefing-day-2019.pdf?sfvrsn=dd9c09cd_2.
C. Strike Energy targets FID by 2020 and production from the phase one development in 2022. See Strike Energy, *Perth Basin Strategy & Operation Update*, 21 October 2019, at http://www.strikeenergy.com.au/wp-content/uploads/2019/10/20191021_Perth-Basin-Strategy-Operations-Update.pdf.
D. Woodside targets FID in the first half of 2020, with upstream and downstream ready for start-up (RFSU) in 2023 and 2024, respectively. See Woodside, *Half-Year 2019 Results Briefing,* 15 August 2019, at https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/029-half-year-2019-results-and-briefing-pack.pdf?sfvrsn=d49db311_6.
E. Woodside targets FID in the first half of 2021 and RFSU in 2026 (Calliance and Brecknock) and 2027 (Torosa). See Woodside, *Third Quarter 2019 Report,* 17 October 2019, at https://files.woodside/docs/default-source/investor-documents/quarterly-and-half-yearly-pdfs-and-data-tables/2019/third-quarter-2019-report.pdf.

West Erregulla

The West Erregulla field is located onshore in the Perth basin, approximately 230 km north of Perth. The field is owned by Strike Energy (50%, operator) and Warrego Energy (50%).

Gas was discovered at West Erregulla in early September 2019[63] and Strike Energy announced a staged development plan in October 2019[64] as follows:

- Phase One – development of between 25 and 75 TJ/day capacity[65].
- Phase Two – development of capacity between 100 and 200 TJ/day. Completion of the project development concept selection is targeted for early 2022.

AEMO modelled the project as a domestic gas-only project commencing in 2022.

Scarborough

The Scarborough gas field is located approximately 375 km west-north-west off the Burrup Peninsula in the Carnarvon Basin. The field is owned by Woodside (75%, operator) and BHP (25%).

AEMO has modelled Scarborough as an LNG-linked project developed through an expansion at Pluto (second train) commencing in 2024, with an estimated DMO volume of 150 TJ/day[66]. Domestic gas infrastructure of about 225 TJ/day is proposed to be included as part of the Pluto expansion[67].

[63] Strike Energy, "West Erregulla adds a further significant gas discovery", 6 September 2019, at http://www.strikeenergy.com.au/wp-content/uploads/2019/09/20190906_West-Erregulla-Adds-A-Further-Signifcant-Gas-Discovery.pdf.

[64] Strike Energy, "Perth Basin strategy & operations update", 21 October 2019, at http://www.strikeenergy.com.au/wp-content/uploads/2019/10/20191021_Perth-Basin-Strategy-Operations-Update.pdf.

[65] A gas sale option has been executed by Strike Energy with CSBP Limited for up to 25 TJ/day from commencement of production. The option is conditional on a successful result at the West Erregulla-2 well and the project taking FID. See Strike Energy, "Strike grants offtake option West Erregulla to significant WA industrial gas user", 29 May 2019, at http://www.strikeenergy.com.au/wp-content/uploads/2019/05/20190529_Strike-grants-West-Erregulla-Gas-Offtake-Option.pdf.

[66] Calculated based on Woodside's equity share of 112.5 TJ/day. See Woodside, "Investor Briefing Day 2019", 19 November 2019, at https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/investor-briefing-day-2019.pdf?sfvrsn=dd9c09cd_2.

[67] See https://files.woodside/docs/default-source/our-business---documents-and-files/pluto---documents-and-files/pluto-lng-expansion-overview.pdf?sfvrsn=81e1de87_8.

Browse

The Browse project consists of the Brecknock, Calliance, and Torosa gas fields and is in the Browse Basin, approximately 425 kilometres north of Broome. The project is owned by a joint venture consisting of Woodside (30.6%, operator), Shell (27%), BP (17.33%), MIMI Browse (14.4%), and PetroChina International Investment (10.67%).

The Browse joint venture has been progressing the development of Browse to supply around 10 mtpa of LNG via a roughly 900 km subsea pipeline to the KGP, underpinned by a preliminary tolling agreement with the NWS joint venture partners[68]. AEMO modelled Browse as an LNG-linked project commencing in 2026 (to align with the commencement of production from the Calliance and Brecknock fields) with 230 TJ/day capacity.

3.3.3 Spare capacity at the Karratha Gas Plant

In September 2019, the WA Government introduced a bill into Parliament to extend the State Agreement with the NWS joint venture partners until 2059[69], which would allow the KGP to continue to operate until this date. Woodside has submitted several proposals to the EPA, including one to extend the life of the KGP up to 2070 and allow processing of third-party gas[70]. While these approvals are underway, there is uncertainty about keeping the plant operating at full LNG export capacity of 16.9 mtpa over the long term.

Spare LNG production capacity is expected to emerge at the KGP from the early 2020s as reserves in the producing fields are depleted, despite additional reserves being connected in late 2018 through the Greater Western Flank (GWF) Phase Two project. The development of an additional 435 bcf of reserves at the GWF Phase Three project could extend the production plateau into the mid-2020s, but this project has not reached FID[71].

To maintain operation at full capacity, development and connection of new gas fields to the KGP will be required, which will be subject to the Domestic Gas Policy (see Section 3.2.2)[72].

AEMO has modelled Browse as the key source of backfill for the KGP, but notes there are several alternative options that could be developed instead of, or in addition to[73], the Browse project. Available capacity could be filled by a combination of the following sources[74]:

- Scarborough – excess gas could be used to fill spare capacity via the Pluto-KGP interconnector, which is expected to have a capacity of at least 5 mtpa[75].

[68] Woodside. "North West Shelf Venture signs preliminary agreements to process third-party gas", Media release, 7 November 2018, at https://files.woodside/docs/default-source/media-releases/north-west-shelf-venture-signs-preliminary-agreements-to-process-third-party-gas.pdf?sfvrsn=d43825b4_16.

[69] A 2015 amendment allows processing of third-party gas at the KGP. See https://www.parliament.wa.gov.au/parliament/bills.nsf/180C243BDB5DB1CA4825848100024603/$File/Bill140-1.pdf.

[70] Woodside. "North West Shelf Project Extension Proposal - Environmental Scoping Document", August 2019. See http://www.epa.wa.gov.au/sites/default/files/Environmental_scoping_document/NWS%20Project%20Extension%20-%20ESD%20-%20Revision%202%20%2829%20August%202019%29.pdf.

[71] Woodside targets FID in Q1 2020. See https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/investor-briefing-day-2019.pdf?sfvrsn=dd9c09cd_2.

[72] DJTSI, "Western Australian LNG project domestic gas agreements", at: https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/wa-lng-project-domestic-gas-agreements.pdf?sfvrsn=d706731c_6. Viewed 22 October 2019.

[73] There may be an opportunity for smaller projects, or excess gas from Scarborough delivered through the Pluto-KGP interconnector, to fill spare capacity before Browse commences in 2026.

[74] This list is not exhaustive. Other potential backfill candidates include Corvus and the Greater Gorgon fields, however, these are more speculative than the listed fields.

[75] The interconnector is expected to have a capacity of up to 1.5 mtpa from 2022 until Browse commences, then expand to more than 5 mtpa. See https://files.woodside/docs/default-source/asx-announcements/2019-asx-announcements/investor-briefing-day-2019.pdf?sfvrsn=dd9c09cd_2.

- Clio-Acme – the NWS joint venture signed a preliminary non-binding agreement with Chevron Australia in November 2018 to allow Clio-Acme gas to be developed through the KGP[76].
- Equus – while Western Gas is currently pursuing a 2 mtpa small-scale LNG project[77], the project could be developed as backfill for the KGP.
- Perth basin fields (including Waitsia and West Erregulla) – these projects could supply the KGP through the DBP.

AEMO expects that if Browse is not developed, several of these projects would be required to fill the spare capacity at the KGP, given the volume of available capacity and the size of the projects. There is likely to be short-term spare production capacity at the KGP until Browse commences in 2026, which could be filled by one or more of these projects. Depending on the combination of projects chosen, if Browse does not go ahead there could be less gas supply available to the WA domestic gas market than in AEMO's base scenario potential gas supply forecasts.

AEMO will continue to monitor these projects and will report on progress on the backfill candidates for the KGP in future WA GSOOs.

3.4 Potential gas supply forecasts

Depending on the various input assumptions[78] for the low, base, and high scenarios, prospective supply sources are triggered to commence if:

- Forecast WA domestic gas prices exceed the LRC of production, for domestic gas-only projects.
- Forecast Asian LNG prices exceed the LRC, for LNG-linked projects. If the project commences, AEMO assumes that an associated DMO will be offered to the domestic gas market.

AEMO's potential gas supply forecasts for the three scenarios are shown in Figure 11 and Table 17. Potential gas supply forecasts in all three scenarios are lower than the total available nameplate production capacity expected over the outlook period.

In summary:

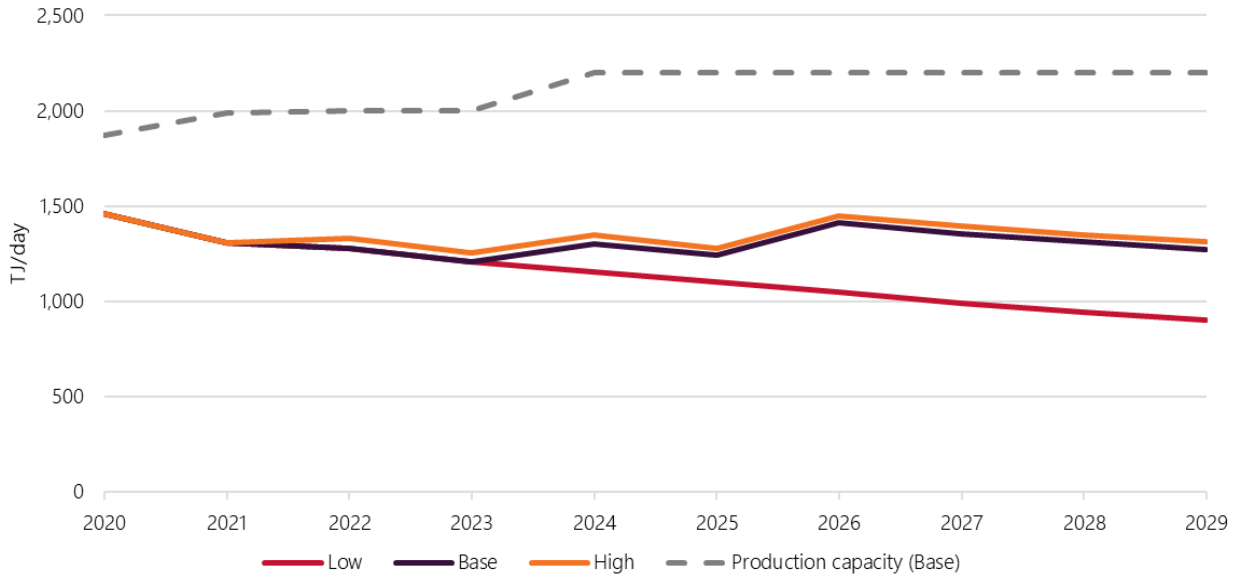
- Potential gas supply is equal in all three scenarios in 2020 and 2021, reflecting the availability of only existing and committed gas supply projects.
- In the low scenario, LNG and domestic gas prices are sufficient to trigger one prospective supply project in 2022, but potential gas supply still declines at an average annual rate of 5.2% between 2020 and 2029, due to reserve depletion at existing production facilities.
- In the base and high scenarios, LNG and domestic gas prices are sufficient for prospective supply to enter the market in 2022, 2024, and 2026, partly offsetting reserve depletion at existing production facilities between 2020 and 2029.
- The high scenario includes additional capacity at one prospective supply project, reflecting higher domestic gas and LNG prices which are expected to encourage expansion (compared to the base scenario) of prospective supply sources.

[76] Woodside. "North West Shelf Venture signs preliminary agreements to process third-party gas", Media release, 7 November 2018, at https://files.woodside/docs/default-source/media-releases/north-west-shelf-venture-signs-preliminary-agreements-to-process-third-party-gas.pdf?sfvrsn=d43825b4_16.

[77] Western Gas, "Equus project on track for first gas in 2024", 11 September 2019, at https://www.westerngas.com.au/sites/default/files/Equus%20Gas%20Project%20-%20Project%20Update%20September%202019.pdf.

[78] See Section 3.2 and Appendix A3.3 for further details of the potential gas supply modelling assumptions and methodology.

Figure 11 Potential gas supply and production capacity[A] forecasts (TJ/day), 2020 to 2029



A. Production capacity reflects the projects included in the base scenario forecasts (existing, committed, and prospective).

Table 17 Potential gas supply forecasts (TJ/day), 2020 to 2029

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average growth pa (%)	10-year average growth pa (%)
Low	1,458	1,307	1,280	1,209	1,155	1,102	1,047	991	942	902	-5.7	-5.2
Base	1,458	1,307	1,280	1,207	1,299	1,243	1,411	1,357	1,311	1,272	-2.8	-1.5
High	1,458	1,307	1,328	1,255	1,346	1,277	1,447	1,395	1,350	1,314	-2.0	-1.1

3.5 Comparison of 2019 and 2018 WA GSOO potential gas supply forecasts

The base scenario potential gas supply forecasts developed for the 2018[79] and 2019 WA GSOOs are compared in Figure 12.

For the 2019 WA GSOO, AEMO updated the list of the prospective supply sources, gas reserves and resources, and assumptions for reserve depletion rates, production costs, domestic gas price, and Asian LNG price forecasts. This makes up for the bulk of the difference between the base scenario 2018 and 2019 WA GSOO potential gas supply forecasts.

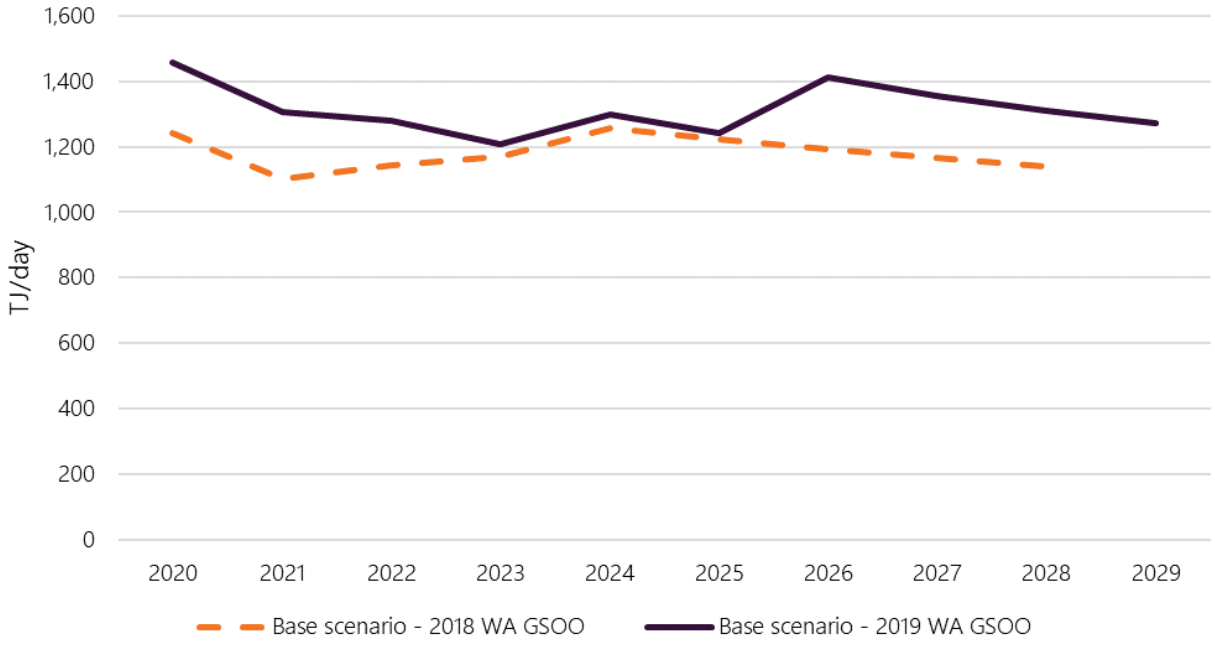
[79] The potential gas supply forecasts in the 2018 WA GSOO covered the outlook period 2019 to 2028.

In summary:

- The 2019 WA GSOO forecasts a higher level of potential gas supply over the outlook period under the base scenario compared to the 2018 WA GSOO forecasts. In both forecasts, prospective supply sources enter the market in 2022 and 2024.
- In the 2019 WA GSOO base scenario forecasts, LNG and domestic gas prices are sufficient to trigger one prospective supply project in 2026. This prospective supply source was uneconomic in the base scenario in the 2018 WA GSOO.

For further information about the potential gas supply methodology, see Appendix A3.3.

Figure 12 2018 and 2019 base scenario potential gas supply forecasts (TJ/day), 2020 to 2029



4. Domestic gas market supply-demand balance

This chapter summarises the gas demand and potential gas supply forecasts discussed in Chapter 2 and Chapter 3. In the base scenario, potential gas supply exceeds forecast domestic gas demand over the outlook period.

4.1 Summary of gas demand and potential gas supply forecasts

4.1.1 Domestic gas demand

Growth in domestic gas demand over the outlook period is expected to be supported by:

- Four resources projects that are either committed or currently under construction, which are expected to add 62 TJ/day to gas demand by 2023 in all three scenarios. This figure includes two projects that have taken FID since the 2018 WA GSOO was published (see Section 2.2.2 for further information).
- Strong global demand for battery-related commodities, including lithium, cobalt, and nickel, which is expected to boost general gas demand growth in the mining sector in all three scenarios.
- The staged retirement of two units at the coal-fired Muja C power station (2022 and 2024) will be offset by increasing small and large-scale renewable generation capacity that is expected to commence in 2020. However, the retirement of two Muja units is expected to increase gas demand for electricity generation in the SWIS over the outlook period (see Section 2.2.3 for further information).
- The addition of 10 prospective demand projects in the high scenario totalling 168 TJ/day of gas demand by 2025.

As an improvement to gas demand forecasting, AEMO has included two projects that are expected to reduce gas demand by around 2.5 TJ/day in all three scenarios, partially offsetting the expected growth (see Section 2.2.2 for further detail).

4.1.2 Potential gas supply

In the base scenario, potential gas supply is forecast to decline at an average annual rate of 1.5% over the outlook period, in line with reserve depletion at existing production facilities.

In 2019, two new gas supply sources commenced operation, adding 245 TJ/day of gas supply capacity to the WA domestic gas market. The Wheatstone production facility (205 TJ/day) commenced in March 2019, while Pluto began directly injecting up to 25 TJ/day into the domestic pipeline in December 2018 and started its domestic LNG truck-loading facility (15 TJ/day) in April 2019.

An additional 126.5 TJ/day of gas supply capacity is expected to become available by 2021 from two committed projects:

- The Xyris production facility, which will expand from 11.5 TJ/day to 20 TJ/day in 2020.
- The second tranche from the Gorgon domestic gas plant (118 TJ/day) in 2021.

From 2022, prospective supply sources could add up to 405 TJ/day to potential gas supply in the base scenario if they are developed. The West Erregulla domestic gas-only project is expected to commence in 2022 at a capacity of 25 TJ/day. Scarborough (150 TJ/day from 2024) is proposed to be developed through an expansion at Pluto (adding a second LNG train), while Browse (230 TJ/day from 2026) is expected to be connected to the KGP, where spare LNG capacity is projected to become available from the early 2020s.

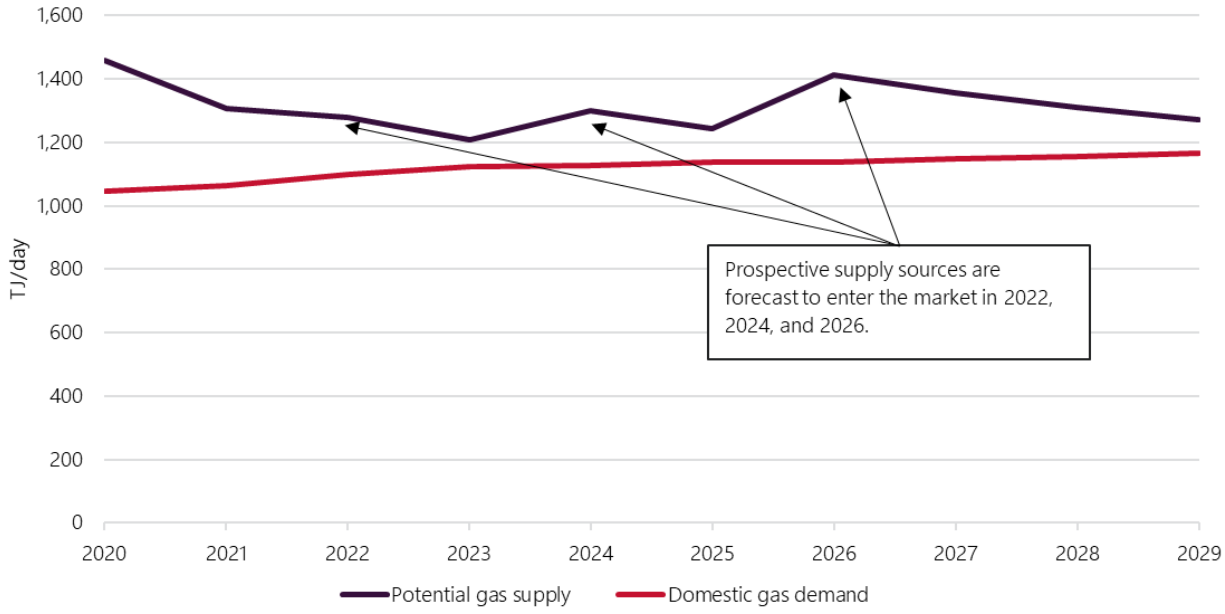
Further information on these prospective supply projects can be found in Section 3.3.

4.2 Supply-demand balance

4.2.1 Base scenario

Potential gas supply is expected to exceed gas demand over the outlook period, as shown in Figure 13 and Table 18.

Figure 13 Domestic gas market balance, base scenario, 2020 to 2029



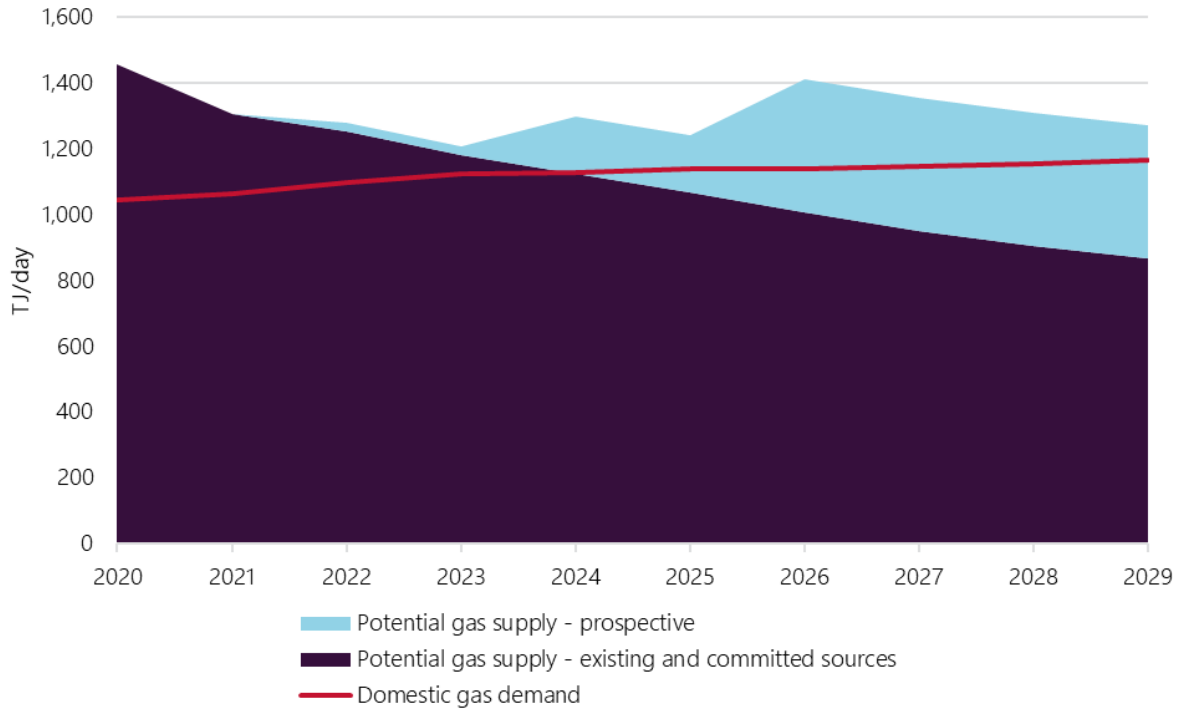
Potential gas supply is forecast to decline at an average annual rate of 1.5% over the outlook period, in line with reserve depletion at existing production facilities. Prospective supply sources are expected to be available and economically viable to enter the market in 2022, 2024, and 2026, partly offsetting the decline in potential gas supply from existing production facilities due to reserve depletion (see Section 3.4 for further information).

Table 18 Potential gas supply and demand forecasts, base scenario (TJ/day), 2020 to 2029

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Potential supply	1,458	1,307	1,280	1,207	1,299	1,243	1,411	1,357	1,311	1,272	-2.8	-1.5
Demand	1,046	1,065	1,098	1,124	1,128	1,139	1,138	1,148	1,154	1,165	1.9	1.2

The development of prospective gas supply sources is required to maintain supply adequacy over the outlook period, as shown in Figure 14. In contrast to the base scenario, if prospective supply sources are not developed, AEMO forecasts a supply deficit of 4 TJ/day in 2024, with the deficit increasing over the outlook period to 299 TJ/day in 2029.

Figure 14 Potential gas supply compared to gas demand, base scenario, 2020 to 2029



4.2.2 High and low scenarios

Low scenario

In the low scenario, potential gas supply declines at an average annual rate of 5.2% between 2020 and 2029, in line with reserve depletion at existing production facilities, despite the forecast entry of one prospective supply project in 2022. As a result, potential gas supply is insufficient to meet the low scenario domestic gas demand forecasts from 2026 until the end of the outlook period, as shown in Table 19.

Table 19 Potential gas supply and demand forecasts, low scenario (TJ/day), 2020 to 2029

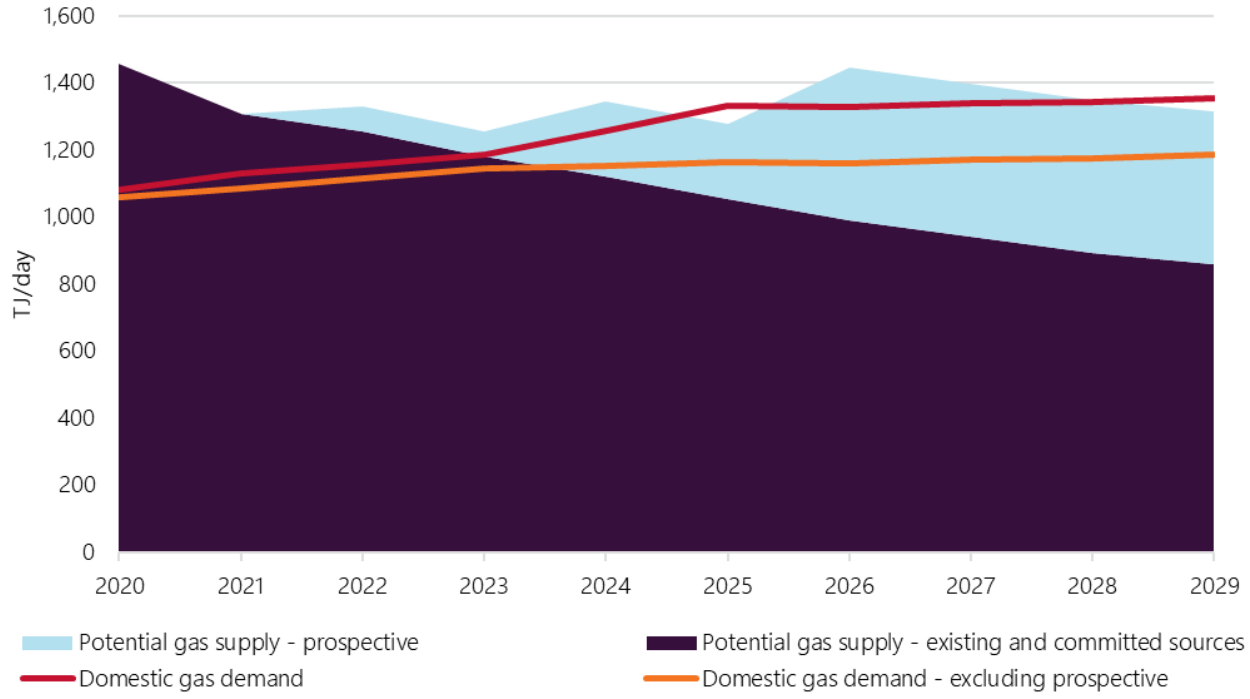
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	5-year average annual growth (%)	10-year average annual growth (%)
Potential supply	1,458	1,307	1,280	1,209	1,155	1,102	1,047	991	942	902	-5.7	-5.2
Demand	1,033	1,050	1,079	1,103	1,105	1,092	1,092	1,098	1,102	1,108	1.7	0.8

High scenario

Although one of the prospective supply sources has a higher capacity in the high case, the high scenario potential gas supply forecasts are almost identical to the base scenario, with the same set of prospective supply sources being triggered (see Section 3.4 for further information). The high gas demand scenario contains prospective demand projects totalling 168 TJ/day by 2025, which are not included in the low and base demand scenarios (see Section 2.2.2 for further information).

Gas demand exceeds potential gas supply in 2025 and 2029, as shown in Figure 15. However, if prospective demand is excluded from the gas demand forecasts, potential gas supply is sufficient to meet gas demand over the entire outlook period.

Figure 15 Potential gas supply compared to gas demand, high scenario, 2020 to 2029



AEMO notes that there is a large volume of gas reserves that could supply the WA domestic gas market during the outlook period, but this volume is currently too speculative to include as prospective supply in the potential gas supply forecasts. These include, but are not limited to, Clio-Acme, Corvus, Equus, Waitsia Stage 2, and West Erregulla phase 2 (see Section 3.3.3 for further information).

5. 2019 formal information request data analysis

This chapter presents aggregate data submitted by Gas Market Participants (GMPs) and non-GSI participants through the 2019 formal information request (FIR) process. This data is then compared with data received in the 2018 FIR process to provide insights about recent market movements.

Expected demand and contracted volumes have increased since the 2018 FIR process, although prospective demand has fallen.

In line with the GSI Rules, AEMO has conducted a confidential FIR process annually since 2017 to collect data and information from GMPs[80] for the purposes of the WA GSOO. GMPs are required to respond in line with the provisions under the GSI Rules[81], while some non-GSI participants provide information voluntarily.

This data covers roughly 80%[82] of the average daily gas demand in WA. Where possible, AEMO has used the FIR data as an input into developing the gas demand and potential supply forecasts for the 2019 WA GSOO.

The data presented in this chapter includes:

- Gas demand and supply estimates.
- Contracted volumes.
- Gas reserves.
- Domestic gas prices that may cause gas consumers to reduce or increase gas demand.

Data has been presented in aggregate form. Other information[83] submitted in the FIR process has not been presented, to preserve confidentiality for individual respondents.

AEMO has taken all due care to reconcile the information received, but accepts no liability for any errors in the supplied data. The data reported here is from the 2019 FIR process, unless otherwise specified. All data presented is the latest available as at April 2019 and should be considered indicative only. Note the data does not represent AEMO forecasts.

[80] Under GSI Rule 106, AEMO may require GMPs to provide information for the WA GSOO. This does not cover all participants in the WA domestic gas market.

[81] Under GSI Rule 21, GMPs include Registered Facility Operators and Registered Shippers, although some exemptions are available. For example, some facilities that consume gas are not responsible for the shipping of this gas and are thus not required to be registered. The GSI Register for GMPs and facilities is maintained and updated regularly by AEMO. Both are available at: https://www.aemo.com.au/Gas/WA-Gas-Services-Information/GSI-participant-information/GSI-register.

[82] Including GPGs, but excluding facilities that are not required to be registered as GMPs (such as small commercial gas users).

[83] Other information collected through the 2019 FIR process, but not reported, includes future and prospective supply or gas-consuming facility names, their capacities and development status, and consumption by pipeline and storage facilities. This information is used as inputs into AEMO's potential gas supply and domestic gas demand forecasts.

5.1 Gas demand and supply data

For the 10-year outlook period 2020 to 2029, AEMO asked GMPs[84] to provide the following data on a facility basis:

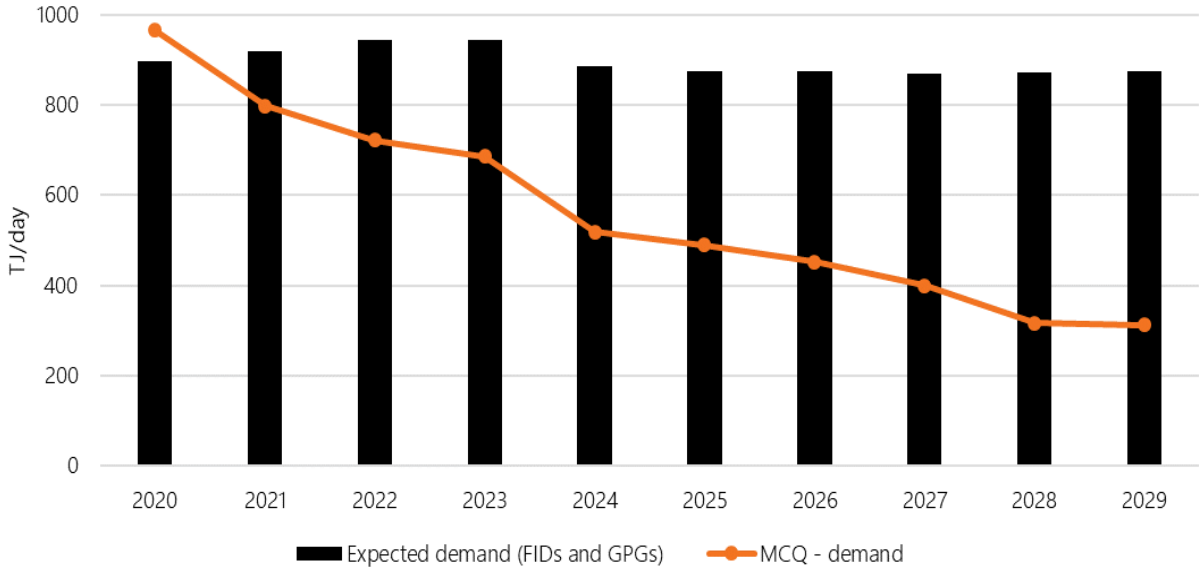
- For gas consumers – total expected and maximum contracted gas demand estimates.
- For gas production facility operators and their joint venture partners – total firm supply capacity and maximum contracted gas supply estimates.

The sections below provide comparisons between these measures to give indicative insights on the WA gas market over the next 10 years.

5.1.1 Total expected and maximum contracted gas demand

Figure 16 presents the expected demand[85] and maximum contracted quantities (MCQ) submitted by gas consumers through the 2019 FIR (covering around 80% of total WA gas consumption). Expected demand includes demand for GPGs and committed projects with positive FID[86].

Figure 16 Total expected gas demand and maximum contracted quantity, 2020 to 2029



Source: GMPs.
Note: The figure excludes incremental prospective[87] demand provided by GMPs (which included diesel to gas fuel switch projects, as well as new or expanded gas-consuming facilities). The prospective demand is lower than in the 2018 FIR data, reflecting some projects taking FID.

Based on the 2019 FIR data, gas demand is expected to grow by 1.5% between 2020 and 2022, then to fall by 6.1% between 2023 and 2024, likely due to the end of production life for some mines. Expected demand is relatively stable from 2024 to 2029. These trends are consistent with observations from the 2018 FIR process.

MCQ is lower than expected demand over the outlook period from 2021, indicating that consumers are not fully contracted.

[84] In total, 46 GMPs and six non-GSI participants responded to the 2019 FIR, providing responses related to 52 gas-consuming facilities, nine gas production facilities, eight pipelines, two storage facilities, and the main distribution network. All non-GSI submissions were from gas suppliers. The FIR excluded multiple entities which report for the same facility, facilities no longer operating but not de-registered, and retailers (to avoid double-counting).

[85] Total expected gas demand includes projects that have taken FID and are expected to commence by 2019 or later, and includes GPGs.

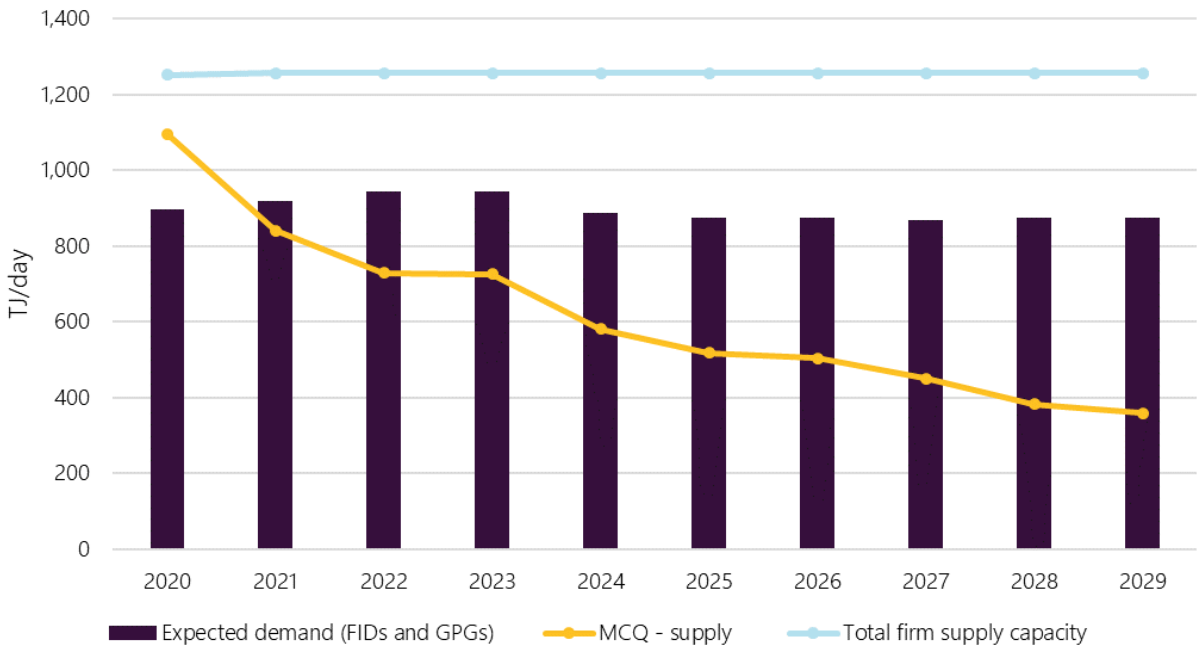
[86] A definite conclusion(s) reached to execute a course of action that is binding in its entirety on a person, company, or entity to whom it is addressed.

[87] Projects were classified according to development stage – FID, environmental approval, internal approval, or speculative.

5.1.2 Total firm gas supply capacity and maximum contracted gas supply

Domestic gas production facility operators and joint venture partners submitted estimates of total firm gas supply and MCQ for their facilities and individual corporate entities, as shown in Figure 17. The total firm gas supply capacity represents the supply capacity of gas production facilities that respondents expect to make available to the WA domestic gas market each year over the outlook period.

Figure 17 Expected gas demand and MCQ (from suppliers) compared to total firm supply capacity, 2020 to 2029



Source: GMPs and some non-GSI participants.

MCQ is lower than total firm gas supply capacity throughout the outlook period.

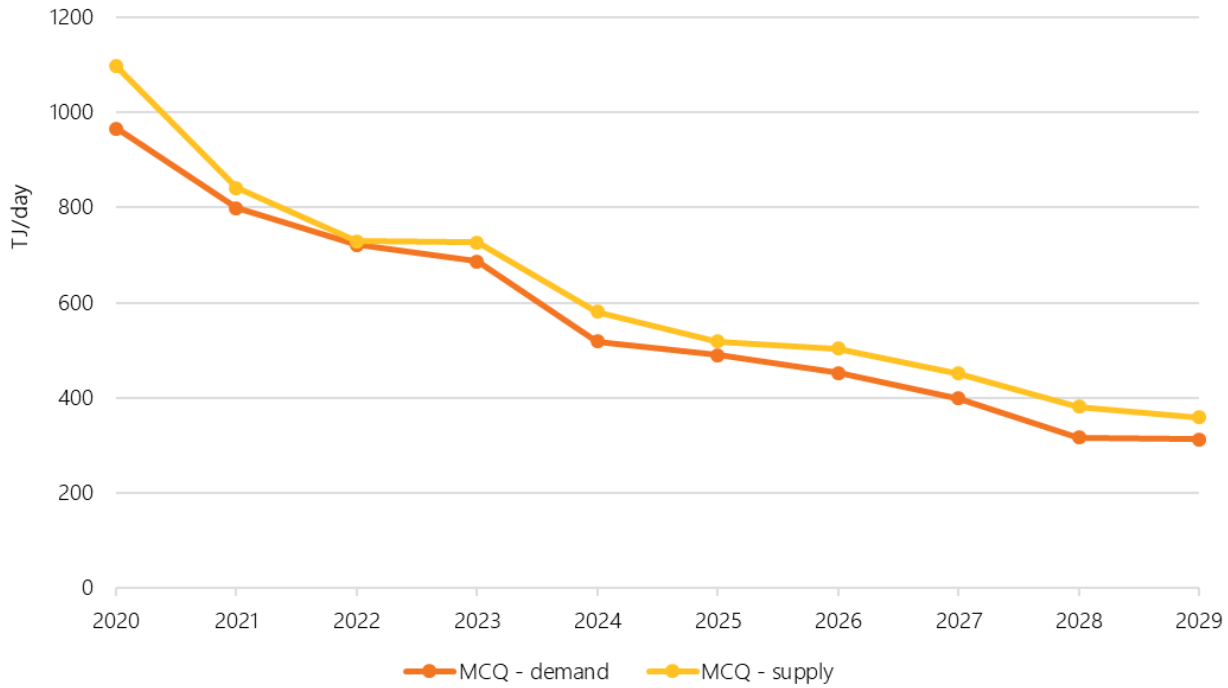
In 2020, the MCQ is estimated to be almost 90% of the total firm gas supply capacity. This proportion is expected to fall every year over the outlook period to 29% in 2029. MCQ is expected to decrease sharply after 2023 as long-term contracts expire, indicating there is supply available to be contracted.

In 2020, the estimated total firm supply capacity is 1,252 TJ/day. After a slight increase to 1,257 TJ/day in 2021, firm supply capacity is expected to be constant at that amount for the remainder of the outlook period.

5.1.3 Total maximum contracted gas supply and demand

AEMO requested MCQ from both gas suppliers and consumers as part of the FIR process to enable a comparison between the demand-side and supply-side contracts. The total MCQ from the supply-side and demand-side is compared in Figure 18.

Figure 18 Comparison of total MCQ from suppliers and consumers, 2020 to 2029



Source: GMPs and some non-GSI participants.

Since the FIR process captures all suppliers but only about 80% of total WA gas demand, MCQ sourced from the suppliers is higher than the MCQ from consumers by around 52 TJ/day on average until 2029. However, the trend for both suppliers and consumers is consistent, with MCQ falling over the outlook period, reflecting the expiry of long-term contracts from 2020.

Based on the 2019 FIR data, by 2029, MCQ is expected to be around one-third of the MCQ in 2020. Between 2020 and 2022, MCQ from suppliers falls by 368 TJ/day, equal to roughly one-third of total WA gas consumption. MCQ then falls gradually between 2022 and 2029. In 2029, the MCQ from suppliers is 46 TJ/day higher than MCQ from consumers.

5.1.4 Comparison of 2018 and 2019 FIR data

A comparison of 2018 and 2019 FIR data shows that MCQ (both from suppliers and consumers) has increased, indicating additional long-term contracts may have been signed since last year.

Expected gas demand has increased in the 2019 FIR compared with 2018 FIR data, as shown in Figure 19.

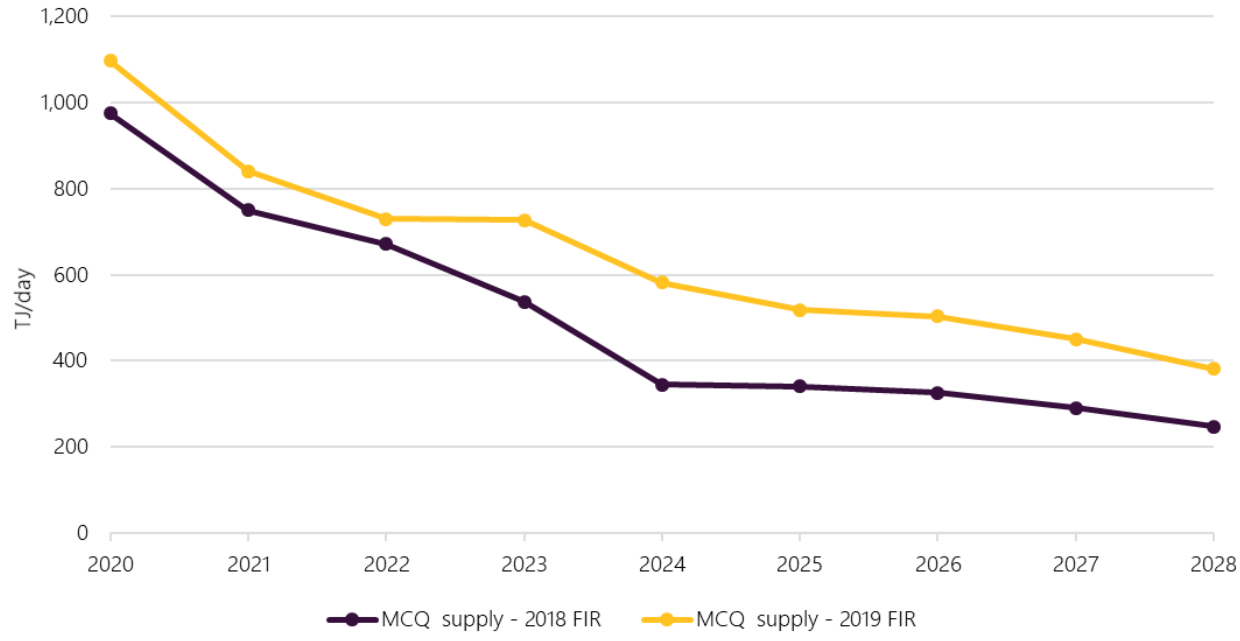
Figure 19 Comparison of expected demand, 2018 and 2019 FIRs

Source: GMPs.

On average, expected gas demand is roughly 10% higher (88 TJ/day) in the 2019 FIR data compared to the 2018 FIR data across the entire outlook period, except for 2023 when the difference increases to 13% (100 TJ/day). This reflects additional demand from projects that have attained FID and GPGs.

The difference in MCQ for suppliers between the 2018 and 2019 FIR data peaks at 236 TJ/day in 2024, as shown in Figure 20.

Figure 20 MCQ from suppliers, 2018 and 2019 FIRs



Source: GMPs and some non-GSI participants.

5.1.5 Gas supply-demand balance

The 2019 FIR data indicates that the total firm supply capacity is expected to exceed gas demand over the entire outlook period, even when accounting for prospective demand.

Surplus firm supply capacity is expected to range from 336 TJ/day in 2020 to 381 TJ/day in 2029, as shown in Figure 21, except for 2023, when the forecast excess decreases to 313 TJ/day due to an increase in expected demand. Prospective demand remains relatively constant throughout this period at 14 TJ/day.

Figure 21 Total firm gas supply capacity and gas demand estimates, 2020 to 2029

Source: GMPs and some non-GSI participants.

In 2020, the sum of the expected and prospective demand is 916 TJ/day, accounting for 73% of the total firm supply capacity. This proportion is expected to be roughly maintained throughout the outlook period.

5.2 Reserves

Domestic gas production facility operators and joint venture partners reported the volumes of 2P gas reserves associated with all their WA petroleum production licences, as well as 2P gas reserves that are physically connected to each existing domestic gas production facility[88]. This data is an input into AEMO's potential gas supply model.

The 2P gas reserves connected to domestic gas production facilities are compared with the information collected in previous FIRs in Table 20[89]. Connected 2P reserves (developed and undeveloped) have decreased relative to the 2018 WA GSOO estimates by 4,755 PJ (9.9%), generally reflecting LNG and domestic gas production from the associated fields in the past year.

[88] Reserves are quantities of gas that are anticipated to be commercially recoverable from known accumulations. Proved and probable reserves (2P) are considered the best estimate of commercially recoverable reserves. Contingent resources (2C) were not collected for the 2019 FIR process, since they are considered less commercially viable than reserves.

[89] Volumes reported at standard conditions (60°C and 1 atmosphere [101.325 kPa] pressure).

Table 20 Total 2P gas reserves from 2017, 2018, and 2019 FIRs (PJ)

Gas reserves and resources	2017	2018	2019
Total 2P reserves connected to domestic gas production facilities	35,159	47,886	43,131

Source: GMPs and some non-GSI participants.

5.3 Gas prices that would influence gas consumption

Eleven gas consumers (representing around one-third of WA gas consumption) provided WA domestic gas prices[90] they said would affect their gas demand over the outlook period, either by encouraging expansion (new or existing facilities) or prompting reduction of their gas demand (closure or curtailment). These consumers provided comments on gas prices and other factors that may affect their operations.

A summary of the gas prices provided by the 11 gas consumers is shown in Table 21.

Table 21 Gas price estimates that could result in changes in gas consumption (A$/GJ)

Price range	Minimum	Median	Maximum
Expanding existing or building new gas-consuming facilities[A]	$1.50	$2.50	$3.80
Reducing or closing existing gas-consuming facilities	$5.74	$8.23	$11.50

Source: GMPs.
A. The prices are low compared to recent historical gas prices, which averaged $4.11/GJ in 2018. This figure was sourced from DMIRS. *Latest Statistics Release – 2018 Major Commodities Resource File,* at http://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx.

In addition to gas prices, some other factors – such as international commodity prices, construction and labour costs, the cost of alternative fuels, and decarbonisation – were mentioned as triggers for gas consumers to consider expanding or reducing their current operations.

[90] Gas prices (A$/GJ) were provided in 2019 dollars.

6. Implications of government and industry initiatives

This chapter examines activities and initiatives that may affect current and/or future gas supply in WA.

6.1 Activities affecting gas supply and demand

In addition to new gas resource discoveries in WA, the supply of conventional gas could be supported by developments arising from recent Government focus on retention lease holders.

On the demand side, there is potentially 330 TJ/day of gas demand from two large-scale petrochemicals projects, with further gas demand expected to come from the shipping and mining industry.

6.1.1 Petroleum licence reviews

Review of NWS retention leases

The National Offshore Petroleum Titles Administrator (NOPTA) completed a NWS Commerciality Review in March 2018 with the outcomes provided to the Commonwealth – Western Australia Offshore Petroleum Joint Authority (being the responsible Australian Government Minister and the relevant State Minister) in March 2018. The Joint Authority have been regularly updated on the progress of titleholders towards development, with the most recent update provided in July 2019.

Two of the resources considered by the NWS Commerciality Review are being actively progressed towards development, with the Browse titleholders (WA-28-R, WA-29-R, WA-30-R, WA-31-R and WA-32-R) seeking to develop the resource through the existing NWS infrastructure and the Scarborough titleholders (WA-1-R) considering an expansion of the Pluto LNG facility to support development. Final investment decisions are expected during 2020 or 2021 and NOPTA continues to engage with titleholders on progress towards development.

Council of Australian Governments (COAG) Energy Council Review of Petroleum Licencing Regulations

The COAG Energy Council reviewed the petroleum licensing regulations in response to concerns raised by large domestic gas users regarding the use of retention lease provisions by the petroleum industry[91]. The concerns related to possible strategies of retention lease holders to progress development of proven and commercially viable resources at a rate that affects supply and demand balances in downstream markets (commonly referred to as warehousing).

[91] COAG Energy Council, COAG Energy Council Review of Petroleum Licensing Regulations, 29 March 2018, at http://www.coagenergycouncil.gov.au/publications/coag-energy-council-review-petroleum-licensing-regulations.

The COAG Energy Council Upstream Petroleum Resources Working Group (UPR) contracted Noetic Solutions Pty Limited (Noetic) to conduct a review of the petroleum licencing regulations across Australian jurisdictions. The outcomes from the review were published in August 2018[92]. While the COAG Energy Council is considering the report's recommendations, discussions are underway with licence holders about developing proven and commercial resources sooner rather than later[93].

6.1.2 PRRT gas transfer pricing arrangements

On 2 November 2018, the Australian Government released a final response to the review of the Petroleum Resource Rent Tax (PRRT). The changes to the PRRT from 1 July 2019 included:

- Reducing the uplift rates that apply to certain categories of carried-forward expenditure.
- Removing onshore projects from the scope of the PRRT.

As a part of the final response to the PRRT review, the Australian Government asked Treasury to lead an additional review of gas transfer pricing arrangements in relation to the PRRT. The consultation process for this review has been completed, and stakeholder submissions are available for viewing. The review is scheduled for completion before October 2020[94].

6.1.3 West-East Gas Pipeline (WEGP) pre-feasibility study

Shortly after the publication of the 2018 GSOO, results from the WEGP pre-feasibility study (which was detailed in the 2018 GSOO) were publicly released. The WEGP pre-feasibility study concluded that, although a West to East Gas Pipeline is technically possible, it is not currently the best or most economical option for increasing gas supplies in the eastern and south-eastern Australia gas market[95].

6.1.4 Gas used in processing lithium and other energy metal resources

The bullish outlook for lithium demand and subsequent 'value-add' processing of lithium in WA has dampened over the past 12 months. The lower than anticipated demand for lithium over the short term has been primarily caused by the cessation of subsidies for electric vehicles in China in 2018. Over the medium term, however, gas demand from this industry is expected to be as significant as previously forecast.

Despite demand for lithium products not materialising at the rate anticipated, construction of lithium processing plants in WA are proceeding, but at a pace that matches the slower increase in global demand for lithium products.

6.1.5 Gas as a marine fuel

The International Maritime Organisation (IMO) has committed to reducing the sulphur content of marine fuels from 3.5% to 0.5% by 2020. The use of LNG as a fuel for shipping is viewed as the primary solution for curtailing sulphur emissions from 2020 compared to alternative options, which include low-sulphur fuel oil and exhaust gas cleaning technology.

As shown in Figure 22, the global shipping fleet represents a significant source of greenhouse gas (GHG) emissions. Consequently, the IMO has committed to reducing the amount of GHG emissions from world shipping by 50% from 2008 levels by 2050. Over this time, the number of ships in the world shipping fleet is

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[92] Noetic Group. *Review of Petroleum Retention Lease Arrangements in Australian Jurisdictions*, Report for the Department of Industry, Innovation and Science, July 2018, at http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Noetic%20Group%20report_Review%20of%20Petroleum%20Licencing%20Regulations.pdf.

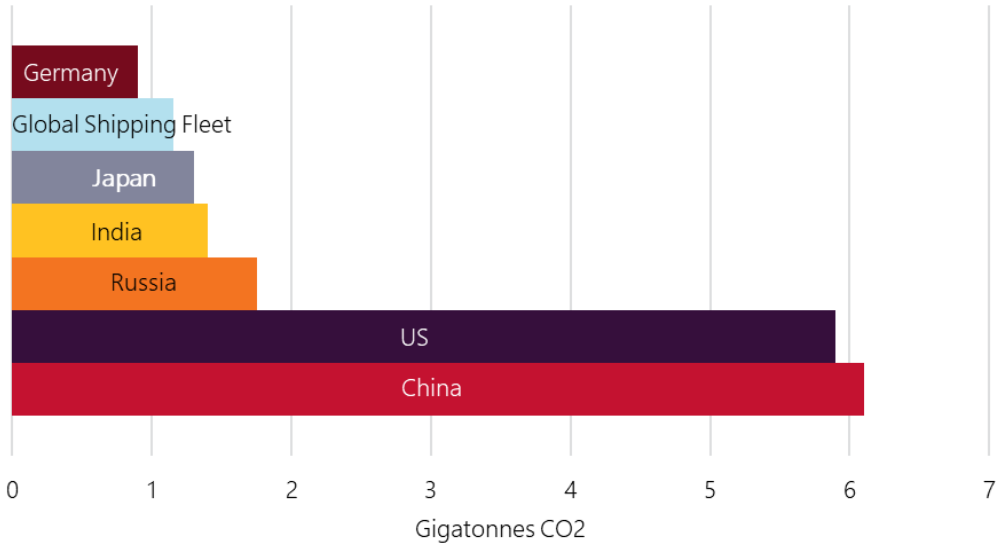
[93] See https://www.watoday.com.au/national/western-australia/woodside-warned-use-it-or-lose-it-over-stalled-wa-project-20190723-p529r6.html; and https://www.afr.com/companies/energy/woodside-gets-high-level-support-on-lng-20190709-p525hn.

[94] Australian Treasury, "Petroleum Resource Rent Tax: Review of Gas Transfer Pricing arrangements", at https://treasury.gov.au/consultation/c2019-t364690.

[95] Department of Environment and Energy, "West-East gas pipeline pre-feasibility study", December 2018, at https://www.energy.gov.au/publications/west-east-gas-pipeline-pre-feasibility-study.

expected to triple, meaning individual ships will have to reduce emission by approximately 70% from 2008 levels by 2050[96].

Figure 22 Comparing emissions from the global emissions fleet



Source: IMO.

Although LNG emits a lower amount of GHG than fuel oil when used in a combustion engine, the use of LNG as a shipping fuel with current combustion engine technologies will not, by itself, be sufficient to meet the IMO's 50% GHG emissions reduction target. However, LNG is viewed by large users of shipping, such as BHP and Woodside, as a transitional fuel for the global shipping fleet while it reduces GHG emissions in line with the IMO's 50% GHG emissions reduction target.

BHP, which is one of the world's largest vessel charterers, currently issues tenders for shipping services that favour providers offering reduced carbon, sulphur, and nitrous oxide emissions[97]. BHP expects to ship up to 27 million tonnes of iron ore to China in vessels powered by LNG, with delivery targeted for late 2021, and estimates a 25% reduction in GHG emissions compared to the GHG emissions that would have been released from the combustion of low-sulphur fuel oil for these shipments[98].

6.1.6 Demand from downstream gas processing and value-add

Construction costs, Western Australian domestic gas prices, and the Australian dollar have declined over recent years to levels that are increasingly supportive of establishing gas-centric manufacturing in WA. Additionally, gas processing plants being proposed for WA are being actively encouraged by the State Government, with the WA Premier using the Australian Petroleum Production and Exploration Association (APPEA) 2019 Oil and Gas conference in Brisbane to highlight the availability of cheap and reliable gas supply in WA, and to declare that those who locate their business in WA may expect support from the State Government through joint initiatives such as the LNG Futures Facility and LNG Jobs Taskforce (see Section 6.3.1 below for more details).

Two significant downstream gas processing plants, described below, are being proposed and are supported by the Australian and State Governments.

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[96] IMO. "Reducing greenhouse gas emissions from ships", accessed 11 December 2019, at www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx.

[97] BHP. "Greater freight partnerships sets course for sustainable shipping", 18 June 2019, at https://www.bhp.com/media-and-insights/prospects/2019/06/greater-freight-partnerships-sets-course-for-sustainable-shipping.

[98] Australian Financial Review. "BHP calls for LNG-powered iron ore vessels", 14 July 2019, at https://www.afr.com/companies/mining/bhp-calls-for-lng-powered-iron-ore-vessels-20190714-p52743.

Urea fertiliser plant

Perdaman is currently developing a urea fertiliser plant with a production capacity of 2 mtpa of granulated urea in the Pilbara, which is expected to be completed in 2024. A memorandum of understanding is in place with Woodside to supply up to 130 TJ/day of gas over a 20-year period. The estimated cost is $4.5 billion and will be the first plant in Australia to export the fertiliser[99].

The project was granted Major Project Status in March 2019 by the Australian Government Department of Industry, Science and Technology, which will expedite relevant Government approvals and support. The details of this project are to be assessed by the EPA[100].

The next stages of this project include:

- Finalising sale agreements amounting to 2 mtpa of urea.
- Bringing partners into the project.
- Finalising financing arrangements and remaining government approvals.

Methanol plant

A consortium including Coogee Chemicals, Wesfarmers, and Mitsubishi Corporation has proposed the construction and operation of a methanol and monoethylene petrochemical plant on the Burrup Peninsula. The plant will have a production capacity of approximately 5,000 tonnes per day[101]. Total gas feedstock could amount to 200 TJ per day (based on the estimated consumption of a similar methanol plant planned by Coogee Chemicals for the Northern Territory[102]).

This project is estimated to cost $1.3 billion, and in December 2018 the EPA decided to proceed to the environmental assessment stage[103]. Objections have been raised about emissions from the plant and the effect on local rock art[104], which will be included and considered by the EPA during its environmental assessment stage.

6.2 Initiatives with market-wide impact

This section discusses key initiatives that may have a wider impact on the WA domestic gas market, including federal policies that may have direct or flow-on effects to WA.

6.2.1 Greenhouse Gas Emissions Policy for major projects

With the aspirational aim of moving all sectors of WA's economy towards producing net zero greenhouse gas emissions by 2050, the WA Government announced an emission policy on 28 August 2019 that is intended to include greenhouse gas emissions from major projects.

The policy supports development of 'greenhouse gas management plans' from proponents of major new projects or project expansions, when deemed necessary by the State Government. These 'greenhouse gas management plans' would detail how emissions from the project could be managed so that the emissions

[99] For more information, see https://cciwa.com/about-us/news-and-media-statements/perdaman-releases-scoping-document; https://thewest.com.au/business/agriculture/major-boost-for-45b-pilbara-fertiliser-plant-ng-b881148443z https://www.energynewsbulletin.net/environment/news/1364577/perdaman-submits-draft-ep-for-comment-for-burrup-fertiliser-plant; https://perdaman.com.au/2019/03/27/perdaman-announces-major-project-facilitation-status-granted-australian-federal-government-karratha-urea-project/.

[100] EPA, Downstream Processing Chemical Production Facility, at http://epa.wa.gov.au/proposals/downstream-processing-chemical-production-facility.

[101] For more information, see https://www.spiritradio.com.au/news/news/burrup-foi-response-suggests-something-to-hide-ng-b88871896z/#; http://epa.wa.gov.au/proposals/downstream-processing-chemical-production-facility.

[102] Oil and Gas Journal, "Coogee plans methanol plant for Northern Territory", 4 September 2019, at https://www.ogj.com/pipelines-transportation/lng/article/14039244/coogee-plans-menthanol-plant-for-northern-territory.

[103] EPA, public record of determination, at http://epa.wa.gov.au/sites/default/files/Extract_of_determination/CMS17372-CD-031218.pdf.

[104] West Australian, "Proposed Burrup projects a heritage threat to rock art", 2 May 2018, at https://thewest.com.au/news/pilbara-news/proposed-burrup-projects-a-heritage-threat-to-rock-art-ng-b88817607z.

from the project align with the State achieving its aspiration target of net zero emissions by 2050. The WA Government has indicated that a State Climate Policy will be released in 2020[105].

The EPA released a draft greenhouse gas emissions guideline[106] in December 2019 to support the State Government's policy.

6.2.2 Fracking in Western Australia

A hydraulic fracturing moratorium on existing petroleum titles in WA was lifted on 6 September 2019, following the introduction of a state-wide moratorium at the end of 2018. Fracking is currently limited to 2% of WA, with all new exploration and production projects to be referred to the EPA for assessment and regulated under new requirements[107].

6.3 Collaborative initiatives

6.3.1 LNG Futures Facility

This joint initiative between the WA Government and industry aims to secure support from the Australian Government for the following key activities:

- Construct a world-first microscale LNG project (10 tonnes per day capacity) in Kwinana[108].
- Facilitate participant testing of new technology and processes.

The project involves collaboration between the University of Western Australia, Chevron, Shell, Hyundai Heavy Industries, and National Energy Resources Australia. The FID for the facility is due in 2019 ($10 million has been committed by the WA Government) and will form an integral part of the Future Energy Exports Cooperative Research Centre[109].

6.3.2 LNG Jobs Taskforce

The LNG Jobs Taskforce is a joint initiative implemented by the WA Government and industry. The aim of the taskforce is to maximise local jobs in WA's LNG sector, and create new opportunities for industry on the back of WA's competitively priced gas supply and position as a global LNG hub. Chaired by the Premier, the Taskforce includes Chevron, Woodside, Shell, Santos, and INPEX, as well as representatives from APPEA and UnionsWA[110].

6.3.3 Hydrogen from WA

The relatively low cost of renewable electricity generation in WA, and the rising demand from overseas for low-emission hydrogen, has generated interest from industry, government agencies, and academia over the past 18 months.

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[105] To view the greenhouse gas emissions policy, visit https://www.der.wa.gov.au.

[106] EPA. "Draft greenhouse gas emissions guideline released", December 2019, at http://www.epa.wa.gov.au/pages/greenhouse-gas-emissions-assessment-guidance-consultation.

[107] WA Government, "Hydraulic fracturing remains banned on 98 per cent of WA", media statement, 6 September 2019, at https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/09/Hydraulic-fracturing-remains-banned-on-98-per-cent-of-WA.aspx.

[108] WA Government, "Premier announces plans for a world-first LNG plant in WA", media statement, 2 April 2019, at https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/04/Premier-announces-plans-for-a-world-first-LNG-plant-in-WA.aspx.

[109] See www.fenex.org.au/.

[110] Prospect: Western Australia's International Resources Development Magazine, Autumn 2019, at https://www.dmp.wa.gov.au/Documents/Community-Education/Prospect_Autumn_2019.pdf.

During July 2019, the WA Government released its WA Hydrogen Strategy paper (H2 Paper) which articulates emerging demand from Japan and Korea for low-emission hydrogen[111]. Growing demand for low-emission hydrogen over the next 10 years has also been highlighted by the International Energy Agency[112].

The Japanese Government has a target to procure 300,000 tonnes of low-emission hydrogen annually by 2030. South Korea is aiming to produce 6.2 million hydrogen cars for domestic use and export, as well as build 1,200 refuelling stations by 2040. The value of Australia's potential low-emission hydrogen exports could reach $2.2 billion by 2030 and $5.7 billion by 2040[112].

In anticipation of increasing low-emission hydrogen demand from Asia and potentially Europe, the following major hydrogen production projects are being planned for WA:

- The Asia Renewable Energy Hub is a 15 GW (50 TWh) power generation project (roughly equivalent to 20% of Australia's current annual electricity production[113]) that is expected to be constructed in the Pilbara to produce hydrogen from renewable energy. If financial close is achieved by 2023, it is anticipated that the $30 billion project will be rolled out in a number of phases over the next decade.
- Plans for the Murchison Renewable Hydrogen Project located close to Kalbarri include 5 GW of solar and wind generation to be used in the production and export of emission-free hydrogen. The company proposing the project, Hydrogen Renewables Australia is currently negotiating an Indigenous Land Use Agreement[114].

Other relevant activities relating to hydrogen production in WA include:

- The Hazer Group and Mineral Resources Limited are commissioning a pilot plant that can produce low-emission hydrogen and graphite from iron ore and LNG. The pilot plant in the Kwinana industrial area uses patented technology referred to as the Hazer Process.
- ATCO, which owns the gas distribution network in and around Perth, is investigating the opportunity of blending distributed natural gas with hydrogen for domestic and commercial consumption, pointing to precedents set in the 1970s when town gas was distributed through the Perth region with a 50% hydrogen mixture[115].

The COAG Energy Council is working towards releasing a national hydrogen strategy by the end of 2019[116].

[111] Hydrogen produced where low or zero amounts of greenhouse gases are created during production.

[112] Department of Primary Industries and Renewable Development, Western Australian Renewable Hydrogen Strategy, July 2019, at http://www.drd.wa.gov.au/Publications/Documents/wa_renewable_hydrogen_strategy.pdf.

[113] Renew Economy, "Pilbara green hydrogen project grows to 15 GW wind and solar", 12 July 2019, at https://reneweconomy.com.au/pilbara-green-hydrogen-project-grows-to-15gw-wind-and-solar-97972/.

[114] Renew Economy, "Massive 5,000MW solar and wind projects set to fuel WA's hydrogen expansion", 8 October 2019, at https://reneweconomy.com.au/massive-5000mw-solar-and-wind-projects-set-to-fuel-was-hydrogen-expansion-91993/.

[115] ATCO. "Clean energy innovation hub: researching a cleaner energy future", accessed 11 December 2019, at https://yourgas.com.au/energy-future/clean-energy-innovation-hub/.

[116] For further information and the workplan, see http://www.coagenergycouncil.gov.au/publications/establishment-hydrogen-working-group-coag-energy-council.

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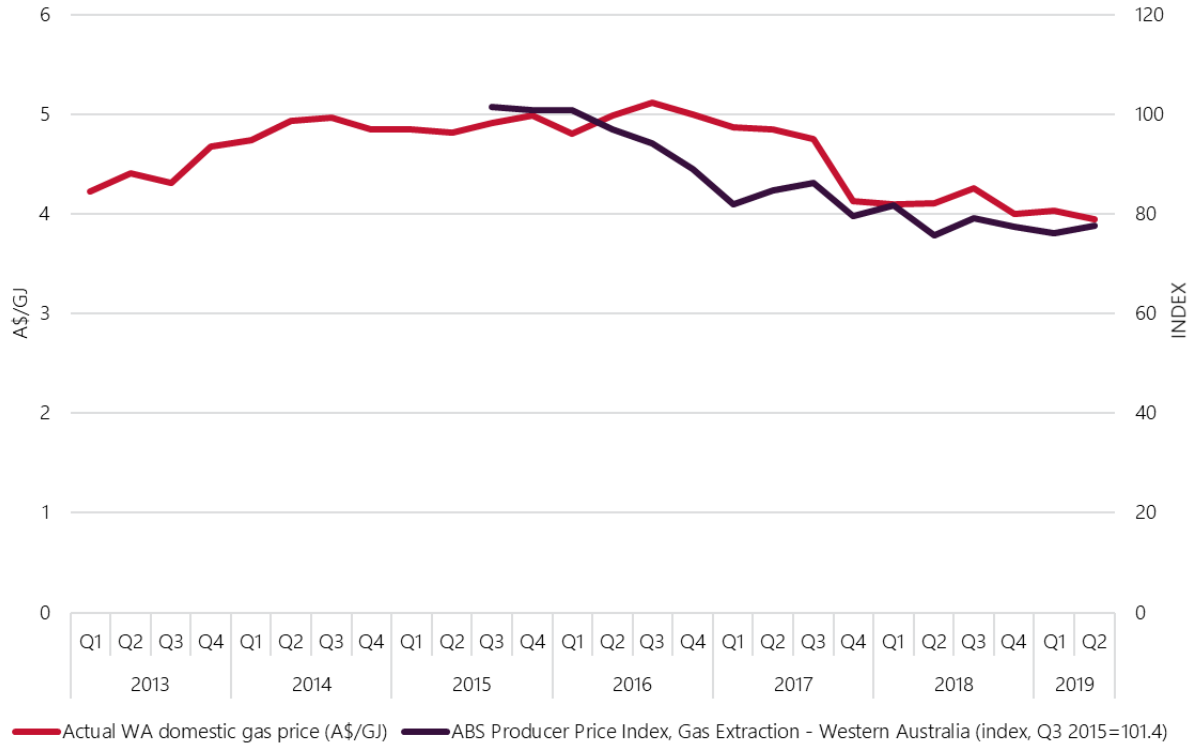
A2. Historical domestic gas prices and forward reference prices

A2.1 Historical domestic gas prices

The quarterly historical domestic gas contract price[117] is compared with the Australian Bureau of Statistics' (ABS) producer price index (PPI)[118] for gas extraction in Figure 23.

Figure 23 Historical domestic gas contract prices (A$/GJ, nominal) and ABS PPI – Western Australia (gas extraction, index), Q1 2013 to Q2 2019



Source: ABS and DMIRS.

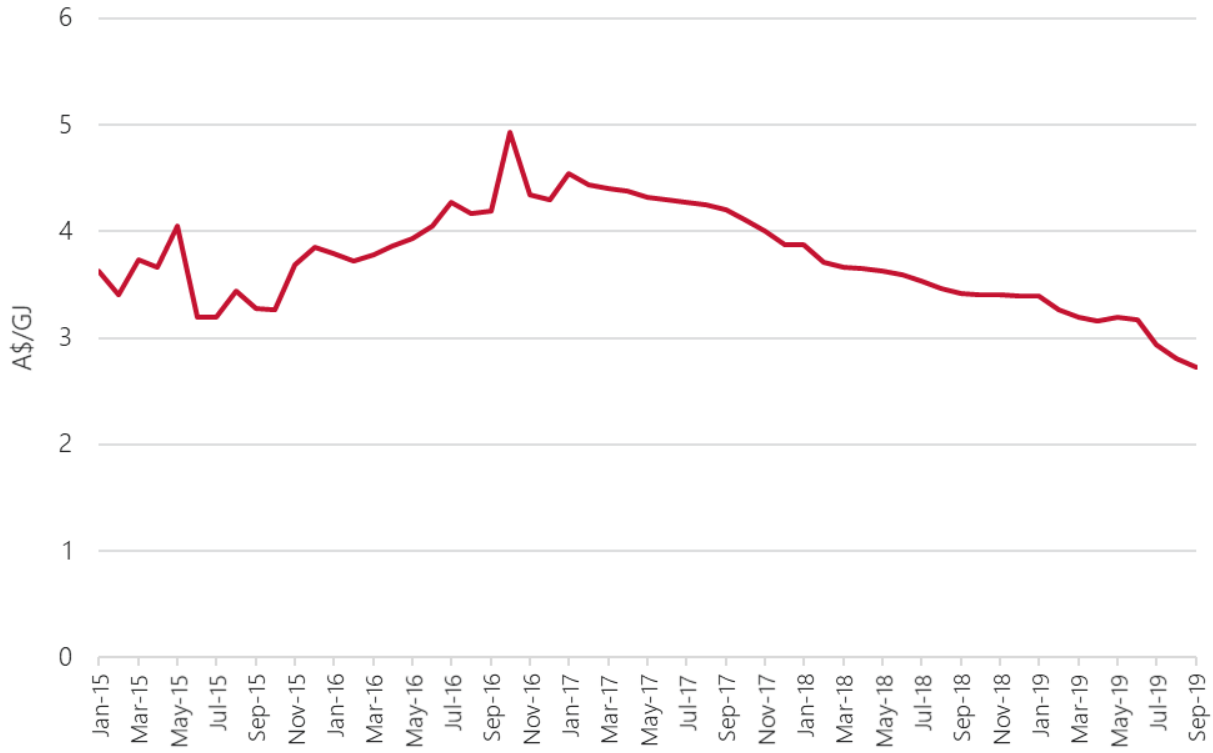
[117] DMIRS. *Latest Statistics Release – 2018-19 Major Commodities Resources File*, at http://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx.

[118] The base for the index is FY 2015-16. ABS 2019. *Producer Price Indexes, Australia, Jun 2019*, Table 36 – Output of the Mining industries, index numbers. Available at https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6427.0Jun%202019?OpenDocument.

Prices fell between the end of 2016 and the second quarter of 2018, from A$5/GJ to A$4.12/GJ. After a slight increase in quarter three of 2018 to A$4.26/GJ, the price has continued to fall to a low of A$3.95/GJ in quarter two of 2019. The ABS PPI (gas extraction) shows a similar trend until the second quarter of 2019, where it increases slightly.

Figure 24 shows monthly nominal spot prices since early 2015 (before the expiry of NWS and Gorgon joint marketing authorisation from the Australian Competition and Consumer Commission (ACCC) at the end of 2015[119]), published by gasTrading. Spot prices for gas traded via gasTrading increased from A$3.63/GJ in January 2015 to peak at A$4.93/GJ in October 2016, before declining by around 40% from $4.54/GJ in January 2017 to A$2.73/GJ in September 2019.

Figure 24 WA spot gas prices from gasTrading (A$/GJ, nominal), January 2015 to September 2019



Source: gasTrading.

The falling domestic gas price is largely a result of excess supply in the market, as well as:

- Increased competition among suppliers following the expiry of joint marketing arrangements[120] at the end of 2015.
- Limited growth in WA domestic gas demand.

A2.2 Reference prices for the WA domestic gas market

Following the outcomes of the five-yearly GSOO review[121], AEMO has discontinued domestic gas price forecasts. Instead, AEMO presents a reference price series for the 10-year outlook period, as shown in Figure 25.

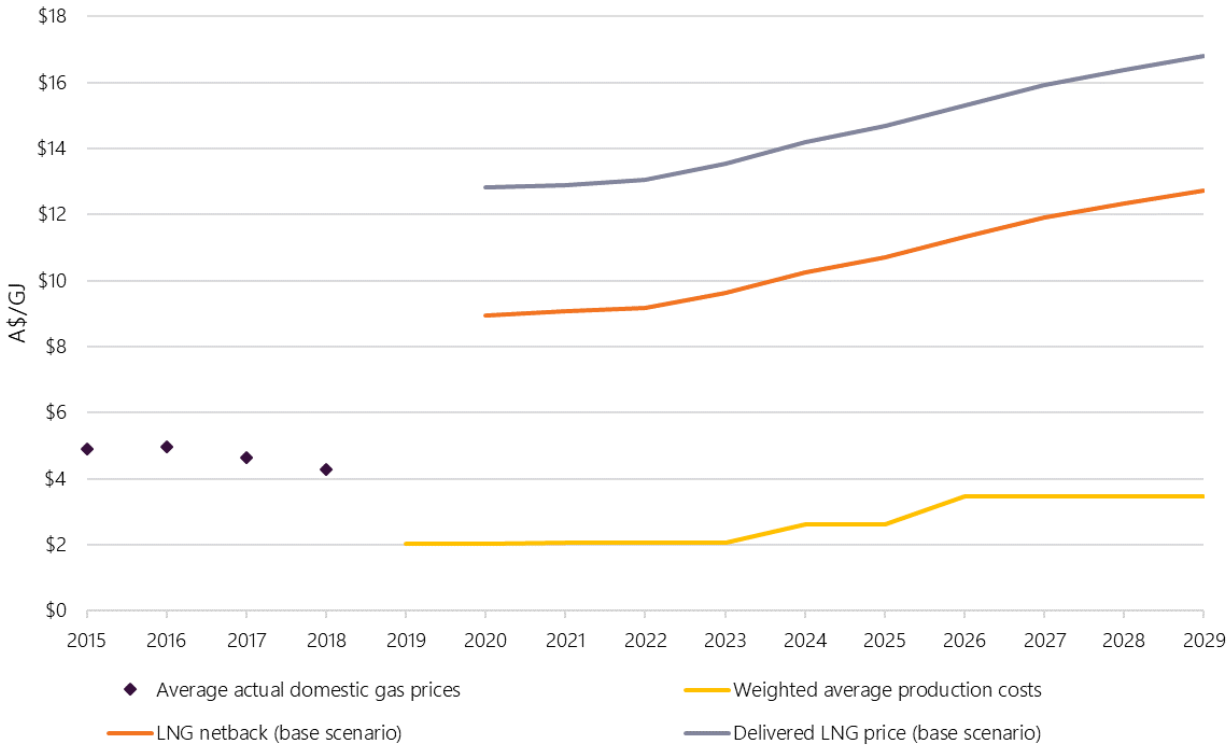
[119] ACCC. *The North West Shelf Project – Authorisations*, A91220-A91223, 31 March 2010. Available at https://www.accc.gov.au/public-registers/authorisations-and-notifications-registers/authorisations-register/the-north-west-shelf-project-authorisations-a91220-a91223.

[120] As authorised by the ACCC.

[121] AEMO. *Five-Yearly Review – Western Australian Gas Statement of Opportunities*, August 2018. Available at https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/WA_GSOO/2018/Five-Yearly-Review-of-the-WA-GSOO.pdf.

Reference prices are designed to provide a confidence band depicting the lower and upper bounds which may guide the formation of WA domestic gas contract prices[122]. These include weighted average production costs, LNG netback[123], and delivered LNG prices. Since diesel is a substitute for natural gas, for comparison purposes AEMO calculated the current wholesale diesel price as A$26.07/GJ[124].

Figure 25 Reference prices for the WA domestic gas market (A$/GJ), 2015 to 2029



Note: Weighted average production costs include prospective supply sources.
Source: AEMO calculations based on data sourced from EnergyQuest and Wood Mackenzie (converted from US$/MMBtu to A$/GJ). Actual domestic gas prices were sourced from DMIRS.

AEMO used the following assumptions to calculate weighted average production costs[125]:

- Short-run (operating) costs were used for existing facilities.
- Long-run (capital) costs plus short-run (operating) costs were used for new developments.
- For projects being developed as backfill to existing domestic gas production facilities, tolling costs were assumed to be A$0.5/GJ.
- New projects were introduced to the market according to the timeframes publicly announced by the project operator (see Sections 3.3 and 3.4 for further information about these dates).
- A 10% internal rate of return was included.

[122] AEMO has sourced forecast weighted average WA domestic gas price forecasts from Wood Mackenzie to use as inputs to the WA potential gas supply model. These figures are proprietary and cannot be provided in the public domain.

[123] The LNG netback price represents the price a gas supplier would expect to receive from a domestic gas buyer at which the supplier would be indifferent between selling the gas domestically or exporting it as LNG. LNG netback is calculated by taking the delivered price (from Australia to Japan) paid for LNG and subtracting or 'netting back' costs incurred by the supplier to convert the gas to LNG and ship it to the destination port. For the reference price series, AEMO subtracted the cost of liquefaction (US$2/MMBtu) and shipping (US$0.93/MMBtu) from delivered LNG price forecasts.

[124] Based on the Perth Terminal Gate Price of 135.4 cents/L on 29 November 2019, as published by the Australian Institute of Petroleum at https://www.aip.com.au/pricing/terminal-gate-prices. The price has been adjusted to account for the excise rebate of 41.8 cents/L (see https://www.ato.gov.au/Business/Fuel-schemes/Fuel-tax-credits---business/Rates---business/From-1-July-2019/).

[125] AEMO consulted EnergyQuest and Wood Mackenzie, as well as making its own estimates, to develop these figures.

- Costs were weighted by the nameplate capacity of the production facility for both existing facilities and prospective supply sources[126].

As new supply sources enter the market, AEMO expects domestic gas prices to increase, due to the higher production costs for these projects. Step changes in production costs over the outlook period occur when new supply sources are assumed to enter the market in the forecasts, particularly when the projects are large and are more expensive than existing production facilities[127]. For example, the assumed entry of new supply in 2026 causes the weighted average production cost to increase by almost 33% (A$0.86/GJ). If all prospective supply sources commence supply to the WA domestic gas market, AEMO estimates that the weighted average cost of production could increase by nearly 70% from the 2019 level to reach A$3.47/GJ.

[126] For existing facilities, AEMO has used the nameplate production capacity. For prospective supply sources, the DMO quantity or the expected production capacity has been used as applicable. See Chapter 3 – Gas supply for further details of production capacity.

[127] This is partly because long-run costs are used for new projects, which are typically higher than the short-run costs used for existing production facilities.

A3. Input assumptions and methodologies

This appendix provides details of input assumptions and methodologies used for the 2019 WA GSOO to forecast:

- Domestic gas demand.
- Total gas demand.
- Potential gas supply.

A3.1 Economic and commodity forecasts

There is a direct relationship between WA's economic environment and domestic gas demand. Historically, gas demand has been influenced by:

- Commodities in the mining and minerals processing sectors. Strong growth in commodity prices generally stimulates investment in new mining operations and minerals processing facilities, which has historically driven gas demand in regional and remote WA.
- The productivity of commercial and industrial users on the distribution networks, whose gas demand may increase or decrease in line with changes in the level of economic activity in the South West region of WA.

This section provides an overview of WA's economic and commodity forecasts that were inputs into AEMO's gas demand modelling processes for developing this WA GSOO report. A summary of the inputs into the potential gas supply model can be found in Section 3.2.

A3.1.1 Economic outlook

To maintain consistency between long-term electricity and gas forecasting, AEMO used the economic forecasts that were prepared by Deloitte Access Economics (DAE)[128] for the 2019 WEM ESOO as inputs into the development of WA domestic gas demand forecasts.

DAE developed low, expected, and high projections for WA GSP, as presented in Table 22. The GSP forecasts were used as inputs into the gas demand forecasts and were underpinned by various assumptions on:

- Population growth.
- Labour force participation.
- Real household disposable income.
- Industrial production.
- Service sector activity.
- Exchange rate (United States dollar to Australian dollar) trends.

[128] DAE. 2019, *Long term economic scenario forecasts*, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/Long-term-economic-scenario-forecasts---Deloitte-Access-Economics.pdf.

Table 22 WA GSP forecasts, 2019-20 to 2023-24 financial years

Scenario	2019-20 (%)	2020-21 (%)	2021-22 (%)	2022-23 (%)	2023-24 (%)	Average annual 10-year growth (%)
High	2.7	3.6	3.8	3.9	3.7	4.1
Base	2.3	3.1	3.3	3.5	3.3	3.6
Low	1.7	2.5	2.8	3.0	2.8	3.0

Source: DAE.

On average over the outlook period, WA's GSP is forecast to grow at 3.6% in the base scenario, compared to growth of 2.6% forecast in the 2018 WA GSOO base scenario. This difference largely reflects anticipated improvements in productivity, which would increase growth in the second half of the outlook period.

A3.1.2 Commodity outlook

AEMO engaged the National Institute of Economic and Industry Research (NIEIR) to provide commodity forecasts[129] as inputs to the development of the WA domestic gas demand forecasts. NIEIR combined information about new projects and expansions for each commodity with consensus price forecasts to develop the commodity production forecasts.

Over the next 10 years in the base case, NIEIR projects strong average annual production growth for the following commodities:

- Cobalt (9.5%).
- Mineral sands (8.3%).
- Nickel (5.6%).
- Lithium (4.1%).

Following a short-term slowdown in 2019, projected growth in lithium, cobalt, and nickel is underpinned by a relatively strong global demand forecast for batteries (used in consumer electronics and electric vehicles) over the outlook period, with new mines in WA expected to commence operation to meet this demand. WA is one of the world's largest producers of mineral sands, and several large projects are currently being considered (including Sheffield Resources' Thunderbird and Diatreme Resources' Cyclone) which will support higher future production.

Two of WA's other major commodities, iron ore and alumina, are expected to grow at more modest average annual rates of 1.5% and 0.4% respectively over the outlook period. Most of the investment in iron ore over the next 10 years is expected to replace existing mine capacity which is reaching end-of-life, rather than substantially increasing production volumes. For alumina, no major expansions of existing refining capacity are expected in the base scenario[130].

Gold production is projected to be more volatile over the outlook period, reflecting the price sensitivity of many gold operations.

Since the 2018 WA GSOO, the commodity production forecasts have been revised as follows:

- The forecasts for lithium are higher over the outlook period, but lower in the short term to 2021, reflecting delays in some projects caused by a recent fall in the lithium price[131].

[129] NIEIR prepared forecasts for the following commodities – iron ore, alumina, gold, nickel, zinc, copper, lithium, lead, cobalt, and mineral sands.

[130] An expansion to Alcoa's Pinjarra refinery is included in the high scenario alumina forecasts.

[131] See https://publications.industry.gov.au/publications/resourcesandenergyquarterlyseptember2019/documents/Resources-and-Energy-Quarterly-September-2019.pdf.

- Nickel forecasts have increased over the outlook period, reflecting mines being commissioned or restarting in response to strong global demand for stainless steel and batteries.

Projections for the remaining commodities (alumina, copper, gold, iron ore, and zinc)[132] are broadly in line with the 2018 WA GSOO forecasts. Further information about the commodity forecasts can be found in NIEIR's report[133].

A3.2 Gas demand forecast methodology

AEMO presents WA domestic and total gas demand forecasts, defined as:

- Domestic gas demand forecasts – all major mining and minerals processing, industrial, and commercial demand, GPG demand in the SWIS and non-SWIS areas, and small-use customers connected to WA's gas transmission and distribution networks.
- Total gas demand forecasts – domestic gas demand plus an estimate of the total quantity of gas required for LNG exports, reflecting an overall assessment of WA gas demand.

The methodology for preparing these forecasts is summarised in Sections A3.2.1 and A3.2.2.

A3.2.1 Domestic gas demand

AEMO forecast domestic gas demand by separately modelling each of the following sectors:

- **Tariff V**, the residential and commercial distribution network customers distribution network (including the Kalgoorlie and Leonora distribution networks).
- **Tariff D**, including the following transmission-connected consumers:
  - Minerals processing.
  - Mining.
  - Industrial.
- Other industrial customers that are located within the distribution network.
- GPG (including SWIS and non-SWIS).

Forecasts of SWIS GPG gas demand were prepared by RBP[134] and were added to AEMO's forecasts to estimate total WA domestic gas demand.

The mining, minerals processing, industrial, and other industrial forecasts are largely driven by:

- Forecast mining activity.
- Commodity prices.
- Expected mine production and outages.
- Production costs.
- Exchange rate forecasts.

AEMO applied NIEIR's commodity production forecasts as inputs into the gas demand forecasts for these sectors and combined them with additional information received from gas consumers as part of the 2019 FIR.

The methodology applied in forecasting each sector is summarised below.

[132] Forecasts for lead, cobalt, and mineral sands were not prepared for the 2018 WA GSOO.

[133] NIEIR. 2019. *Commodity forecasts for Western Australia to 2030*. September 2019, at https://aemo.com.au/Gas/National-planning-and-forecasting/WA-Gas-Statement-of-Opportunities.

[134] RBP. 2019. *Gas powered generation forecast modelling – final report*. December 2019, at https://aemo.com.au/Gas/National-planning-and-forecasting/WA-Gas-Statement-of-Opportunities.

Residential and commercial distribution customers (Tariff V)

The distribution network includes the low-pressure pipelines used to supply small-use residential and non-residential retail customers. This accounts for approximately 2% of WA's domestic gas demand.

AEMO forecast Tariff V total consumption by applying different assumptions based on the customer type (residential or non-residential), scenario, and the consumption per connection.

The heating[135] and baseload consumption per connection was forecast separately and then adjusted for:

- Future economic growth.
- Growth in connection numbers.
- Energy efficiency.
- Fuel switching.
- Weather and climate change effects.
- Gas price impacts.

Further information about the WA Tariff V forecasting methodology can be found in Chapter 5 of the *Gas Demand Forecasting Methodology Information Paper*[136].

Tariff D consumption

Tariff D consumers account for approximately 75% of WA's total domestic gas demand, and include:

- Mining consumers such as:
  - Iron ore producers – BHP, CITIC Pacific, FMG, and Rio Tinto.
  - Gold producers – AngloGold Ashanti, Blackham Resources, and Newcrest.
  - Nickel producers – BHP NickelWest.
  - Lithium producers – Minerals Resources and Tianqi.
  - Base metals producers – Nifty.
- Minerals processing consumers such as Alcoa, BHP, and South32.
- Industrial consumers such as Yara Pilbara, Orica, and CSBP.
- Other industrial customers that are in the distribution network.

From the list of industrial consumers, it has been assumed that Tariff D gas consumers are associated with specific processes that require natural gas for operating, such as minerals processing calcination facilities, mining equipment that is associated with the processing of specific minerals, the mining of specific minerals, and the production of specific finished products.

Due to these requirements, the growth or decline in future gas consumption has been linked to the quantity of minerals processed, mined, or produced for their customers. AEMO used NIEIR's commodity forecasts as an input into the Tariff D demand forecasts (see Section A3.1.2 for further information).

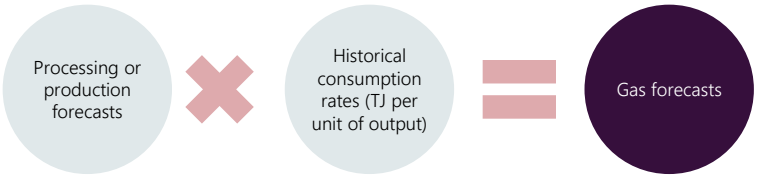
Minerals processing, mining, and industrial sectors

AEMO's approach to forecasting the mining, minerals processing, and industrial sectors is summarised in Figure 26. Gas demand for each customer was calculated based on historical gas consumption rates (from the WA GBB) per unit of output (for example, million tonnes of iron ore), multiplied by the forecast production.

[135] Heating load is largely dependent on the projections of future weather effects (heating degree days).

[136] See https://aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2019/Gas-Demand-Forecasting-Methodology.pdf.

Figure 26 Gas demand forecasting for the mining, minerals processing, and industrial sectors



Other Tariff D consumption

While gas consumption for the minerals processing, mining and industrial sectors is available on the WA GBB, only aggregated data on distribution-connected industrial customers is readily available to AEMO.

To estimate the gas demand of this segment, an econometric model was applied to split consumption into heating and baseload. The aggregated forecasts were then adjusted to account for climate change (reduction in expected heating load requirements), similar to the process used to estimate WA's Tariff V forecasts.

SWIS GPG

The most variable component of gas demand, electricity generation by GPG in the SWIS, accounts for roughly 20% of domestic gas demand in WA. Around 2,955 MW[137] of SWIS generation capacity (including gas/diesel dual fuel facilities) can generate electricity for the SWIS using natural gas. Two-thirds of this capacity is peaking or mid-merit[138]. Typically, the SWIS relies on GPG to supply peak load over the summer season and for the provision of Load Following Ancillary Services (LFAS)[139]. The scenarios used by RBP for the GPG modelling are shown in Table 23.

Table 23 Scenario mapping for GPG modelling

Scenario	High	Base	Low
Operational consumption[A]	High	Base	Low
50% probability of exceedance (POE) peak demand[A]	High case 50% POE	Expected case 50% POE	Low case 50% POE
Gas price[B]	Low	Expected	High
Behind the meter PV and battery storage[A]	Expected	Expected	Expected
Electric vehicles and block loads[A]	High	Expected	Low
New entrant costs[C]	2019 Integrated System Plan (ISP) Fast change	2019 ISP Central	2019 ISP Slow change
Generation retirements	Staged retirement of Muja C: • MUJA_G5 retires 1 October 2022. • MUJA_G6 retires 1 October 2024.		

[A] Sourced from the 2019 WEM ESOO. POE is the likelihood that a forecast will be met or exceeded, with a 50% POE forecast statistically expected to be met or exceeded one year in two.
[B] Sourced from Wood Mackenzie.
[C] For any capacity required in excess of known, committed generation projects to avoid unserved energy. Source: AEMO calculations based on data from GHD.

[137] Based on Capacity Credits assigned to gas and dual fuel facilities in the 2019-20 Capacity Year.

[138] Peaking capacity operates less than 10% of the time, and mid-merit capacity operates between 10% and 70% of the time. For more information, see the 2019 WEM ESOO, at https://aemo.com.au/-/media/Files/Electricity/WEM/Planning_and_Forecasting/ESOO/2019/2019-WEM-ESOO-report.pdf.

[139] LFAS is an ancillary service that is called on to help balance electricity supply and demand to support the target frequency range in the SWIS.

RBP used their dispatch optimisation tool, WEMSIM, to co-optimise energy dispatch and Ancillary Services to determine the quantity of gas used for electricity generation, based on the following input assumptions:

- Generator technical data, including capacity, outage rates, ramp rates, heat rates, and cost information.
- Information about network transfer limits and constraints[140].
- Details of generation entry[141] and retirements, including:
  - Facilities that hold Capacity Credits through the Reserve Capacity Mechanism for the 2020-21 and 2021-22 Capacity Years[142].
  - Staged retirement of Muja C, with one unit retiring on 1 October 2022 and the other on 1 October 2024[143].
- Operational consumption, peak demand, and distributed energy resources[144] forecasts from the 2019 WEM ESOO[145].
- Previous Balancing Market bids and offers[146] (including negatively priced offers), to allow the model to replicate historical dispatch patterns.
- Fuel prices, including pipeline domestic gas, coal, and diesel price assumptions.

Non-SWIS GPG

Non-SWIS GPG includes the electricity distribution networks operated by Horizon Power. To forecast non-SWIS GPG gas consumption, AEMO collected publicly available information from:

- Horizon Power's annual report.
- The WA GBB.
- Clean Energy Regulator's Greenhouse and Energy Information on electricity generation.
- NWIS reports.

In addition to the information collected, AEMO consulted with Horizon Power and power purchase agreement providers, and used information collected through the 2019 FIR.

The non-SWIS GPG gas consumption was forecast by applying an econometric model that forecasts electricity consumption for each gas consuming non-SWIS area. Due to its location, the gas consuming non-SWIS region is largely located in the "tropical" regions and borders on semi-arid desert climate. As a result, electricity consumption is relatively stable.

The electricity model considered the historical population growth in each non-SWIS area as reported by the ABS, the historical growth of residential behind the meter PV, historical electricity consumption, and the commencement of new electricity generation in these areas.

Gas consumption was estimated by multiplying forecast electricity demand by the gas consumption per megawatt hour (MWh) to derive total gas forecasts for the non-SWIS GPG, as shown in Figure 27.

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[140] RBP has incorporated constraints into the modelling from 1 October 2022, reflecting the WEM's expected move to security constrained economic dispatch.

[141] Additional capacity was selected based on lowest cost from the following technologies: open cycle gas turbines, combined cycle gas turbines, biomass, large scale solar PV and solar thermal with 8 hours storage capacity, battery storage (both 2 hours and 4 hours capacity), and wind. AEMO calculated new technology costs and other technical information for WA from GHD's "AEMO costs and technical parameter review", available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/9110715-REP-A-Cost-and-Technical-Parameter-Review---Rev-4-Final.pdf.

[142] AEMO assigns Capacity Credits to new generation projects two years in advance of commencing operation as part of the Reserve Capacity Mechanism. Capacity Credit information is at https://www.aemo.com.au/Electricity/Wholesale-Electricity-Market-WEM/Reserve-capacity-mechanism/Assignment-of-capacity-credits.

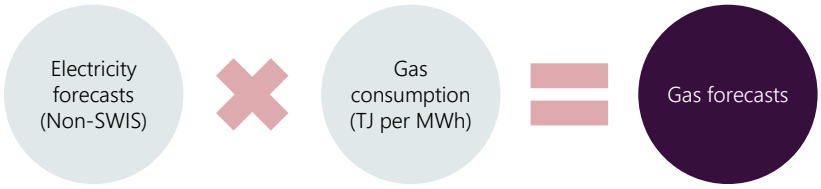
[143] WA Government, "Muja Power Station in Collie to be scaled back from 2022", media statement, 5 August 2019, at https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/08/Muja-Power-Station-in-Collie-to-be-scaled-back-from-2022.aspx.

[144] Including behind the meter PV, battery storage, and electric vehicles.

[145] For further information, see https://www.aemo.com.au/-/media/Files/Electricity/WEM/Planning_and_Forecasting/ESOO/2019/2019-WEM-ESOO-report.pdf.

[146] By default, WEMSIM assumes that energy is offered for dispatch at short-run marginal cost.

Figure 27 Gas demand forecasting for the non-SWIS GPG sector



Committed new project demand

Committed new project demand is defined as gas consuming or reducing projects that have a direct impact on WA gas consumption and have attained FID and/or are already under construction.

These projects include approved upcoming projects that are utilising natural gas as an input feedstock or as an input for power generation or have approved renewable energy projects that will offset existing gas demand. Committed new project demand includes expansions to existing minerals processing, mining, and industrial operations.

Gas consumption for each project under this category has been estimated individually, based on publicly available information, consultation with the project proponent, or from gas consumption information provided to AEMO as part of the FIR. These estimates were added to all three scenarios (see Section 2.2.2 for further details about these projects).

Prospective gas demand for the high gas demand scenario

While gas demand forecasts for all three scenarios include committed projects, the high gas demand scenario includes projects that may be developed and consume gas, projects that are likely to switch from consuming diesel to gas, and renewable energy projects that offset the consumption of gas over the outlook period ("prospective demand").

For a project to be included in prospective demand, each project initially shortlisted was required to meet at least two of the following criteria:

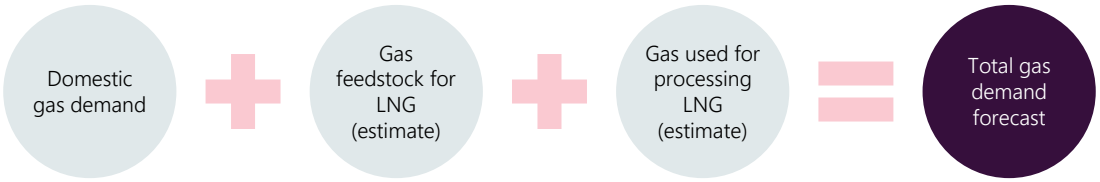
- The project is located within 20 kilometres of a gas transmission pipeline that is under construction, has spare shipping capacity, or is a new pipeline that has attained a favourable FID.
- The project proponent has submitted an environmental approval to the State and/or Australian Government.
- The project proponent has a commercial arrangement with a gas pipeline or gas storage company to expand and/or connect physical infrastructure to withdraw gas.
- The project may (as publicly reported) use existing domestic compressed natural gas or LNG facilities.
- The project proponent has received Capacity Credits as an electricity generator capable of operating on gas.
- Full project finance has been secured.
- The project proponent has publicly announced its intention to use gas.
- The project proponent has investigated converting from diesel to gas.
- The project proponent has publicly announced its intention to build a renewable project or any other projects that specifically offset the use of gas as an input or energy source.
- Existing pipeline operators have identified the project as a potential gas project.

The shortlisted projects were assessed to determine the likelihood that they would consume gas over the outlook period. The finalised list includes projects submitted by GSI and some non-GSI market participants as part of the 2019 FIR process.

A3.2.2 Total gas demand

To develop WA total gas demand forecasts, AEMO estimated the amount of gas required for WA's LNG industry and added it to the domestic gas demand forecasts, as shown in Figure 28.

Figure 28 Total gas demand forecasts



AEMO developed three scenarios (low, base, and high) for total gas demand. LNG forecasts were developed using historical production utilisation data for existing LNG facilities, and publicly available information on the proposed production capacity and commencement of new LNG facilities.

Unlike domestic gas demand forecasts, the LNG feedstock forecast scenarios were not restricted to committed gas-consuming projects. The assumptions applied in each total gas demand scenario are summarised in Table 24.

Table 24 Total gas demand forecast scenarios

Parameter	High	Base	Low
Domestic gas demand forecasts	High	Base	Low
Gas feedstock for LNG exports	Includes facilities outlined in Base scenario assumptions, with the following exceptions: • Gorgon LNG expansion (5.2 mtpa in 2027). • Wheatstone expansion (4.45 mtpa in June 2026). • Ichthys expansion (4.45 mtpa in June 2028).	Includes facilities outlined in the Low scenario assumptions, with the following exceptions: • NWS production maintained via backfill from the Pluto-KGP interconnector (1.5 mtpa from 2024) and Browse fields (10 mtpa from 2026). • Pluto expansion from Scarborough gas (5 mtpa commences 2024). • Equus (2 mtpa commences 2024). • Prelude supported by backfill from Crux (2.9 mtpa commences 2025).	• NWS (18.5 mtpa). • Pluto (4.5 mtpa). • Gorgon (15.6 mtpa). • Wheatstone (8.9 mtpa). • Prelude FLNG (3.6 mtpa). • Ichthys (8.9 mtpa). • Backfill for Darwin in 2021.
Gas used for processing LNG[A]	8%		

A. Processing estimates were calculated by taking the low range of estimates from Lewis Grey Advisory, *Projections of gas and electricity used in LNG*, Public report prepared for AEMO, 18 November 2016, p. vi, https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/NGFR/2016/Projections-of-Gas-and-Electricity-Used-in-LNG-Public-Report-November-2016.pdf.

A3.3 Potential gas supply forecast methodology

Instead of forecasting how much gas is expected to be supplied over the outlook period, AEMO's forecasts of potential gas supply reflect how much gas could be produced if there was market demand for it at the forecast price. This approach is useful in assessing supply adequacy and identifying potential supply shortfalls[147].

[147] Transmission pipeline capacity constraints were not considered in the model.

AEMO's potential gas supply model was redeveloped by ACIL Allen in 2018 following the recommendations of the five-yearly WA GSOO review[148]. For this 2019 WA GSOO, AEMO has updated the input assumptions used in the model.

The model tracks the gas reserves remaining to each domestic-only production facility on an annual basis by incorporating assumptions about the following inputs:

- Initial gas reserves and resources.
- Modelled annual gas sales (contracted and uncontracted).
- Fuel gas requirements.
- Incremental reserves additions.

The operation of the potential gas supply model distinguishes between existing, committed, and prospective supply projects, as shown in Table 25.

Table 25 Potential gas supply model operation

	Existing/committed domestic-only	Existing/committed LNG-linked	Prospective domestic-only	Prospective LNG-linked
Model logic	Potential gas supply equals the minimum of: • Production capacity, or • 15% of remaining reserves.	Potential supply is equal to the DMO. The exception to this rule is the KGP, which either supplies its DMO or its contracted volume, whichever is greater.	Developed when the domestic gas price forecast exceeds the estimated LRC. Once developed, potential gas supply equals the minimum of: • Production capacity, or • 15% of remaining reserves.	Developed when the forecast Asian LNG price exceeds the estimated LRC. Once developed, potential gas supply equals the DMO.
Projects included in the model	• Devil Creek • Beharra Springs • Macedon • Varanus Island • Xyris	• Gorgon • KGP • Pluto • Wheatstone	West Erregulla	• Browse • Scarborough

Where possible, AEMO sourced the model input data from GMPs and non-GMPs through the 2019 FIR and made assumptions based on publicly available information where FIR data was unavailable. Further information about the supply model inputs can be found in Section 3.2.

[148] For further information, see https://aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/WA_GSOO/2018/Five-Yearly-Review-of-the-WA-GSOO.pdf.

A4. Total gas demand forecasts

Table 26 Domestic gas demand forecasts (PJ/annum), 2020 to 2029

Year	Low	Base	High
2020	377.2	381.3	394.7
2021	383.1	388.8	411.6
2022	393.7	400.8	422.2
2023	402.6	410.2	433.4
2024	403.4	411.7	458.5
2025	398.8	415.7	486.2
2026	398.5	415.5	484.5
2027	400.6	419.1	488.4
2028	402.3	421.3	490.6
2029	404.2	425.3	494.6

Table 27 LNG feedstock forecasts (PJ/annum), 2020 to 2029

Year	Low	Base	High
2020	3,292.2	3,292.2	3,292.2
2021	3,113.0	3,113.0	3,113.0
2022	3,113.0	3,113.0	3,113.0
2023	3,113.0	3,113.0	3,113.0
2024	3,113.0	3,395.6	3,395.6
2025	3,017.1	3,569.4	3,569.4
2026	2,921.2	3,592.6	3,682.5
2027	2,825.3	3,592.6	3,913.2
2028	2,729.5	3,592.6	4,150.0
2029	2,633.6	3,592.6	4,275.7

Table 28 LNG processing forecasts (8% of feedstock) (PJ/annum), 2020 to 2029

Year	Low	Base	High
2020	286.3	286.3	286.3
2021	270.7	270.7	270.7
2022	270.7	270.7	270.7
2023	270.7	270.7	270.7
2024	270.7	295.3	295.3
2025	262.4	310.4	310.4
2026	254.0	312.4	320.2
2027	245.7	312.4	340.3
2028	237.3	312.4	360.9
2029	229.0	312.4	371.8

Table 29 Total gas demand forecasts (PJ/annum), 2020 to 2029

Year	Low	Base	High
2020	3,955.7	3,960.3	3,973.2
2021	3,766.8	3,772.5	3,795.3
2022	3,777.4	3,784.5	3,805.9
2023	3,786.3	3,793.9	3,817.0
2024	3,787.0	4,102.6	4,149.4
2025	3,678.2	4,295.5	4,365.9
2026	3,573.8	4,320.5	4,487.2
2027	3,471.6	4,324.1	4,742.0
2028	3,369.1	4,326.3	5,001.4
2029	3,266.8	4,330.3	5,142.1

A5. Sector classifications

Table 30 Classification of gas consumers into sectors (GBB delivery points)

Sector	Gas consumers		
Minerals processing	• Alcoa Kwinana. • BHP Kwinana. • Kwinana nickel refinery. • Tiwest Chandala. • Worsley alumina[B].	• Alcoa Pinjarra[A]. • BP refinery Kwinana[A]. • Pinjarra power station. • Tiwest Kwinana.	• Alcoa Wagerup. • Hismelt Kwinana. • Southern System power station.
Mining	• Agnew. • Cape Lambert power station. • Gwalia. • Leinster. • Mt Morgans. • Paraburdoo power station. • Saracen. • Sunrise Dam. • West Angelas power station. • Windimurra. • Yarnima power station.	• Birla Nifty. • Cosmos. • Hill 60[C]. • Magellan. • Murrin Murrin. • Parkeston power station. • Sino Iron project power station. • Telfer gold mine. • Wiluna gold. • Yurrali Maya power station. • Wodgina.	• Boonamichi Well. • Granny Smith goldmine. • Jaguar. • Mount Keith power station. • Newman power station. • Plutonic. • Solomon power station. • Tropicana. • Wiluna Jundee. • Yamarna.
Industrial	• Australian Gold Reagents. • CSBP ammonia. • Midland Brick. • Whiteman Brick.	• Boodarie. • Fero industries. • Tip Top Canning Vale. • Yara fertilisers.	• Cockburn Cement. • Maitland. • Wesfarmers[D].
SWIS GPG	• Kemerton power station. • NewGen Kwinana and Cockburn power stations. • Wagerup power station.	• Kwinana power station[E]. • NewGen Neerabup power station.	• Mungarra power station. • Pinjar power station.
Non-SWIS GPG	• Carnarvon power station. • Port Hedland power station.	• Exmouth power station. • Onslow power station.	• Karratha power station. • South Hedland.

[A] Includes one delivery point on the DBP and one on the Parmelia pipeline.
[B] Includes two delivery points on the DBP.
[C] Includes the mine site and power station (two delivery points).
[D] Including Wesfarmers gas and LNG facilities.
[E] Includes two delivery points on the DBP and one on the Parmelia pipeline.

A6. WA gas infrastructure

WA gas infrastructure includes multi-user gas storage facilities, domestic gas transmission pipelines, spot and short-term trading mechanisms, and LNG export production facilities. Information on domestic gas production facilities is provided in Chapter 3.

A6.1 Multi-user gas storage facilities

WA has two multi-user gas storage facilities in operation, as shown in Table 31.

Table 31 WA multi-user gas storage facilities, 2019

	Operator	Gas storage capacity (PJ)	Injection/withdrawal capacity (TJ/day)
Mondarra Gas Storage Facility	APA Group	18	70/150
Tubridgi Gas Storage Facility	Australian Gas Infrastructure Group	52	90/60
Total		**70**	**160/210**

Since the 2018 WA GSOO was published, the Tubridgi Gas Storage Facility has expanded its storage capacity by 10 PJ, as well as its injection and withdrawal capabilities by 40 TJ/day and 10 TJ/day, respectively[149].

A6.2 Gas transmission pipelines

The 123-kilometre Wheatstone Ashburton West Pipeline commenced operations in Q1 2019 and has capacity to deliver up to 337 TJ/day of gas from the newly constructed Wheatstone domestic gas production facility into the DBP[150].

A map of WA's gas transmission network is shown in Figure 29.

[149] Energy News Bulletin. "AGIG expands WA's largest gas storage facility", 22 March 2018, at https://www.energynewsbulletin.net/pipelines/news/1334579/agig-expands-wa%E2%80%99s-largest-gas-storage-facility.

[150] AEMC. *WA: Wheatstone Ashburton West Pipeline*, at https://www.aemc.gov.au/energy-rules/national-gas-rules/gas-scheme-register/wa-wheatstone-ashburton-west-pipeline. Viewed: 13 September 2019.

Figure 29 Gas transmission pipelines in WA

A6.3 Spot and short-term trading

AEMO does not operate a spot or short-term trading market in WA. Instead, most of the short-term demand is met by confidential contracts settled between parties.

Short-term gas may also be procured through two independent and non-aligned mechanisms:

- gasTrading Australia Pty Ltd operates a spot market where sellers advise the operator of any surplus gas for the coming month, which is broadcast to the market and subsequently allocated depending on the ranking of the purchasers' offers and availability. The exact volumes available are confirmed by the seller one day ahead. The trade data is published on gasTrading's website at the completion of each month.
- Energy Access Services Pty Ltd operates a real-time energy trading platform where members enter gas trade agreements with a focus on supply durations of up to 90 days. The trades can encompass firm and interruptible gas arrangements, as well as imbalances. Trade data is published on the Energy Access website monthly.

AEMO estimates that approximately 3-5% of total gas consumption in WA is traded on a short-term basis. The recent increase in gas storage capacity resulting from the introduction of the Tubridgi Gas Storage Facility (refer to Appendix A6.1 above) may provide support to short-term trading mechanisms.

Information in the public domain regarding the quantity and associated prices of spot or short-term gas is provided by gasTrading Australia Pty Ltd[151] and Energy Access Services Pty Ltd[152].

A6.4 LNG export production facilities

WA's LNG nameplate production capacity totals 47.5 million tonnes per annum (mtpa) and consists of four production facilities:

- NWS (KGP) – 18.5 mtpa.
- Pluto – 4.5 mtpa.
- Gorgon – 15.6 mtpa.
- Wheatstone – 8.9 mtpa.

Two additional facilities source gas from WA waters, but the liquefaction either occurs offshore or in a separate state and therefore do not contribute to WA's overall LNG production capacity. These facilities are:

- Prelude – a 3.6 mtpa floating LNG facility operated by Royal Dutch Shell plc, which exports directly from the offshore vessel.
- Ichthys – a 8.9 mtpa LNG project operated by Inpex Corporation, which has an onshore liquefaction plant located in Darwin.

[151] See http://www.gastrading.com.au/.

[152] See https://www.energyaccessservices.com.au/.

A7. Conversion tables

The following conversion factors have been applied in preparing figures for the 2019 WA GSOO.

Table 32 Conversion factors

	To						
	Billion cubic meters NG	**Billion cubic feet NG**	**Million tonnes of oil equivalent**	**Million tonnes LNG**	**Trillion British thermal units**	**Million barrels of oil equivalent**	**Petajoule**
From	**Multiply by**						
Billion cubic meters NG	1	35.3	0.9	0.74	35.7	6.6	37.45
Billion cubic feet NG	0.028	1	0.025	0.0216	1.01	0.19	1.06
Million tonnes oil equivalent	1.11	39.2	1	0.82	39.7	7.33	-
Million tonnes LNG	1.36	48	1.22	1	48.6	8.97	55.43
Trillion British thermal units	0.028	0.99	0.025	0.021	1	0.18	1.06
Million barrels oil equivalent	0.15	5.35	0.14	0.11	5.41	1	5.82
Petajoule	0.027	0.943	-	0.018	0.943	0.172	1

Abbreviations and units of measure

Units of measure

Abbreviation	Unit of measure
A$	Australian dollar
bcf	Billion cubic feet
GJ	Gigajoule
mtpa	Million tonnes per annum
MW	Megawatt
PJ	Petajoule
Q	Quarter
tcf	Trillion cubic feet
TJ	Terajoule
US$	US dollar
MWh	Megawatt hour

Abbreviations

Abbreviation	Expanded name
1P	Proved reserves
2C	Contingent resources
2P	Proved and probable reserves
ACCC	Australian Consumer and Competition Commission
AEMO	Australian Energy Market Operator
APPEA	Australian Petroleum Production and Exploration Association
COAG	Council of Australian Governments
DBP	Dampier to Bunbury Pipeline

Abbreviation	Expanded name
DJTSI	WA Department of Jobs, Tourism, Science, and Innovation
DMIRS	WA Department of Mines, Industry Regulation and Safety
DMO	Domestic market obligation
EPA	Environmental Protection Agency
ERA	Economic Regulation Authority
ESOO	Electricity Statement of Opportunities
FID	Final investment decision
FIR	Formal information request
GBB	Gas Bulletin Board
GMP	Gas Market Participant
GPG	Gas powered generation
GSI	Gas Services Information
GSOO	Gas Statement of Opportunities
GSP	Gross state product
IMO	International Maritime Organisation
ISP	Integrated System Plan
KGP	Karratha Gas Plant
LNG	Liquefied natural gas
LRC	Long run cost
NOPTA	National Offshore Petroleum Titles Administrator
NWIS	North West Interconnected System
NWS	North West Shelf
PRRT	Petroleum Resource Rent Tax
PV	Photovoltaics
RFSU	Ready for start up
SWIS	South West interconnected system
WA	Western Australia
WEM	Wholesale Electricity Market

Glossary

This document uses terms that have meanings defined in the GSI Rules. The GSI meanings are adopted unless otherwise specified.

Term	Definition
1P	A measure of gas reserves that includes proven (developed and undeveloped) reserves.
2C	A measure of gas resources that are considered less commercially viable than reserves. 2C resources are considered the best estimate of sub-commercial reserves.
2P	A measure of gas reserves that includes proven (developed and undeveloped) and probable reserves.
Committed projects	Gas supply or demand projects that are existing, under construction or have taken a positive FID.
Distribution network	The low-pressure networks operated by ATCO and used to supply residential and non-residential customers in the Perth metropolitan area and regional centres of Albany, Bunbury, Geraldton, and Kalgoorlie.
Domestic gas demand	Includes all major industrial and commercial loads, electricity generators, and small-use customers connected to WA's gas transmission and distribution networks.
Large customers	Gas customers using 10 TJ/day or more (GBB Large Users).
Potential gas supply	AEMO forecasts the potential availability of supply to the WA domestic market as gas that could be economically offered to the domestic market given forecast prices and production costs, subject to the availability of processing capacity and gas reserves. The model does not project how much gas *will* be produced, but how much *could* be produced if there was demand at the forecast price, and distinguishes between existing, committed, and prospective projects by triggering prospective projects when the domestic gas price or Asian LNG price exceeds production costs.
Prospective projects	Prospective gas supply sources include all gas field developments which have been publicly announced that would make supply available to the WA domestic gas market, including LNG projects. Selected prospective supply sources have been included in the potential gas supply model. Prospective gas demand projects are only included in the high scenario and must meet set criteria (described in Appendix A3.2.1). These include projects that may switch from diesel to gas electricity generation.
Ramping requirements	The difference between minimum and peak demand in the SWIS is widening with increasing uptake of behind the meter PV and large-scale solar. This, combined with increased intermittent wind generation, requires generation (usually GPG) that is capable of rapidly increasing output ("ramping") over a short period of time to meet evening peak demand.
Total gas demand	Domestic gas demand plus an estimate of the gas required to produce LNG for export, reflecting an overall assessment of the demand for natural gas in WA.
Transmission network	The high-pressure pipelines used to transport large volumes of gas from the production facilities to customers. Large customers can connect directly to the transmission network, while smaller customers are supplied through the distribution network connected to the transmission network.