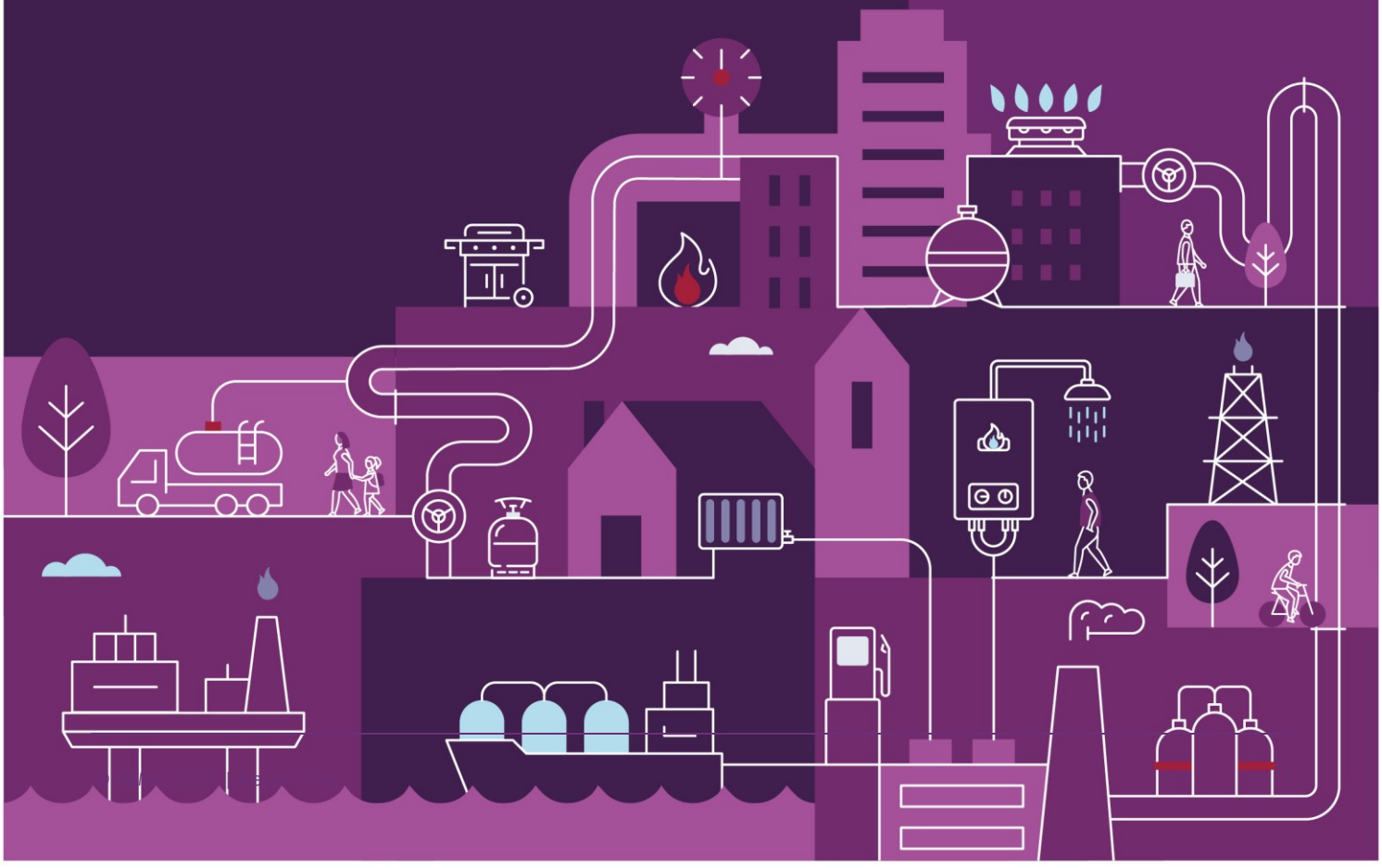
Appendices to 2021 Western Australia Gas Statement of Opportunities

December 2021

Market outlook to 2031

A report for the natural gas industry in Western Australia

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR



Contents

Tables

Figures

A1. Year in review sources

Supply projects

Beach Energy. “Announcement Ironbark 1 Update”, 29 December 2020. Available at: https://yourir.info/resources/0c5a441cf54ff229/announcements/bpt.asx/2A1272633/BPT_Ironbark-1_Exploration_Well_Update.pdf.

Beach Energy. “Announcement Waitsia Gas Project Stage 2 reaches FID”, 23 December 2020. Available at: https://www.openbriefing.com/AsxDownload.aspx?pdfUrl=Report%2FComNews%2F20201223%2F02326370.pdf.

Chevron. “Jansz-Io compression project to proceed”, 2 July 2021. Available at: https://australia.chevron.com/news/2021/jansz-io-compression-project-to-proceed.

Environment Protection Agency. “West Erregulla processing plant and pipeline”. Available at: https://www.epa.wa.gov.au/proposals/west-erregulla-processing-plant-and-pipeline.

Government of Western Australia. “State Government approves Pilbara gas project”, media statement, 29 January 2021. Available at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/01/State-Government-approves-Pilbara-gas-project.aspx.

Government of Western Australia. “Implementation of WA domestic gas policy”. Available at: https://www.wa.gov.au/government/publications/implementation-of-the-wa-domestic-gas-policy.

Mineral Resources Ltd. “AGM Presentation Mineral Resources Ltd”, 18 November 2021. Available at: https://clients3.weblink.com.au/pdf/MIN/02453725.pdf.

Mineral Resources Ltd. “Lockyer Deep-1 Gas Discovery”, 9 September 2021. Available at: https://clients3.weblink.com.au/pdf/MIN/02419018.pdf.

Mitsui E&P. “Waitsia Stage 2”. Available at: https://mitsuiepmidwest.com.au/what-we-do/development/waitsia-stage-2/.

Santos. “2020 full year results announcement and presentation”, 18 February 2021. Available at: https://www.santos.com/wp-content/uploads/2021/02/2020-Full-Year-Results-Announcement-and-Presentation.pdf.

Strike Energy. “Strike delivers maiden Perth Basin gas reserve”, 1 October 2021. Available at: https://app.sharelinktechnologies.com/announcement/asx/4c5eb4c32850a6737329d838394c1659.

Strike Energy. “Greater Erregulla gas”. Available at: https://strikeenergy.com.au/greater-erregulla.

Woodside Energy. “First Quarter Report for period ended 31 March 2019”, 18 April 2019. Available at: https://www.asx.com.au/asxpdf/20190418/pdf/444dykrp1hkzmb.pdf.

Woodside Energy. “Half-Year Report 2021”, 30 June 2021. Available at: https://files.woodside/docs/default-source/asx-announcements/2021-asx/half-year-2021-report.pdf.

Woodside Energy. “Building gas supply in Western Australia”, 29 January 2021. Available at: https://files.woodside/docs/default-source/media-releases/building-gas-supply-in-western-australia.pdf.

Woodside Energy. “Scarborough and Pluto Train 2 Developments Approved”, 22 November 2021. Available at: https://files.woodside/docs/default-source/asx-announcements/2021-asx/060.-scarborough-and-pluto-train-2-developments-approved.pdf.

Infrastructure developments

APA. “Annual Report 2021”, 25 August 2021. Available at: https://www.apa.com.au/globalassets/asx-releases/2021/apa-fy21-annual-report.pdf.

APA. “Northern Goldfields Interconnect Pipeline. EPA Environmental referral supporting document”. Available at: https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Supporting%20Document_2.PDF.

Woodside Energy. “Project Pluto-KGP Interconnector”. Available at: https://www.woodside.com.au/what-we-do/australian-growth-projects/pluto-KPG-interconnector.

Demand projects

Australian Potash. “Low Cost, Organically Certified, Environmentally Sustainable, Green Sulphate of Potash”, August 2021. Available at: https://www.australianpotash.com.au/site/PDF/01712869-d563-43af-8236-267bdefb64ab/DiggersDealersMiningForumPresentation.

Australian Potash. “Hybrid Renewable Energy Microgrid; Greenhouse Gas Emissions Assessment”, 7 September 2021. Available at: https://www.australianpotash.com.au/site/PDF/5a2e9ada-e962-4c8d-a676-fa100fb9b217/HybridRenewableEnergyMicrogrid.

Bellevue Gold. “Bellevue Gold Project Stage One Feasibility Study: Bellevue set to generate strong profits and robust free cashflows”, 18 February 2021. Available at: https://wcsecure.weblink.com.au/pdf/BGL/02342810.pdf.

Bellevue Gold. “November Non Deal Roadshow”, November 2021. At: https://wcsecure.weblink.com.au/pdf/BGL/02449270.pdf.

BHP. “Two new solar farms and battery to help power mines at BHP's Nickel West”, 30 July 2021. At: https://www.bhp.com/news/media-centre/releases/2021/07/two-new-solar-farms-and-battery-to-help-power-mines-at-bhps-nickel-west.

Clean Energy Fuels Australia. “Mid-West LNG Hub”. Available at: https://www.cefa.com.au/lng-hub/.

Clean Energy Fuels Australia. “CEFA signs 5-year contract with Beach Energy and Mitsui E&P Australia”, July 2021. Available at https://www.cefa.com.au/cefa-signs-5-year-contract-with-beach-energy-and-mitsui-ep-australia/.

Clean Energy Fuels Australia. “CEFA signs 15-year contract with WA Kaolin”, May 2021. Available at: https://www.cefa.com.au/cefa-signs-15-year-contract-with-wa-kaolin/.

Environmental Protection Authority. “Port Hedland Power Station Expansion”, accessed 13 September 2021. At: https://www.epa.wa.gov.au/proposals/port-hedland-power-station-expansion.

Milne, P. “Rio Tinto pumps $2b to power Pilbara with clean energy”. Sydney Morning Herald, 5 November 2021. At https://www.smh.com.au/business/companies/rio-tinto-pumps-2b-to-power-pilbara-with-clean-energy-20211103-p595j4.html

Mineral Resources. “MARBL JV to restart Wodgina Lithium Mine”, 25 October 2021. At: https://clients3.weblink.com.au/pdf/MIN/02440344.pdf.

Mineral Resources. “Mineral Resources Ltd Annual Report 2019”. Available at: https://clients3.weblink.com.au/pdf/MIN/02156834.pdf.

Rio Tinto. “Investor Seminar”, 20 October 2021. Available at: https://www.riotinto.com/-/media/Content/Documents/Invest/Presentations/2021/RT-Investor-Seminar-2021-combined.pdf.

Strike Energy. “Greater Erregulla to drive development of Project Haber for Mid-West Fertilisers”, 11 January 2021. Available at: https://app.sharelinktechnologies.com/announcement/asx/3a1d792283199ebf85b9218ea2dc8b3b.

Hydrogen

bp Australia. “bp to cease production at Kwinana refinery and convert to fuel import terminal”, 30 October 2020. Available at: https://www.bp.com/en_au/australia/home/media/press-releases/kwinana.html.

bp Australia. “bp to undertake green hydrogen feasibility study in first development at clean energy hub”, 7 September 2021. Available at: https://www.bp.com/en_au/australia/home/media/press-releases/green-hydrogen-feasibility-study-at-clean-energy-hub.html.

Department of Industry, Science, Energy and Resources. “Funding available for clean hydrogen industrial hubs”, Australian Government, 22 September 2021. Available at: https://www.industry.gov.au/news/funding-available-for-clean-hydrogen-industrial-hubs.

Government of Western Australia. “WA to become global clean energy powerhouse”, media statement, 25 October 2021. Available at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/10/WA-to-become-global-clean-energy-powerhouse.aspx.

Government of Western Australia. “$61.5 million boost for WA’s renewable hydrogen industry”, media statement, 7 September 2021. Available at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/09/61-point-5-million-dollar-boost-for-WAs-renewable-hydrogen-industry.aspx.

Government of Western Australia. “$117.5 million to progress two renewable hydrogen hubs”, media statement, 25 November 2021. Available at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/11/117-point-5-million-dollars-to-progress-two-renewable-hydrogen-hubs.aspx.

Government of Western Australia. “Western Australian Renewable Hydrogen Fund”. Available at: https://www.wa.gov.au/government/publications/western-australian-renewable-hydrogen-fund.

Government of Western Australia. “Western Australian Renewable Hydrogen Strategy and Roadmap”. Available at: https://www.wa.gov.au/government/publications/western-australian-renewable-hydrogen-strategy-and-roadmap.

Hazer Group. “Quarterly activities and cashflow report”, 30 September 2021. Available at: https://hazergroup.com.au/wp-content/uploads/2021/10/211018-Hazer-Group-Limited-Appendix-4C-and-Commentary-FINAL.pdf.

Minister for Industry, Energy and Emissions Reduction. “Future hydrogen industry to create jobs, lower emissions and boost regional Australia”, Australian Government, 20 September 2021. Available at: https://www.minister.industry.gov.au/ministers/taylor/media-releases/future-hydrogen-industry-create-jobs-lower-emissions-and-boost-regional-australia.

Pilot Energy. “Pilot to commence mid-west WA blue hydrogen feasibility studies”, 12 August 2021. Available at: https://www.pilotenergy.com.au/sites/pilotenergy.com.au/files/asx-announcements/61045427.pdf.

Province Resources. “HyEnergy Zero Hydrogen™ Project Forging Ahead on Multiple Fronts”, 13 August 2021. Available at: https://www.provinceresources.com/investors.

Woodside Energy. “Woodside’s H2Perth to make Western Australia a hydrogen powerhouse”, 25 October 2021. Available at: https://files.woodside/docs/default-source/media-releases/woodside's-h2perth-to-make-western-australia-a-hydrogen-powerhouse.pdf.

Regulatory update

Economic Regulation Authority. “DBNGP Access Arrangement“. Available at: https://www.erawa.com.au/cproot/21861/2/DBNGP---DBP---AA5---ERA-APPROVED---DBNGP-revised-Access-Arrangement.PDF.

Government of Western Australia. “Improved governance arrangements for WA’s energy sector”, media statement, 1 July 2021. Available at: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/07/Improved-governance-arrangements-for-WAs-energy-sector.aspx.

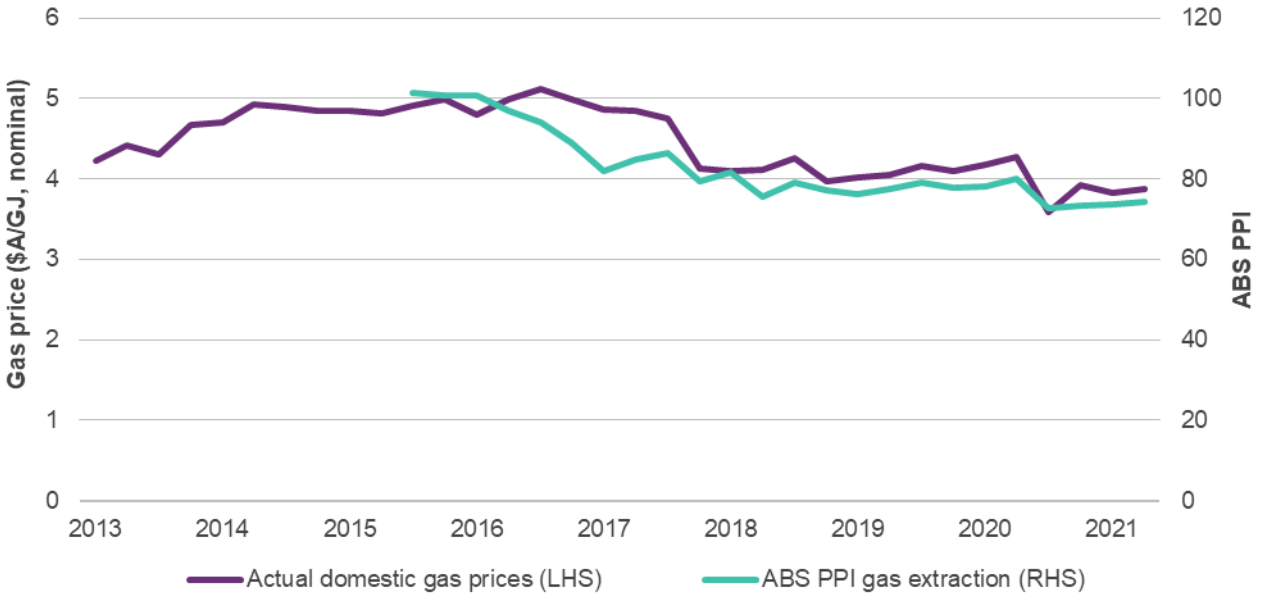
A2. Historical domestic gas prices and forward reference prices

All costs and prices in these appendices refer to 2021 Australian dollars unless otherwise specified.

A2.1 Historical domestic gas prices

The quarterly historical domestic gas contract price[1] is compared with the Australian Bureau of Statistics (ABS) producer price index (PPI)[2] for gas extraction in Figure 1.

Figure 1 Historical domestic gas contract prices and ABS PPI – WA (gas extraction, index), Q1 2013 to Q2 2021



Source: ABS and DMIRS.

The historical gas contract price in Q2 2021 was $3.87/GJ. This is 9.4% lower than in Q2 2020 ($4.27/GJ) and the third-lowest price since 2013 (the lowest price was $3.59/GJ in Q3 2020). This follows the trend of sales values in the petroleum sector, which dropped to a five-year low in 2020-21[3]. The ABS PPI (gas extraction) shows a similar downward trend since 2015, with the index in Q2 2021 being 26.7% lower than in Q3 2015.

Figure 2 shows monthly nominal spot prices (for gas traded via gasTrading[4]) since early 2015. After a prolonged downward trend in spot prices between October 2016 and May 2020, the trend then reversed, and prices increased from $2.30/GJ in June 2020 to $5.30/GJ in October 2021. Spot prices are now more aligned with contract prices. The increase observed since June 2020 may indicate some emerging market tightness following the fall in production from the Karratha Gas Plant (KGP).

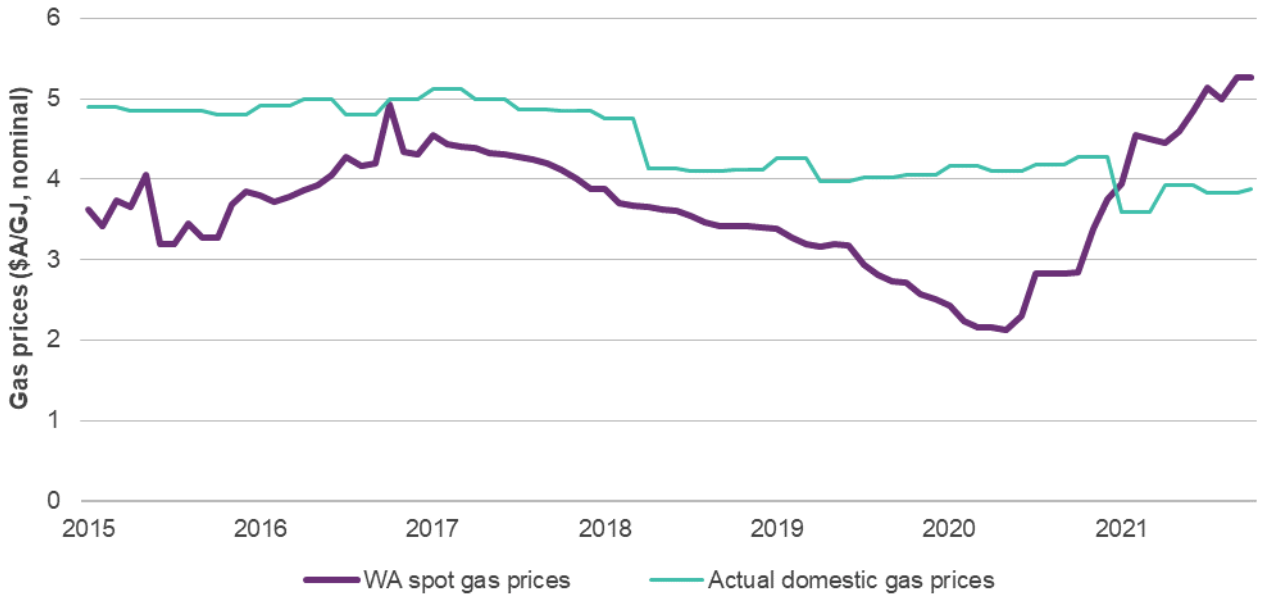
[1] See: http://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx.

[2] The base for the index is the 2015-16 financial year. See: https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/producer-price-indexes-australia/sep-2021.

[3] See: http://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx.

[4] See: http://www.gastrading.com.au/spot-market/historical-prices-and-volume/13-historical-prices-and-volume/27-price-history-table.

Figure 2 WA spot gas prices from gasTrading, January 2015 to October 2021



Source: gasTrading.

A2.2 Production costs for the WA domestic gas market

AEMO has estimated the weighted average cost of production for the 10-year outlook period. These costs range from $2.27/GJ in 2022 to $3.11/GJ in 2031. The production costs have been used to develop the forecast domestic gas prices used in the potential gas supply model.

Table 1 Production costs, 2022 to 2031

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Weighted average costs of production (A$/GJ, $ real, 2021)	2.27	2.32	2.36	2.39	2.41	2.68	2.93	3.00	3.03	3.11

Weighted average production costs have been calculated using the following assumptions:

- The short-run marginal cost (SRMC) has been used for onstream projects.
- Whole of project costs have been used for under-development and prospective projects.
- New projects were introduced to the market according to the timeframes publicly announced by project operators (see Appendix A3.3 for further information about these dates).
- A 10% discount rate has been used.
- Costs were weighted by gas production by field and the cost of that field for both existing facilities and prospective supply sources[5].

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

A3. Input assumptions and methodologies

This appendix provides details of input assumptions and methodologies used for the 2021 Western Australia (WA) Gas Statement of Opportunities (GSOO) to forecast potential gas supply, domestic gas demand, and total gas demand.

A3.1 Economic and commodity forecasts

This section provides an overview of the WA economic and commodity forecasts used as inputs in AEMO's potential gas supply and gas demand models.

WA's domestic gas demand is primarily driven by the economic environment. 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.

More recently, the impact of renewable penetration is impacting demand for gas power generation (GPG). For the 2021 WA gas demand forecasts and information on the drivers of demand over the outlook horizon, see Section 2.2.

Mining projects in WA are often located in remote areas, outside the South West Interconnected System (SWIS). Gas usage at these mines can include power generation for use at the mine site and adjoining towns. GPG at these sites is likely to be replaced by renewable generation in the future.

Hydrogen is expected to have a minimal impact on the WA GSOO over the 10-year outlook to 2031 because:

- It is not currently cost-competitive as a replacement for pipeline gas[6].
- While the WA Government is supportive of developing hydrogen technologies, the regulatory environment governing access to gas infrastructure currently precludes hydrogen[7].

A3.1.1 Economic outlook

To maintain consistency between long-term electricity and gas forecasting, AEMO used the economic forecasts that were prepared by BIS Oxford Economics[8] for the 2021 Wholesale Electricity Market (WEM)

[6] Several hydrogen feasibility studies are currently being undertaken across WA, including APA's study of the Parmelia Gas Pipeline capability to carry up to 100% hydrogen. See: https://www.apa.com.au/news/media-statements/2021/wa-government-supports-apas-world-leading-hydrogen-research/.

[7] See: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/gas_consultations/2021/hydrogen-blends-and-renewable-gases-procedures-review/consultation-paper.pdf.

[8] See: https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2021/bis-oxford-economics-macroeconomic-projections.pdf.

Electricity Statement Of Opportunities (ESOO) as inputs into the development of WA domestic gas demand forecasts.

Table 2 shows BIS Oxford Economics' low, base, and high projections for Gross State Product (GSP), which were used as inputs into the gas demand forecasts, and Table 3 summarises the assumptions underpinning the GSP projections.

Table 2 WA GSP (%) annual growth forecasts for different economic growth scenarios, 2022-23 to 2031-32 financial years

Sector	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	5-year annual average growth (%)	10-year annual average growth (%)
Low	-0.7	0.4	1.9	3.3	3.7	3.5	3.4	3.0	2.7	2.7	1.9	2.7
Base	2.7	3.2	3.4	3.5	3.3	3.1	3.0	3.0	2.9	2.8	2.7	3.1
High	8.1	2.6	3.3	2.7	3.3	3.4	3.4	3.2	2.8	2.8	2.4	3.0

Source: BIS Oxford Economics

Table 3 Economic scenario assumptions and sensitivities

Scenario	Low	Base	High
Population growth	Lower than Base scenario: Apply ABS Series C NOM dispersion to BIS Oxford Economics baseline	BIS Oxford Economics baseline	Higher than Base scenario: Apply ABS Series A NOM dispersion to BIS Oxford Economics baseline
Investment	Lower than Base scenario	BIS Oxford Economics baseline	Higher than Base scenario
Global demand	Lower demand than Base scenario	BIS Oxford Economics baseline	Higher demand than Base scenario
Climate warming settings	~4°C by 2100 from pre-industrial levels	~2.6°C by 2100 from pre-industrial levels	<1.5°C by 2100 from pre-industrial levels
Resource intensity	Higher than Base scenario	BIS Oxford Economics baseline	Lower than Base scenario
Commodity intensity	Higher than Base scenario	BIS Oxford Economics baseline	Lower than Base scenario
COVID-19 recovery	Slower pace of recovery and international border re-opening is delayed	BIS Oxford Economics baseline	Faster pace of recovery and international border re-opening fast-tracked

Source: BIS Oxford Economics. Further specifications of input assumptions are detailed in the BIS Oxford Economics 2021 Macroeconomic Projections Report.

WA's GSP is forecast to grow at 3.1% on average over the 10 years to 2031 in the Base scenario. This growth reflects anticipated renewed mining investment driving growth in the construction sector and investment spending, leading to increased economic activity, and population growth[9].

[9] The model assumes that international border restrictions will ease in the first quarter of 2022.

A3.1.2 Commodity outlook

AEMO engaged the National Institute of Economic and Industry Research (NIEIR) to provide commodity forecasts[10] as inputs for the development of the WA domestic gas demand forecasts. To develop the commodity production forecasts, NIEIR combined information on new projects, expansions, and closures for each commodity type with consensus price forecasts.

Despite the impact of COVID-19 on global commodity markets, mining activity in WA has remained strong. WA's commodity production was valued at $173 billion in 2019-20 because of increased production of some commodities and higher prices.

Iron ore

While iron ore production in Australia in 2020 was only slightly higher than in 2019, the value of exports increased by 21%. China accounted for nearly 80% of Australian iron ore exports, with Japan and South Korea each accounting for 6% of trade. The outlook beyond 2021 remains strong for iron ore production despite recent price falls.

Gold

Gold production also increased in Australia from 2019 to 2020, with WA accounting for 67% of national production. Gold prices rose sharply during the COVID-19 pandemic, driven by interest rate cuts and lower bond yields. Gold production is expected to continue to grow until 2023, following which gold prices are expected to fall, leading to declining production.

Lithium

In the Base scenario over the 10 years to 2031, NIEIR projects strong average annual growth (10.2%) for lithium production in WA. Global commitments to emissions reductions (leading to an increase in demand for consumer electronic and electric vehicle batteries) has led to a strengthened outlook for lithium since the 2020 WA GSOO. Renewed interest in lithium projects worldwide is likely to result in the development of new projects in the next two to three years.

Copper

The worldwide shift to renewable energy is forecast to drive significant demand for copper, resulting in increased WA production over the medium term.

Cobalt

WA's cobalt production is expected to grow at an average annual rate of 4.7% over the next 10 years to 2031. Despite cobalt prices surging to US$50,000 per tonne in 2021, it remains unlikely that WA's publicly announced projects will proceed until after 2025, when battery prices are expected to decline to a level that encourages mass-market uptake.

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

Lead

Lead production is expected to make steady increases over the outlook period after prices recovered from a COVID-19 related 2020 low.

Mineral sands

Australia is the world's largest producer of mineral sands (rutile and zircon) and produces nearly a quarter of the world's ilmenite resources. WA's mineral sand production has steadily increased since 2017 in line with increasing price trends. The commencement of Strandline Resources' Coburn operation in late 2022 will further increase production.

Further information about the commodity forecasts can be found in NIEIR's report[11].

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, commercial, 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 Liquefied Natural Gas (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 forecasts domestic gas demand by separately modelling each of the following sectors:

- **Tariff V** – volumetrically tariffed customers, which includes residential and commercial distribution network customers. These consumers typically use less than 10 TJ/year. Distribution networks include Kalgoorlie and Leonora but exclude Albany which distributes liquefied petroleum gas.
- **Tariff D** – demand tariffed customers that typically use more than 10 TJ/year. This includes industrial customers that are located within the distribution network, and the following transmission-connected consumers:
  - Minerals processing.
  - Mining.
  - Industrial.
- Other industrial customers that are located within the distribution network.
- GPG (including SWIS[12] and non-SWIS).

The methodology applied in forecasting each sector is summarised in the following section.

[11] NIEIR. *Commodity forecasts for Western Australia to 2031*, July 2021, prepared for AEMO and published alongside the WA GSOO.

[12] Forecasts of SWIS GPG gas demand were prepared by Robinson Bowmaker Paul and are published alongside the WA GSOO.

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. These customers account for approximately 3.7% of WA's domestic gas demand. AEMO projected Tariff V total consumption by applying different assumptions based on the customer type (residential or non-residential), scenario, and the consumption per connection.

The average per-connection Tariff V consumption is estimated, consisting of heating[13] and baseload components. This is used as the base for forecasting Tariff V annual consumption, with growth driven by the following factors:

- 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 AEMO's *Gas Demand Forecasting Methodology Information Paper*[14].

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 and Glencore.
  - Lithium producers – Mineral Resources Limited.
  - Base metals producers – Cyprium Metals.
- Minerals processing consumers such as Alcoa, Albemarle, TLEA, BHP, and South32.
- Industrial consumers such as CSBP and Yara Pilbara.
- Construction materials producers such as Midland Brick and Cockburn Cement.
- Domestic LNG producers such as EDL and Wesfarmers.
- Other industrial customers that are connected to the distribution network.

[13] Heating load is largely dependent on future weather projections, specifically the frequency and severity of cold days. This is referred to as HDDs (heating degree days).

[14] See: https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/gsoo/2021/2021-gas-statement-of-opportunities-methodology-demand-forecasting.pdf.

From the list of industrial consumers, AEMO assumed that Tariff D gas consumers are associated with natural gas intensive processes, such as minerals processing calcination facilities, equipment used to mine specific minerals, and 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. AEMO used NIEIR's commodity forecasts as an input into the Tariff D demand forecasts (see Section A3.1.2 for further information). The mining, minerals processing, and industrial forecasts are largely driven by:

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

AEMO has used information received from gas consumers as part of the 2021 Formal Information Request (FIR) for developing the gas demand forecasts for these sectors. Where FIR information was unavailable, AEMO has applied NIEIR's commodity production forecasts.

Minerals processing, mining, and industrial sectors

AEMO's forecasts of the mining, minerals processing, and industrial sectors are based on data gathered using the following sequence:

1. Tier 1 (preferred method) – obtained forecast data from the facility operator, usually through the FIR, with data quality checks performed against historical consumption along with any public announcements about the facility's operations.
2. Tier 2 (if no site-specific forecast was available) – used other causal information such as commodity forecasts. Historical usage data was analysed to calculate either a regression-based energy coefficient (commodity-specific) or an energy intensity factor. Scenario bandwidths were calculated using this method for the low, base, and high commodity forecasts.
3. Tier 3 (where data for the first two approaches was unavailable) – historical pattern matching across multiple years of consumption data determined whether the forecast was based on a trend or a median level of usage, with scenario bandwidths based on statistical levels of certainty.

Other Tariff D consumption

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

To estimate gas demand, the segment was split into two components: aggregate and large users. An econometric model was applied to forecast the aggregate component, which considered the impact of annual gross state product growth, climate-adjusted weather, and weekdays. The large user component was forecast using information provided by the distribution network service provider.

SWIS GPG

The most variable component of gas demand, electricity generation from SWIS GPG[15], accounted for approximately 16.4% of domestic gas demand in WA in 2021. In the 2021-22 Capacity Year, 2,977 megawatts (MW) of Capacity Credits were assigned to gas or dual fuel gas-and-diesel generators, of which about two-thirds are peaking or mid-merit[16]. Typically, the SWIS relies on GPG to supply peak load over the summer season and for the provision of Load Following Ancillary Services (LFAS)[17].

Forecasts of SWIS GPG gas demand were prepared by Robinson Bowmaker Paul (RBP) and were added to AEMO's forecasts. The scenarios used by RBP for the GPG modelling are shown in Table 4.

RBP used its 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, minimum stable levels, utility-scale intermittent profiles, and cost information.
- Information about network transfer limits and constraints[18].
- Details of generation entry and retirements, including:
  - Facilities that hold Capacity Credits through the Reserve Capacity Mechanism for the 2021-22 Capacity Year.
  - Staged retirement of Muja C, with one unit retiring from October 2022 and the other from October 2024.
  - Committed generation new builds, including East Rockingham Resource Recovery Facility coming online from October 2022 as well as prospective new builds obtained from the 2021 Expressions of Interest for Reserve Capacity[19].
- Operational consumption, peak demand, and Distributed Energy Resources (DER)[20] forecasts from the 2021 WEM ESOO.
- Previous Balancing Market bids and offers[21] (including negatively priced offers), to allow the model to replicate historical dispatch patterns.
- Fuel prices, including pipeline domestic gas, coal, and diesel price assumptions.

[15] Some GPG that participates in the Wholesale Electricity Market (for example, Alcoa Wagerup power station) serves large behind-the-fence loads in the minerals processing, mining, or industrial sectors and is excluded from SWIS GPG gas demand in the WA GSOO. For a full description of how AEMO classifies facilities, see Appendix A5.

[16] Peaking capacity operates less than 10% of the time, and mid-merit capacity operates between 10% and 70% of the time. See: https://www.aemo.com.au/-/media/files/electricity/wem/planning_and_forecasting/esoo/2021/2021-wholesale-electricity-market-electricity-statement-of-opportunities.pdf.

[17] LFAS is the power system security ancillary service whereby assigned generators automatically and constantly change their output to compensate for the differences between load and dispatched energy, as well as fluctuations caused by intermittent generation. Load following units will respond automatically to any over or under frequency events (including generator trips and load rejection events), thus regulating the system frequency.

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

[19] See: https://aemo.com.au/en/energy-systems/electricity/wholesale-electricity-market-wem/wa-reserve-capacity-mechanism/expressions-of-interest.

[20] Including behind-the-meter solar PV, battery storage, and electric vehicles.

[21] By default, WEMSIM assumes capacity is offered for dispatch at short-run marginal cost.

Table 4 Scenario mapping for GPG modelling

Scenario	Low	Base	High
Operational consumption[A]	Low	Expected	High
Peak demand[A]	Low case 90% probability of exceedance (POE)	Expected case 50% POE	High case 10% POE
Gas price[B]	Low	Expected	High
Behind the meter PV and battery storage[A]	Expected	Expected	Expected
Generation retirements	• PPP_KCP_EG1 retired 1 December 2021 (excluded in modelling) Staged retirement of Muja C: • MUJA_G5 retires 1 October 2022. • MUJA_G6 retires 1 October 2024.		
Generation new builds	• East Rockingham Resource Recovery Facility 1 October 2022 (28.9 MW) • Other Facilities obtained from 2021 Expressions of Interest for Reserve Capacity and assigned to scenarios based on internal assessment (not listed here due to confidentiality)		

[A] Sourced from the 2021 WEM ESOO.
[B] Sourced from Energy Quest.

Non-SWIS GPG

Non-SWIS GPG includes the electricity distribution networks operated by Horizon Power. To forecast non-SWIS GPG gas consumption, AEMO has used information received from gas consumers as part of the 2021 FIR. As the non-SWIS region has relatively stable electricity consumption, where FIR information was unavailable AEMO has applied the 2020 WA GSOO forecast methodology, which was calculated using an econometric model that forecasts electricity consumption for each gas consuming non-SWIS area.

Committed new project demand

Committed new project demand is defined as projects that have a direct impact on WA gas consumption (either by increasing or decreasing consumption) and have taken a final investment decision (FID) or are under construction.

These projects include approved upcoming projects that will use natural gas as an input feedstock, for power generation, or where renewable energy projects 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 2021 FIR process. These estimates were added to all three scenarios (see Section 2.2 for further details about these projects).

Prospective gas demand in the High 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 consumption of gas over the outlook period ("prospective demand").

Projects included in the prospective demand forecasts were 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 FID.
- The project proponent has submitted an environmental approval to the WA 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 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 included projects submitted by Gas Market Participants (GMPs) and some non-GMPs as part of the 2021 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 3. The total gas demand forecasts are shown in Appendix 4.

Figure 3 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 dates 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 5.

Table 5 Total gas demand forecast assumptions

Scenario	Low	Base	High
Domestic gas demand forecasts	Low	Base	High
Gas feedstock for LNG exports	• North West Shelf (NWS) (16.9 million tonnes per annum [mtpa], supported by gas from Greater Western Flank 3 in 2022). • NWS production maintained via backfill from Waitsia (1.5 mtpa from 2024 to 2027). • Pluto LNG (4.5 mtpa). • Gorgon LNG (14.7 mtpa). • Wheatstone LNG (8.9 mtpa). • Prelude FLNG (3.6 mtpa). • Ichthys LNG (8.9 mtpa). • Pluto train one supported by backfill from Scarborough (2.5 mtpa from 2028). • Pluto train two expansion from Scarborough gas (5.0 mtpa, commences 2028).	Includes facilities outlined in the Low scenario assumptions, with the following exceptions: • NWS production maintained via backfill through the interconnector from Pluto (0.75 mtpa from 2022 to 2025). • Pluto train one supported by backfill from Scarborough (2.5 mtpa from 2027). • Pluto train two expansion from Scarborough gas (5.0 mtpa, commences 2027).	Includes facilities outlined in the Base scenario assumptions, with the following exceptions: • Gorgon LNG (15.6 mtpa). • Pluto train one supported by backfill from Scarborough (3.0 mtpa from 2026). • Pluto train two expansion from Scarborough gas (5 mtpa, commences 2026).
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, at 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 Gas supply model

A3.3.1 Resources and reserves

AEMO uses estimates made under the Society of Petroleum Engineers (SPE) system of reserves classification[22], which is standard across the gas industry. Gas accumulations are categorised into either reserves or resources, based on the level of commercial and technical uncertainty associated with extraction[23].

A summary of the terms has been provided in Table 6.

Table 6 Classification of reserves and resources

Classification	Definition
1P	A measure of gas reserves that includes proven (developed and undeveloped) reserves, and a reasonable certainty (normally at least 90% confidence) of being recoverable.
2P	A measure of gas reserves that includes proven (1P) and probable 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.

[22] See: https://www.spe.org/en/industry/reserves/.

[23] 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.

Over time, gas reserves and resources are developed, depleted, or reassessed (particularly against commercial benchmarks), so the forecasts of gas reserves and resources change.

A3.4 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 to assess supply adequacy and identify potential supply gaps[24].

To determine these potential gas supply sources, AEMO sources information on prospective gas supply from external consultants, the WA Department of Jobs, Tourism, Science and Innovation (DJTSI), and information in the public domain. AEMO uses both physical and commercial characteristics sourced from EnergyQuest when assessing prospective supply sources, as summarised in Table 7.

Table 7 Criteria for assessing prospective gas supply sources

Physical characteristics	Commercial characteristics
• Reserves location • Water depth • Reserves volume • Reservoir characteristics • Domestic market obligation (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 • Commercial arrangements (for example, any tolling requirements) • Gas sales contracts

AEMO's potential gas supply model was redeveloped by ACIL Allen in 2018 following the recommendations of the five-yearly WA GSOO review[25]. The model tracks the gas reserves remaining for 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 and backfill.

Where possible, AEMO sourced model input data from GMPs and non-GMPs through the 2021 FIR and made assumptions based on publicly available information where FIR data was unavailable. For this 2021 WA GSOO, AEMO updated the input assumptions used in the model and made improvements to better capture FIR data, DMOs, reserves, and gas storage.

AEMO assessed several new supply sources. Some of these candidates for supply or backfill of existing gas production facilities were excluded 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.

[24] Transmission pipeline capacity constraints are not considered in the model.

[25] See: https://aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/WA_GSOO/2018/Five-Yearly-Review-of-the-WA-GSOO.pdf.

- The development timeframe was likely to extend beyond the end of the outlook period.
- Developing the resource was considered to be uneconomic under current and expected near-term LNG and domestic market conditions.
- The project proponent or operator had not selected a preferred development option.

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

Based on the existing and new gas supply sources that have been included in the gas supply model, Table 8 summarises the selection criteria and basis of assessment.

Table 8 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 • The decline rate advised by the GMP as part of the 2021 FIR, where reserves are insufficient to maintain gas production at nameplate capacity throughout the entire outlook period.	Potential gas supply is equal to the DMO.	Developed when the domestic gas price forecast exceeds the estimated cost of production. Once developed, potential gas supply is maintained at production capacity until reserves are depleted.	Developed when the forecast Asian LNG net back price exceeds the estimated cost of production. Once developed, potential gas supply equals the DMO.
Projects included in the model	• Devil Creek • Beharra Springs • Macedon • Varanus Island • Xyris	• Gorgon (tranche one and two) • KGP • Pluto • Scarborough • Wheatstone • Waitsia[26]	• West Erregulla • Beharra Springs expansion • Lockyer Deep • Corvus	

A3.5 Historical gas production

There are nine gas production facilities supplying the WA domestic market, with a total nameplate capacity of about 1,851 TJ/day[27], as shown in Table 9. The KGP maintains the largest capacity at 630 TJ/day.

The following trends (detailed in Table 9) were observed during the 2020-21 financial year:

- The highest production was from Varanus Island (271 TJ/day) followed by Macedon, Wheatstone, Devil Creek, and Gorgon (ranging from 164 TJ/day to 194 TJ/day). Beharra Springs had the lowest production (7 TJ/day).
- There was no production from Beharra Springs between 1 July 2020 and 18 October 2020, as the facility was awaiting the installation and commissioning of a new cyclonic separator[28], or between 27 February 2021 and 31 March 2021 due to site works to connect the Beharra Springs Deep well[29].

[26] Waitsia has a DMO of 20 TJ/day from 2024 to 2028. From 2029, all gas from Waitsia must be supplied to the domestic market.

[27] Dongara has not operated since Q3 2017 and has therefore been excluded. The nameplate capacity value has been calculated based on data available from the WA Gas Bulletin Board as at 30 June 2021.

[28] See: https://yourir.info/resources/0c5a441cf54ff229/announcements/bpt.asx/2A1258293/BPT_Quarterly_report_for_the_period_ended_30_September_2020.pdf.

[29] See: https://yourir.info/resources/0c5a441cf54ff229/announcements/bpt.asx/2A1295285/BPT_Quarterly_report_for_the_period_ended_31_March_2021.pdf.

- Production from Devil Creek and the KGP declined; the latter has been attributed to the end of at least one Gas Supply Agreement (GSA).
- Production from Varanus Island and Xyris increased. The increase in the Xyris facility has been attributed to the expansion of the facility to 28 TJ/day, with performance exceeding 20 TJ/day in the third quarter, and 28 TJ/day in the fourth quarter[30].
- Production declined at Gorgon from late April 2021 due to plant maintenance activities[31]. Varanus Island and Pluto production declined in the third quarter, while Wheatstone declined in the second and third quarter.
- The Xyris, Macedon, and Gorgon facilities had the highest capacity utilisation (99%, 97%, and 90% respectively), while the KGP and Beharra Springs facilities had the lowest capacity utilisation (7% and 36% respectively). The remaining facilities have been operating at capacity utilisations ranging from 74% to 85%.

Table 9 Domestic gas production facility average production and capacity utilisation, 2020-21 financial year[32]

Facility	Nameplate capacity (TJ/day)	Average production (TJ/day)					Average capacity utilisation (%)[A]				
		1 Jul – 30 Sept 2020 (Q1)	1 Oct - 31 Dec 2020 (Q2)	1 Jan- 31 Mar 2021 (Q3)	1 Apr - 30 Jun 2021 (Q4)	2020-21 financial year	1 Jul - 31 Aug 2020 (Q1)	1 Sept - 31 Dec 2020 (Q2)	1 Jan- 31 Mar 2021 (Q3)	1 Apr - 30 Jun 2021 (Q4)	2020-21 financial year
Beharra Springs[B]	18.5	0	6	5	15	7	0%	34%	30%	82%	36%
Devil Creek	220	191	177	161	126	164	87%	80%	73%	57%	74%
Gorgon	182	163	167	172	154	164	89%	92%	95%	85%	90%
KGP	630	76	47	32	15	43	12%	8%	5%	2%	7%
Macedon[C]	197	194	193	194	196	194	96%	96%	97%	99%	97%
Pluto[D]	25	22	19	16	23	20	87%	75%	65%	91%	80%
Varanus Island	345	265	271	252	295	271	77%	79%	73%	86%	79%
Wheatstone	205	187	162	160	186	174	91%	79%	78%	91%	85%
Xyris[E]	28	6	18	21	29	19	56%	123%	105%	113%	99%
Total	**1,851**	**1,103**	**1,060**	**1,016**	**1,041**	**1,055**	**66%**	**74%**	**69%**	**78%**	**72%**

A. Utilisation was calculated using nameplate capacity and average production for each three-month period.
B. Beharra Springs' capacity was revised to 9 TJ/day between 14 November 2020 and 16 November 2020.
C. Macedon's capacity was revised from 201 TJ/day to 197 TJ/day in March 2021.
D. The Pluto LNG facilities have a nameplate capacity of 40 TJ/day (a 25 TJ/day pipeline gas facility and a 15 TJ/day LNG truck loading facility). The WA GBB however records a registered nameplate capacity of 25 TJ/day effective from 19 March 2021.
E. Xyris capacity was revised from 20 TJ/day in November 2020 to 25 TJ/day in March 2021, to 28 TJ/day in June 2021.

[30] See: https://yourir.info/resources/0c5a441cf54ff229/announcements/bpt.asx/2A1295285/BPT_Quarterly_report_for_the_period_ended_31_March_2021.pdf.

[31] See: https://australia.chevron.com/our-businesses/scheduled-maintenance-activity-notices.

[32] See: https://gbbwa.aemo.com.au/

A4. Total gas demand forecasts

Table 10 Domestic gas demand forecasts (PJ/annum), 2022 to 2031

Year	Low	Base	High
2022	382.8	391.1	409.7
2023	401.8	410.7	432.8
2024	399.7	410.8	460.3
2025	398.6	412.0	486.4
2026	398.3	413.4	516.4
2027	396.2	412.2	517.8
2028	393.2	412.5	518.1
2029	392.2	413.8	521.1
2030	390.5	415.2	524.1
2031	391.7	419.8	526.3

Table 11 LNG feedstock forecasts (PJ/annum), 2022 to 2031

Year	Low	Base	High
2022	2,940.4	3,019.4	3,066.8
2023	2,862.3	2,941.2	2,988.6
2024	2,863.1	2,942.1	2,989.5
2025	2,784.9	2,863.9	2,911.3
2026	2,706.8	2,785.7	3,175.4
2027	2,628.6	3,023.5	3,097.3
2028	2,866.4	2,866.4	2,940.1
2029	2,788.2	2,788.2	2,861.9
2030	2,710.0	2,710.0	2,783.8
2031	2,631.9	2,631.9	2,705.6

Table 12 LNG processing forecasts (8% of feedstock) (PJ/annum), 2022 to 2031

Year	Low	Base	High
2022	235.2	241.6	245.3
2023	229.0	235.3	239.1
2024	229.0	235.4	239.2
2025	222.8	229.1	232.9
2026	216.5	222.9	254.0
2027	210.3	241.9	247.8
2028	229.3	229.3	235.2
2029	223.1	223.1	229.0
2030	216.8	216.8	222.7
2031	210.6	210.6	216.4

Table 13 Total gas demand forecasts (PJ/annum), 2022 to 2031

Year	Low	Base	High
2022	3,558.5	3,652.0	3,721.9
2023	3,493.1	3,587.3	3,660.5
2024	3,491.9	3,588.2	3,688.9
2025	3,406.3	3,505.0	3,630.6
2026	3,321.6	3,422.0	3,945.8
2027	3,235.1	3,677.6	3,862.9
2028	3,488.9	3,508.2	3,693.4
2029	3,403.4	3,425.1	3,612.0
2030	3,317.3	3,342.0	3,530.6
2031	3,234.1	3,262.3	3,448.4

A5. Sector classifications

Table 14 Classification of gas consumers into sectors (GBB delivery points)

Sector	Gas consumers		
Minerals processing	• Alcoa Kwinana • Alcoa Pinjarra[A] • Alcoa Wagerup • Beyondie	• BHP Kwinana • Hismelt Kwinana • Kwinana cogeneration plant • Kwinana nickel refinery	• Tiwest Chandala • Tiwest Kwinana • Worsley alumina[B]
Mining	• Agnew • Birla Nifty • Boonamichi Well • Camel Soak • Cosmos • Granny Smith goldmine • Gwalia • Hill 60[C] • Jaguar • Leinster • Magellan • Mount Keith power station	• Mt Morgans • Murrin Murrin • Newman power station • Paraburdoo power station • Parkeston power station • Pinga Creek Meter Station • Plutonic • Robe River • Saracen • Savory Creek • Sino Iron project power station • Solomon power station	• Southern System Power Station • Sunrise Dam • Telfer gold mine • Tropicana • Wiluna Gold • Wiluna Jundee • Windimarra • Wodgina • Yamarna • Yarnima power station • Yurrali Maya power station
Industrial	• Ashburton • Australian Gold Reagents • Boodarie • Cockburn Cement • CSBP ammonia • Esperance	• Fero industries • Maitland LNG Plant • Midland Brick • Oakley Road • ROC Oil • Rocla[D]	• Thomas Road • Tip Top Canning Vale • Wesfarmers[E] • Whiteman Brick • Yara fertilisers
SWIS GPG	• Kemerton power station • Kwinana power station • Mungarra power station	• NewGen Kwinana & Cockburn power station • NewGen Neerabup power station • Perth Energy Kwinana	• Pinjar power station • Pinjarra power station[F] • Wagerup power station
Non-SWIS GPG	• Carnarvon power station • Exmouth power station	• Karratha 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. Rocla was previously classified as mining but has been reclassified as a result of methodological improvements.
E. Including Wesfarmers gas and LNG facilities.
F. Pinjarra Power Station was previously classified as Minerals Processing but has been reclassified as a result of methodological improvements.

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 Appendix A3.3.

A6.1 Gas transmission pipelines

A map of WA's gas transmission network is shown in Figure 4.

Figure 4 Gas transmission pipelines in WA

A6.2 Multi-user gas storage facilities

WA has two multi-user gas storage facilities in operation, as shown in Table 15.

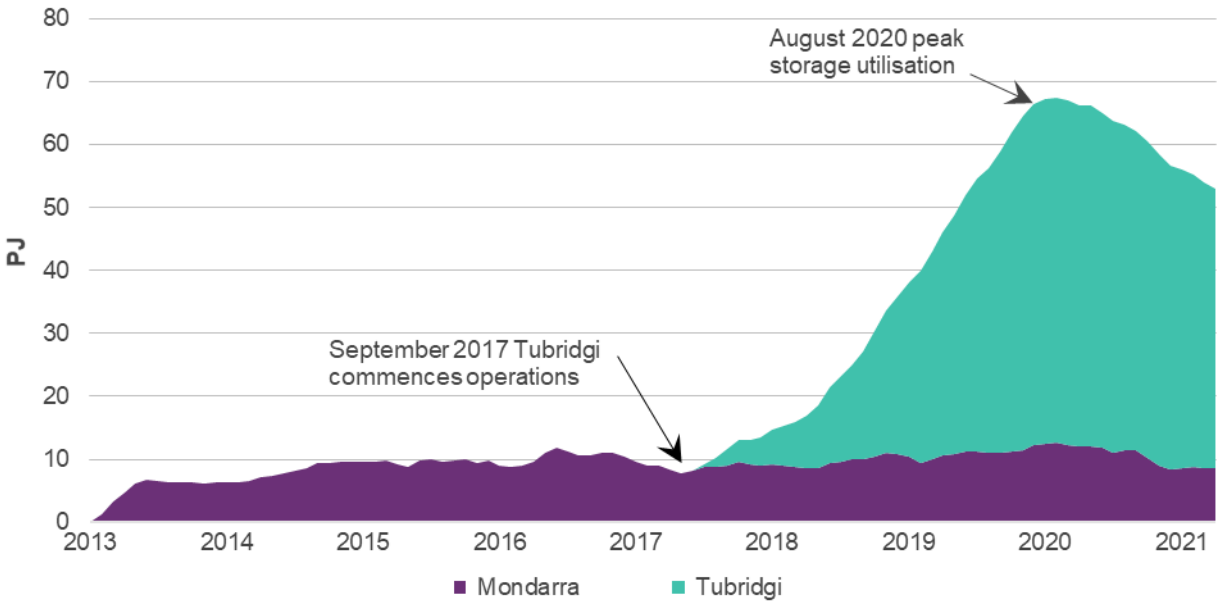
Table 15 WA multi-user gas storage facilities, 2021

Facility	Operator	Commenced operation	Gas storage capacity (PJ)	Injection/withdrawal capacity (TJ/day)
Mondarra	APA Group	2013	18	70/150
Tubridgi	Australian Gas Infrastructure Group	2017	60	90/60
Total			**78**	**160/210**

The amount of gas currently stored in Mondarra and Tubridgi is shown in Figure 5. AEMO estimates that the facilities contained 53 PJ of stored gas in October 2021[33], resulting in a capacity utilisation rate of 68%.

Stored gas peaked in August 2020 and declined between September 2020 and October 2021 as withdrawals outpaced injections. Declines in stored gas since 2020 have coincided with increasing prices in the domestic gas spot market[34].

Figure 5 Cumulative stored gas, 2013 to October 2021



Source: WA GBB.

A6.3 Spot and short-term trading

AEMO does not operate a spot or short-term trading market in WA. Instead, most short-term demand is met by confidential contracts settled between parties. Short-term gas may be procured through two independent and non-aligned mechanisms:

[33] Calculated as net injections less withdrawals over the period August 2013 to October 2021 and excluding cushion gas.

[34] See: http://www.gastrading.com.au/spot-market/historical-prices-and-volume.

- 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. Trade data is published on gasTrading's website at the end 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. Trades can encompass firm and interruptible gas arrangements, as well as imbalances, and trade data is published monthly on the Energy Access website.

AEMO estimates that approximately 1-2%[35] of total gas consumption in WA is traded on a short-term basis. Information in the public domain regarding the quantity and associated prices of spot or short-term gas is provided by gasTrading Australia Pty Ltd and Energy Access Services Pty Ltd.

A6.4 LNG export production facilities

WA's LNG nameplate production capacity totals 46.3 mtpa and consists of four production facilities:

- NWS (KGP) – 16.9 mtpa[36].
- Pluto – 4.9 mtpa[37].
- Gorgon – 15.6 mtpa[38].
- Wheatstone – 8.9 mtpa[39].

All the LNG projects in WA have historically used only equity gas – that is where the ownership of gas does not change from wellhead to export. However, from 2023, third-party use of the NWS liquefaction facility will commence.

The Waitsia joint venture has been given permission to export 7.5 million tonnes of LNG (418 PJ) of its stage two reserves as LNG via the NWS infrastructure. This export deal will be the first time onshore gas has been exported as LNG, and the first time gas been supplied at the southern end of the Dampier Bunbury Pipeline (DBP), but consumed at the northern end. The additional supply and demand created by Waitsia LNG export is shown in Figure 6.

AEMO has excluded these export volumes from the supply/demand balance as it is not true domestic demand. However, the produced gas will be recorded on the GBB and will flow through WA infrastructure.

[35] Calculated using WA Gas Spot Market data and WA GBB. See: http://www.gastrading.com.au/spot-market/historical-prices-and-volume; and https://gbbwa.aemo.com.au/.

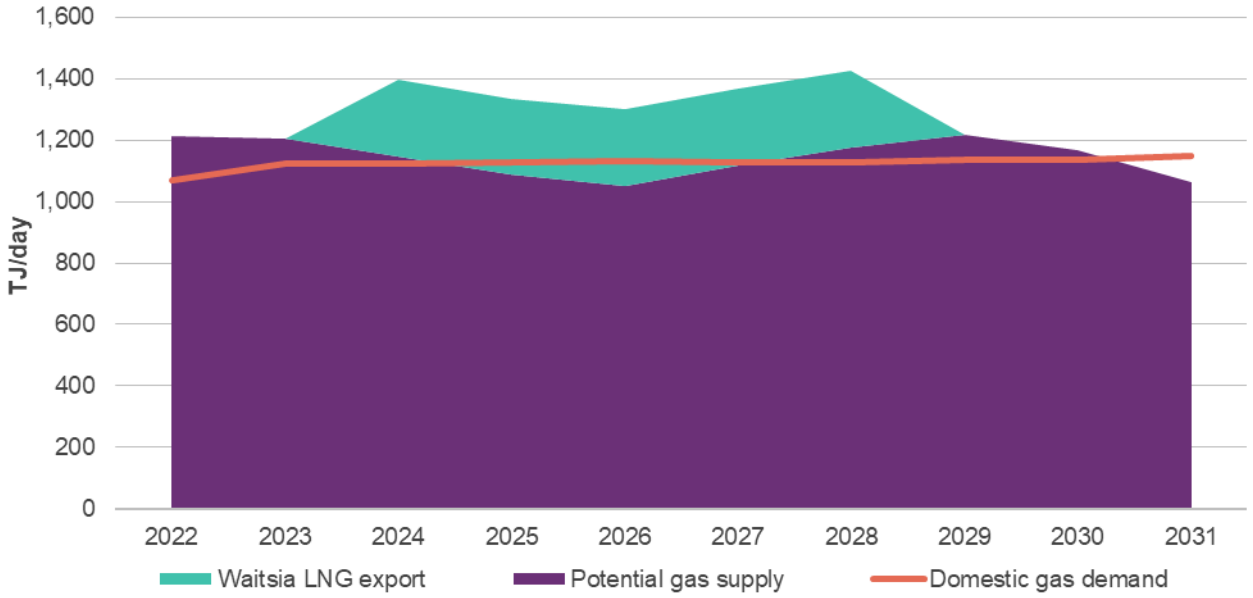
[36] See: https://www.woodside.com.au/our-business/north-west-shelf.

[37] See: https://www.woodside.com.au/our-business/pluto-lng.

[38] See: https://australia.chevron.com/our-businesses/gorgon-project.

[39] See: https://www.woodside.com.au/our-business/wheatstone-project.

Figure 6 Domestic gas prospective supply and demand plus Waitsia-to-KGP LNG export gas



Two additional facilities source gas from Commonwealth waters off the northwest coast of WA, but the liquefaction either occurs offshore or in the Northern Territory and therefore they do not contribute to WA's overall LNG production capacity:

- Prelude – a 3.6 mtpa[40] floating LNG facility operated by Royal Dutch Shell plc, which exports directly from the offshore vessel.
- Ichthys – a 8.9 mtpa[41] LNG project operated by Inpex Corporation, which has an onshore liquefaction plant located in Darwin.

[40] See: https://www.shell.com.au/about-us/projects-and-locations/prelude-flng-facility.html.

[41] See: https://www.inpex.com.au/projects/ichthys-lng/.

A7. Conversion tables

The following conversion factors have been applied in preparing figures for this 2021 WA GSOO.

Conversion factors

	To						
From	**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**	**Petajoules**
	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 of 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 of oil equivalent	0.15	5.35	0.14	0.11	5.41	1	5.82
Petajoules	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
GJ	Gigajoule
mtpa	Million tonnes per annum
MW	Megawatt
PJ	Petajoule
Q	Quarter
tcf	Trillion cubic feet
TJ	Terajoule

Abbreviations

Abbreviation	Expanded name
1P	Proved reserves
2C	Contingent resources
2P	Proved and probable reserves
ABS	Australian Bureau of Statistics
AEMO	Australian Energy Market Operator
CEFA	Clean Energy Fuels Australia
CSBP	Cuming Smith British Petroleum and Farmers Limited
DBP	DBNGP (WA) Transmission Pty Ltd
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DER	Distributed energy resources
DJTSI	WA Department of Jobs, Tourism, Science, and Innovation
DMIRS	WA Department of Mines, Industry Regulation and Safety
DMO	Domestic market obligation
EDL	Energy Developments Limited
EPA	Environmental Protection Agency
ERA	Economic Regulation Authority
ESOO	Electricity Statement of Opportunities
FID	Final investment decision
FIR	Formal information request
FMG	Fortescue Metals Group
GBB	Gas Bulletin Board
GMP	Gas Market Participant
GPG	Gas powered generation

Abbreviation	Expanded name
GSA	Gas Sale Agreement
GSI Rules	Gas Services Information Rules
GSOO	Gas Statement of Opportunities
KGP	Karratha Gas Plant
LNG	Liquefied natural gas
LPG	Liquified petroleum gas
MCQ	Maximum contracted quantity
NIEIR	National Institute of Economic and Industry Research
NWS	North West Shelf
PPI	Producer Price Index
PV	Photovoltaics
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.
Backfill	Connecting additional gas fields or reserves to an existing domestic gas production facility, instead of building new processing infrastructure (sometimes referred to as a tie-back).
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).
LNG feedstock	Natural gas that enters an LNG production train for removal of impurities and liquefaction.
Potential gas supply	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 gaps.
Probability of Exceedance	Probability of Exceedance (POE) is the likelihood that a forecast will be met or exceeded. For example, a 50% POE forecast is statistically expected to be met or exceeded once in every two years.
Producer Price Index	A Producer Price Index measures the change in prices received by domestic producers for the sale of goods and services, it is a measure of inflation based on input costs to producers. A Producer Price Index measures change from the prospective of a seller, in contrast with a Consumer Price Index, which measures price change from a buyer's perspective.
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.
Short Run Marginal Cost	The Short Run Marginal Cost is a concept in economics which refers to the incremental cost of producing each additional unit of output.
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.