GAS STATEMENT OF OPPORTUNITIES

ATTACHMENT A: DETAILED SUPPLY ADEQUACY RESULTS

FOR EASTERN AND SOUTH-EASTERN AUSTRALIA

Published: **April 2015**

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about the natural gas industry in eastern and south-eastern Australia, in accordance with the National Gas Law and Part 15D of the National Gas Rules.

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CHAPTER 1. MODELLING OVERVIEW

This chapter provides a brief overview of the gas market modelling used for the 2015 GSOO. More detailed information is available in the GSOO Methodology document, which is available on the AEMO website[1].

1.1 GSOO Modelling Approach

The GSOO gas supply adequacy assessment aims to:

- Determine the adequacy of gas market infrastructure by highlighting the timing and magnitude of any potential supply gaps, and identifying possible infrastructure upgrades to address these gaps.
- Determine adequacy of reserves and indicate a reserve production profile over a 20-year outlook period.

1.1.1 Gas Infrastructure Adequacy

The GSOO supply and demand model (GSOO model) simulates gas market supply by assessing:

- Capability of gas pipelines to deliver gas to demand centres.
- Capacity of gas processing facilities to supply sufficient gas into the pipelines.
- Capacity of gas storage facilities to store gas at times of low gas demand, and release gas at times of high gas demand.
- Availability of reserves to maintain gas supply.

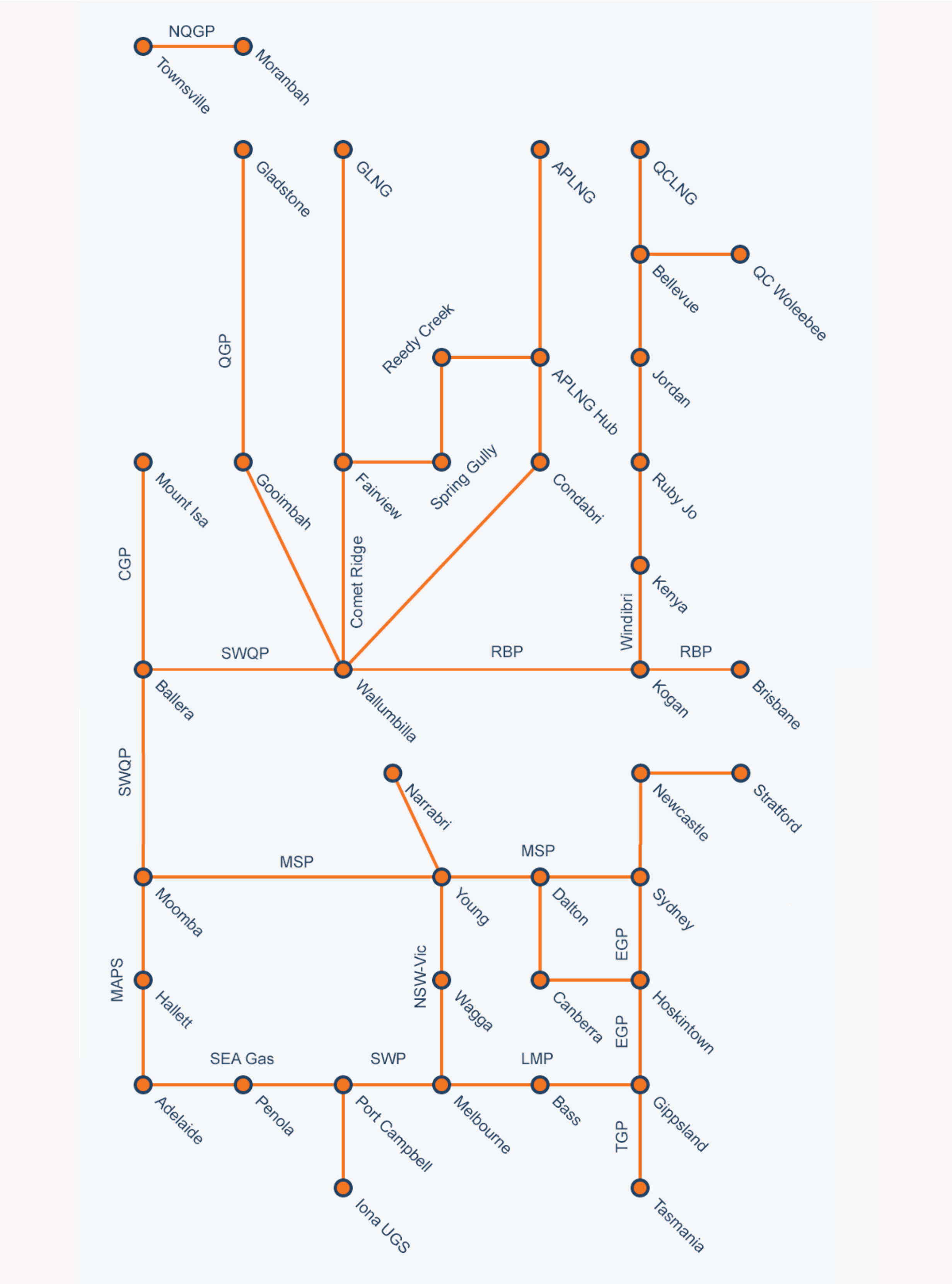
When any of these elements is insufficient to meet demand, the gas model assumes a supply gap, so it substitutes the indicated forecast production with a supply gap of the same amount.

The model also assesses the adequacy of gas market infrastructure upgrades to address potential supply gaps.

Figure 1 shows production centres, demand centres, and pipelines in the GSOO model.

[1] http://www.aemo.com.au/Gas/Planning/Gas-Statement-of-Opportunities.

Figure 1 Production centres, demand centres, and pipelines in 2015 GSOO model



1.1.2 Gas Reserve Adequacy

As existing gas reserves are consumed, new reserves and resources must be developed to maintain an adequate gas supply. The GSOO model develops a reserve production profile based on a least-cost approach: gas from reserves with the lowest production costs is consumed first subject to infrastructure capacity constraints, then more expensive reserves are tapped until all are fully consumed. The model will then develop new reserves and resources, again sourcing the lowest-cost production option first.

1.1.3 GSOO Modelling Data

AEMO sourced data for the 2015 GSOO model in late 2014, including from:

- Gas industry participants, data relating to the capacity of current, committed, and proposed gas market facilities.
- External consultants, data relating to gas facility and production costs, and gas reserves and resources.

In the GSOO model, reserves and resources are categorised according to the internationally-recognised Petroleum Resources Management System:

- Proven and probable (2P) reserves.
- Proven, probable, and possible reserves and contingent resources (2C/3P).
- Prospective resources.

The categories assigned to reserves and resources reflect their commercial development potential.

1.2 Scenarios

After consulting with participants, industry groups, and academics, AEMO develops three gas forecast scenarios – high, medium and low. This report focuses on the medium term scenario as the one most likely to occur.

The scenarios represent high, medium and low gas consumption from a centralised source to reflect the impacts of local energy generation and energy efficiency. They also reflect differing economic and policy assumptions affecting:

- Residential and commercial consumption.
- Large industrial consumption (AEMO seeks guidance directly from large industrial customers about future consumption patterns).
- The magnitude of energy efficiency savings.
- Use of gas powered generation (GPG) in the National Electricity Market (NEM).

AEMO reviews GSOO scenarios every two years to make sure they remain appropriate in light of changed policy, regulatory or economic factors. AEMO last reviewed these scenarios in January 2014. Full scenario details are available in AEMO's 2014 Scenario Descriptions[2].

Table 1 shows how forecast drivers apply in each scenario.

[2] Available at: http://www.aemo.com.au/Electricity/Planning/~/media/Files/Other/forecasting/2014_Planning_and_Forecasting_Scenarios.ashx. Viewed: 1 December 2014

Table 1 Drivers and their expected activity in each planning scenario

Driver	High scenario	Medium scenario	Low scenario
Economic activity and population growth	Higher level of economic activity than reported by the Reserve Bank of Australia (RBA), strong population growth.	Continues consistent with RBA economic activity and historical population growth reported by the Australian Bureau of Statistics.	Lower level of economic activity than reported by the RBA, slow population growth.
Domestic gas production and global LNG	Higher than current market expectations.	Continues according to current market expectations.	Lower than current market expectations.
Energy-intensive industrial sectors	Increased consumption levels.	Continues at current energy consumption levels.	Decreased consumption levels.
Research and development	Slow growth.	Slow to moderate growth.	Moderate to rapid growth in research and development.
Distributed generation	Reduced uptake of distributed generation options.	Moderate penetration of distributed generation.	Strong uptake of distributed generation.
Demand-side response	Weak demand-side response.	Continues at current levels.	Strong demand-side response.
Carbon	Meet the 5% target by 2020 and implement the Direct Action policy reverse auction component only from 2020.	Meet the 5% target by 2020 and implement the Direct Action policy safeguarding emissions from 2020.	Meet the 5% target by 2020 and implement the Direct Action policy safeguarding emissions with high strength from 2020.
GreenPower	Falling sales.	Sales continue at flat rate.	Rising sales.

1.3 Sensitivity Studies

AEMO ran sensitivity studies to assess how upgrades to gas market infrastructure propose addressing potential supply gaps. Other sensitivity studies assessed whether key projects, proposed but not yet committed, could address supply gaps.

AEMO also revised production cost assumptions on advice from participants. As most cost revisions were up, AEMO ran a sensitivity study to the base analysis modelling to examine the effect on gas supply adequacy of higher gas production costs across all facilities.

In all, AEMO considered the following as sensitivities:

- Additional process capacity, delivering 100 TJ per day in the Surat Basin.
- Upgrade of the South West Queensland Pipeline (SWQP) by 60 TJ per day.
- A gas production project located in the Gloucester Basin with transmission to Newcastle, capable of delivering 80 TJ per day, similar to a proposal being considered by AGL.
- A gas production project in the Gunnedah Basin, with transmission to the Moomba–Sydney Pipeline (MSP), able to deliver 100 TJ per day, similar to a proposal being considered by Santos.
- A pipeline between Alice Springs and Moomba to deliver gas to the existing eastern and south-eastern gas network. The amount of gas to be delivered is only limited by the existing infrastructure capacity.
- Increased production and transmission costs.

All sensitivity studies are based on the medium scenario.

CHAPTER 2. MEDIUM SCENARIO AND SENSITIVITIES

This chapter provides results from the market modelling used for the 2015 GSOO.

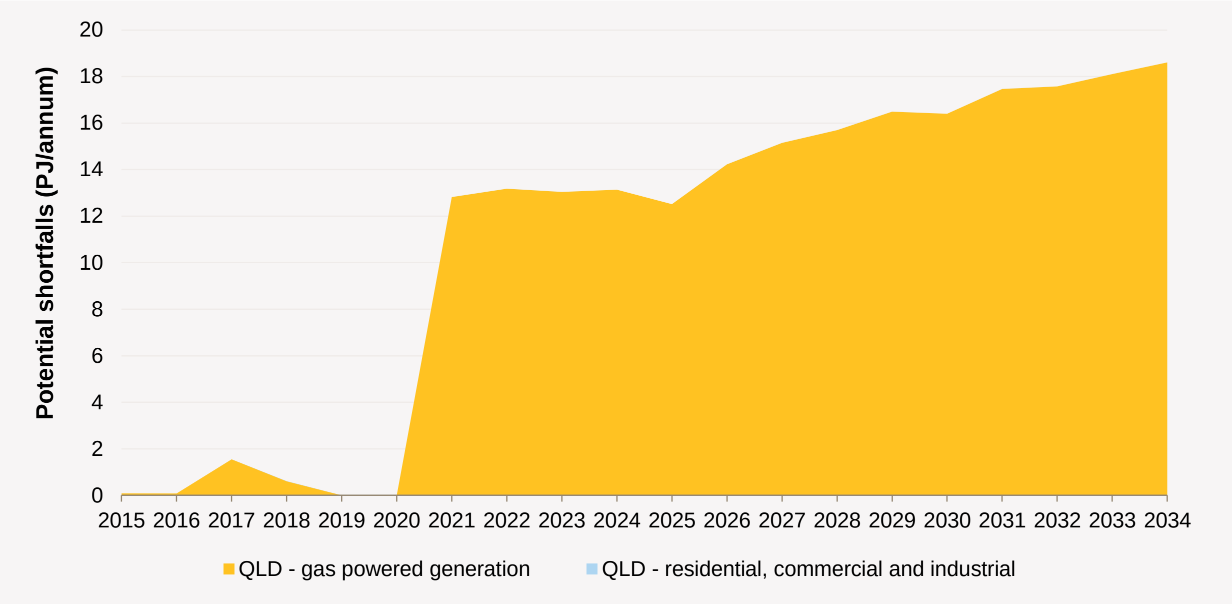
2.1 Medium Scenario

GSOO results reflect the medium scenario, so only existing gas infrastructure and committed projects were included in the model. All sensitivities to this medium scenario (sections 2.2 to 2.6) and the high and low scenarios in Chapter 3 are compared with the results in this medium scenario.

2.1.1 Supply gaps

Projected supply gaps for the medium scenario are shown in Figure 2.

Figure 2 Projected supply gaps, medium scenario



In the medium scenario, all supply gaps are forecast to occur in Queensland.

Forecast supply gaps are shown in 0. As the table shows, most forecast gas supply gaps occur at the Darling Downs Power Station, which is connected to the gas network east of Wallumbilla. The production facility capacity at, and east of, Wallumbilla is 3,840 TJ per day, and the SWQP's capacity to supply gas to Wallumbilla is 340 TJ per day, however the maximum demand for gas east of Wallumbilla is 4,347 TJ per day. This mismatch between supply and demand is a primary cause for supply gaps. Local pipeline constraints may also limit the ability for all production facilities to be 100% utilised at all times of high demand. Note that while gas storage facilities (which ameliorate supply gaps) exist at Wallumbilla, they are not large enough to prevent all supply gaps.

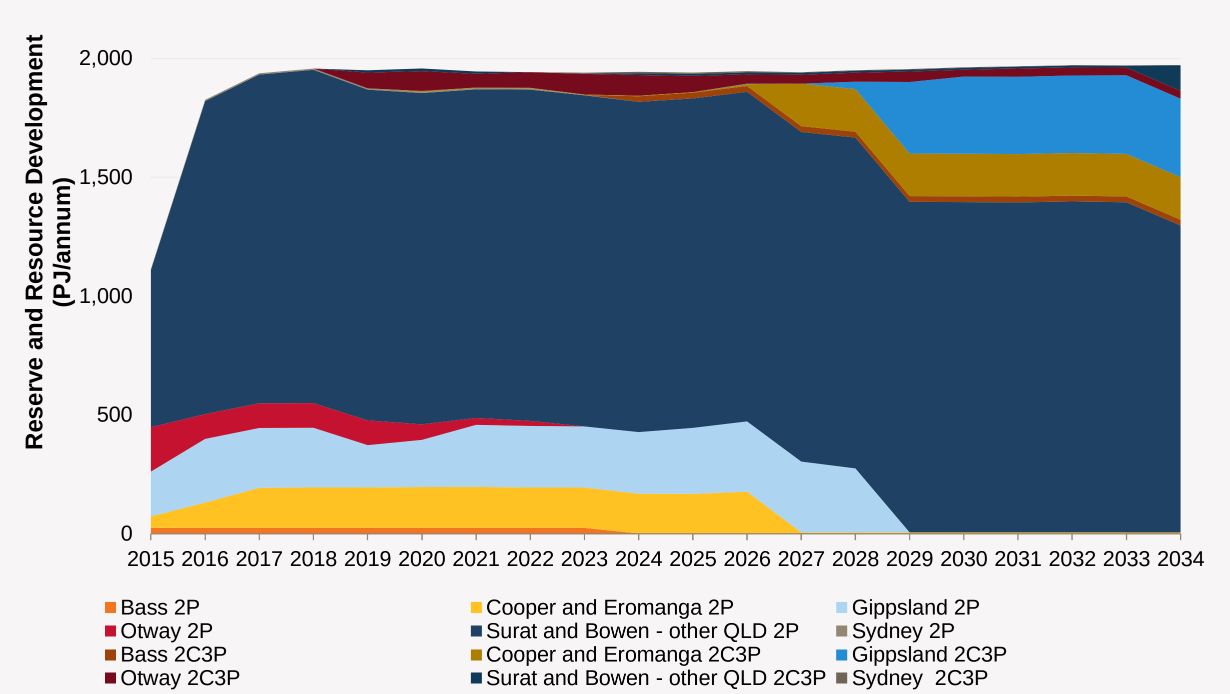
Table 2 Forecast supply gaps for the medium scenario

Location	Region	Type of demand	Timing of supply gaps	Number of supply gaps per year	Maximum supply gap for each year	Average supply gap for each year
Darling Downs	QLD	GPG	2017–34	42–365	31–106 TJ per day	14–51 TJ per day
Gladstone	QLD	Industrial, and residential and commercial	2017–34	1–5	1–3 TJ per day	1–2 TJ per day
Roma	QLD	GPG	2021–23	69–116	3–7 TJ per day	1 TJ per day
Townsville	QLD	GPG	2015–34	1–65	1–14 TJ per day	1–9 TJ per day

2.1.2 Reserve Development

The status of reserves in the medium scenario, over the 20-year study period, is shown in Figure 3.

Figure 3 Medium scenario reserve consumption and reserve and resource development



Production costs in southern offshore conventional basins (Bass, Otway and Gippsland) are among the lowest, due to their geology and accompanying production of liquids. The model will consume these low-cost reserves first before attempting to access higher-cost supply.

As Figure 3 shows, consumption of southern offshore conventional basins begins in 2022, and existing proven and probable reserves from these basins are fully consumed by 2028. To compensate for this consumption, new resources and reserves are being developed. Again, the reserves and resources with the lowest production costs are developed first after taking into account gas infrastructure capability and constraints. Fields with probable reserves and contingent resources within a basin may be developed before the entire proven and probable reserves within the field are consumed.

Table 3 shows consumption dates for existing reserves and dates for new reserves being developed.

Table 3 Reserve and resource consumption and development dates

	Date consumed	Date developed
Proven and Probable Reserves		
Bass	2024	-
Cooper and Eromanga	Not fully consumed	-
Gippsland	2028	-
Otway	2022	-
Surat and Bowen	Not fully consumed	-
Sydney	2023	-
Probable Reserves and Contingent Resources		
Bass	-	2024
Cooper and Eromanga	-	2020
Gippsland	-	2026
Otway	-	2019
Surat and Bowen	-	2019
Sydney	-	2023

2.2 Increased Production Capacity in South Queensland

To address forecast supply gaps, a new production facility with the capacity to supply 100 TJ of additional gas per day was added in 2018 in the Wallumbilla area, extracting gas from the Surat Basin.

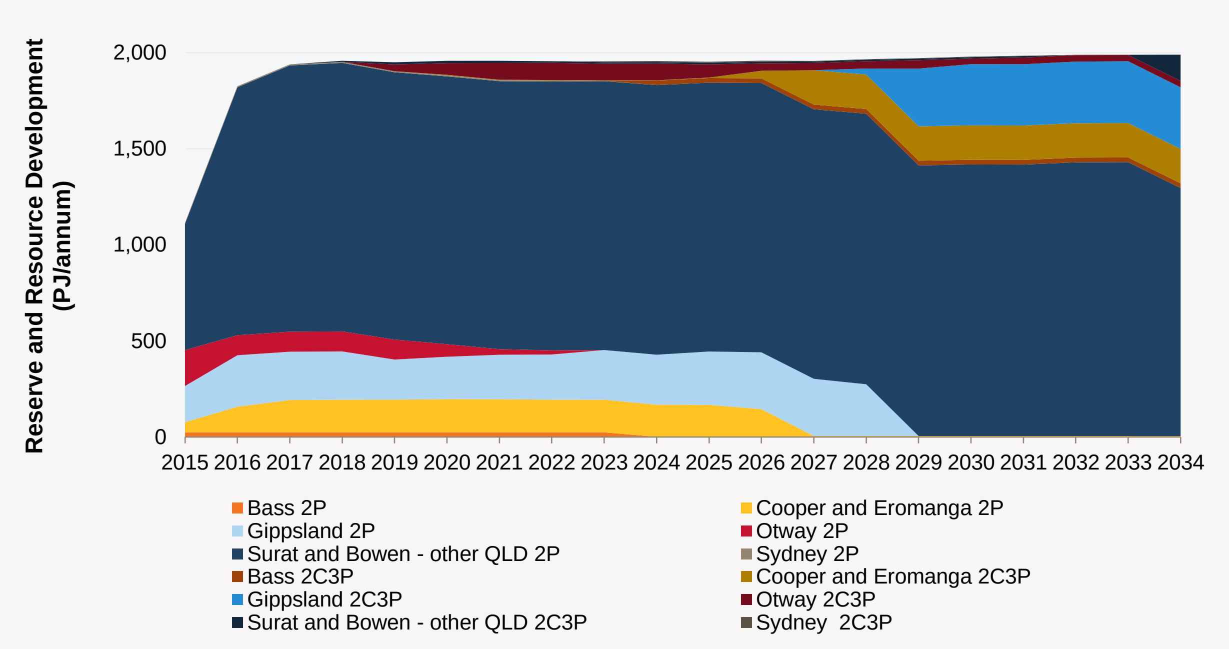
2.2.1 Supply Gaps

The addition of 100 TJ per day of production capacity in the Surat Basin eliminates more than 99% of the supply gaps forecast under the medium scenario.

2.2.2 Reserve Development

Increasing the production capability near Wallumbilla causes more gas to be extracted from the Surat and Bowen reserves, as shown in Figure 4. However, even with the extra production capability, these reserves are still not forecast to be fully consumed over the 20-year GSOO study timeline.

Figure 4 Medium scenario, additional production capacity in Surat Basin, reserve consumption and reserve and resource development



2.3 Increased Capacity of South West Queensland Pipeline

The SWQP's capacity in the direction from Moomba towards Wallumbilla was increased by 60 TJ per day to address forecast supply gaps.

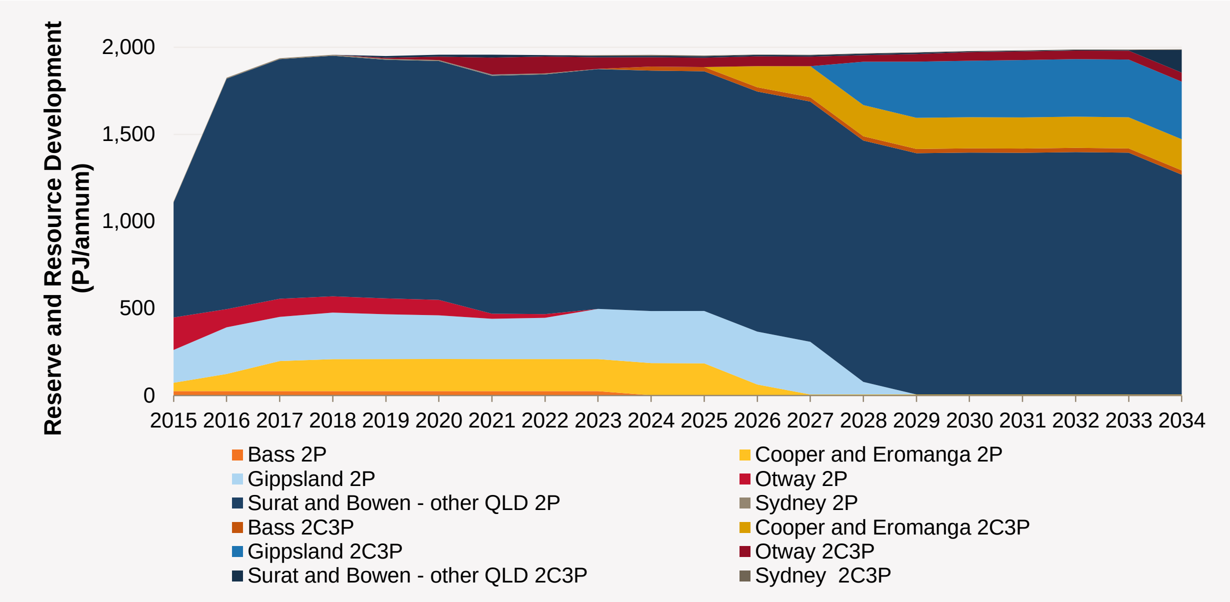
2.3.1 Supply Gaps

The addition of 60 TJ per day of SWQP capacity eliminates more than 95% of the supply gaps forecast under the medium scenario.

2.3.2 Reserve Development

An extra 60 TJ per day capacity on the SWQP results in higher extraction from reserves in the southern offshore conventional basins, as shown in Figure 5. The Gippsland 2P reserves are consumed by 2026, rather than 2028, in the medium scenario.

Figure 5 Medium scenario, additional SWQP capacity, reserve consumption and reserve and resource development



2.4 Gloucester and Narrabri

This sensitivity study examines the effect of Narrabri and Gloucester production facilities on forecast New South Wales shortfalls, with all other modelling data kept the same as the medium scenario. These projects are not committed at the time of writing.

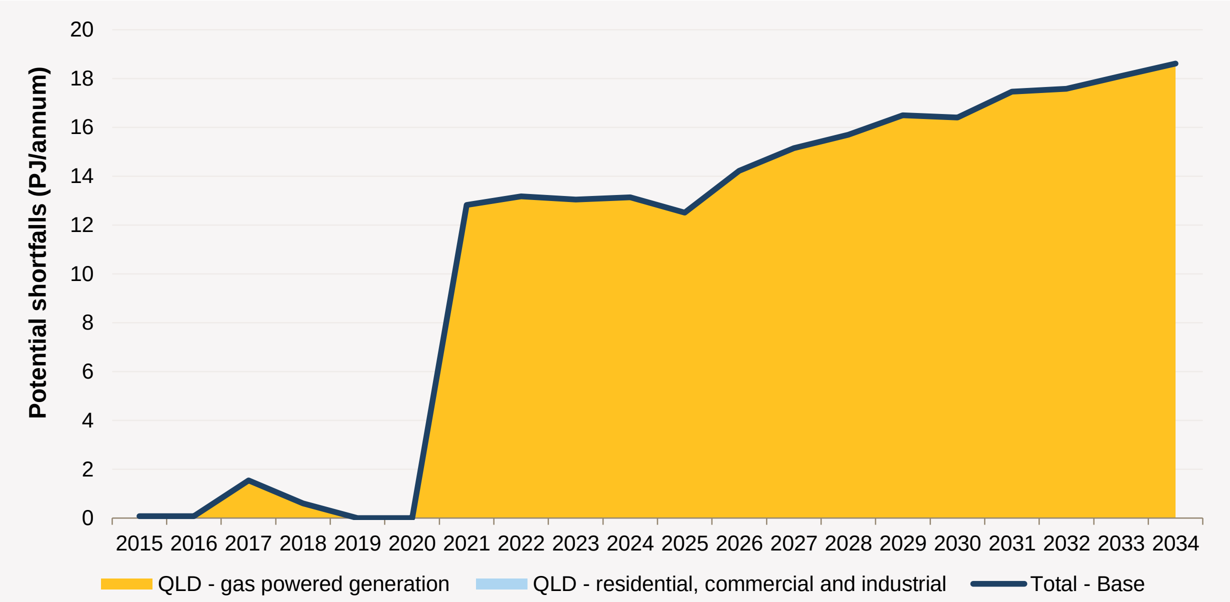
2.4.1 Supply Gaps

Figure 6 shows the supply gaps with the addition of the Narrabri and Gloucester production facilities.

As the medium scenario forecast no supply gaps for New South Wales, there is no impact on the New South Wales forecast.

The additional production did not impact forecast supply gaps in Queensland due to limitations on the SWQP. To further relieve forecast gaps in Queensland, the SWQP capacity would also need to be upgraded by 60 TJ per day.

Figure 6 Projected supply gaps, medium scenario, with Narrabri and Gloucester production facilities

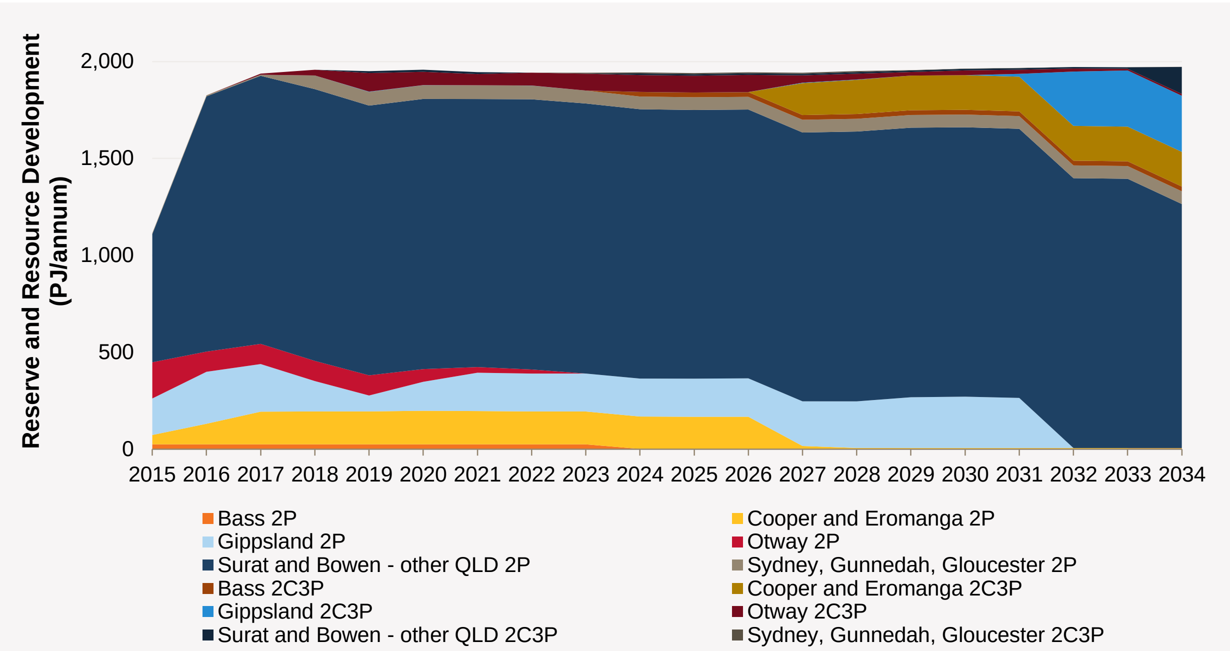


2.4.2 Reserve Development

Because the gas supplied from the Narrabri and Gloucester production facilities is relatively low cost, it is extracted in preference to gas from the Gippsland basin, as shown in Figure 7. This will potentially delay extractions from the Gippsland basin, altering the forecast consumption date to 2031, compared to 2028 in the medium scenario.

The extra gas production also delays development of Gippsland 2C/3P until 2031.

Figure 7 Medium scenario, with Narrabri and Gloucester production facilities, reserve consumption and reserve and resource development



2.5 Northern Territory gas pipeline

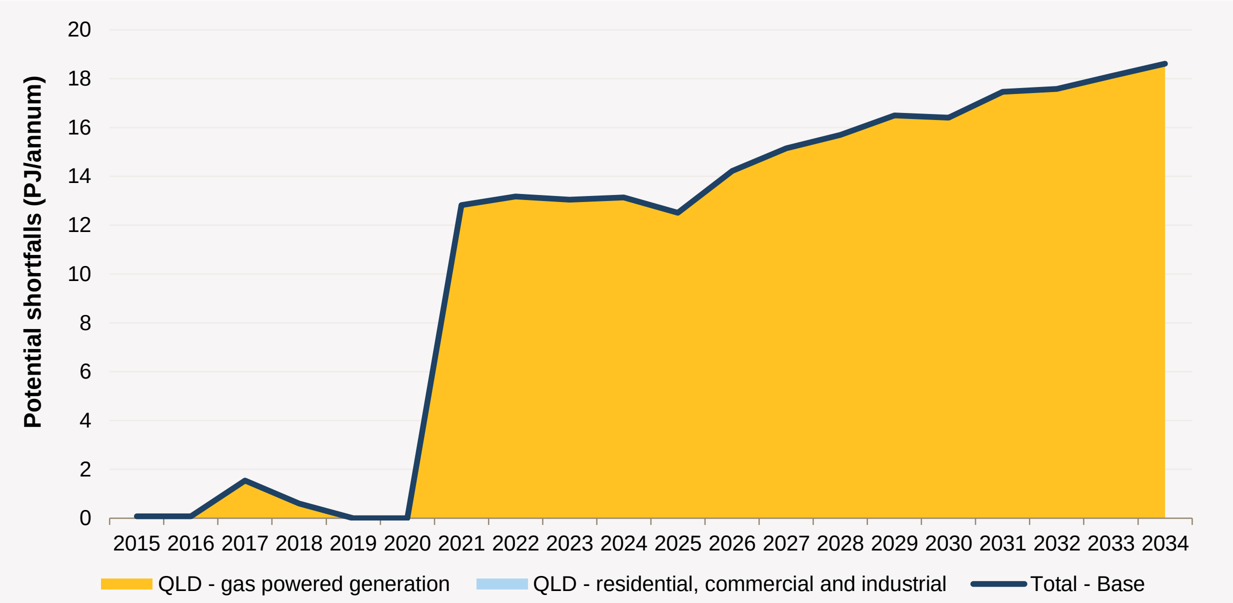
To explore the impact of a gas supply from the Northern Territory, AEMO modelled a pipeline between Alice Springs and Moomba, delivering gas to the existing eastern and south-eastern gas network. The amount of gas to be delivered is only limited by the existing infrastructure capacity.

2.5.1 Supply Gaps

As Figure 8 shows, addition of a gas supply from the Northern Territory does not have any impact on forecast supply gaps due to limitations on the SWQP.

To further relieve forecast supply gaps, the SWQP's capacity would also need to be upgraded.

Figure 8 Projected supply gaps, medium scenario, with gas supply from Northern Territory



2.5.2 Reserve Developments

There is no change to the timing of reserve developments.

2.6 Higher Production Costs

In compiling the GSOO, AEMO used comprehensive data from gas industry participants related to pipelines, production facilities, storage facilities, gas reserves, and production costs.

AEMO also revised production costs following advice from participants on gas production cost assumptions. As most of the revisions made to production costs were upward, AEMO also ran a sensitivity study on the base analysis modelling to examine the effect of higher gas production costs on gas supply adequacy across all facilities. The study found no effect on supply adequacy.

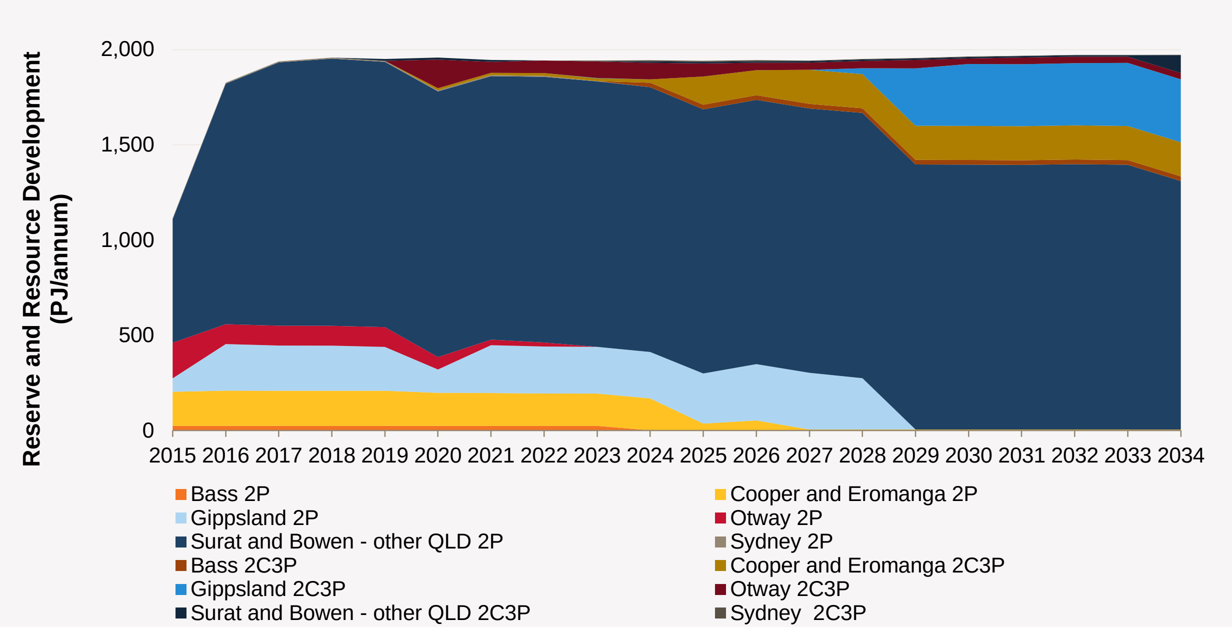
2.6.1 Supply Gaps

The increase in supply costs causes no change in forecast supply gaps from the medium scenario. The GSOO model will always balance supply with demand if the gas market is physically able, so forecast supply gaps are not sensitive to production costs. A different modelling approach, such as one using a partial equilibrium economic model, may provide more information on the impact of increased costs.

2.6.2 Reserve Developments

There is a slight change in the consumption and development timeframe of the Otway basin resources and reserves, as shown in Figure 9. With higher production costs, the current 2P reserves in these basins are forecast to be consumed three years earlier in 2019, followed by development of contingent reserves by the end of 2019.

Figure 9 Medium scenario, with higher production costs, reserve consumption and reserve and resource development



CHAPTER 3. SCENARIO ANALYSIS

3.1 Low Scenario

Overall, low consumption forecasts are 240 PJ per year lower than the medium scenario by 2034. The key drivers for this are:

- Higher gas prices, fewer new customers (due to lower population growth), and more federal energy efficiency savings.
- A reduced production forecast due to less favourable economic conditions, lower gross domestic product (GDP) growth, lower commodity prices, higher gas prices, and higher exchange rates.
- Higher gas prices and slower growth in electricity consumption, resulting in lower use of GPG in the NEM, and therefore faster decline in GPG gas consumption.
- Gas required for LNG export being about 10% lower than the medium scenario.

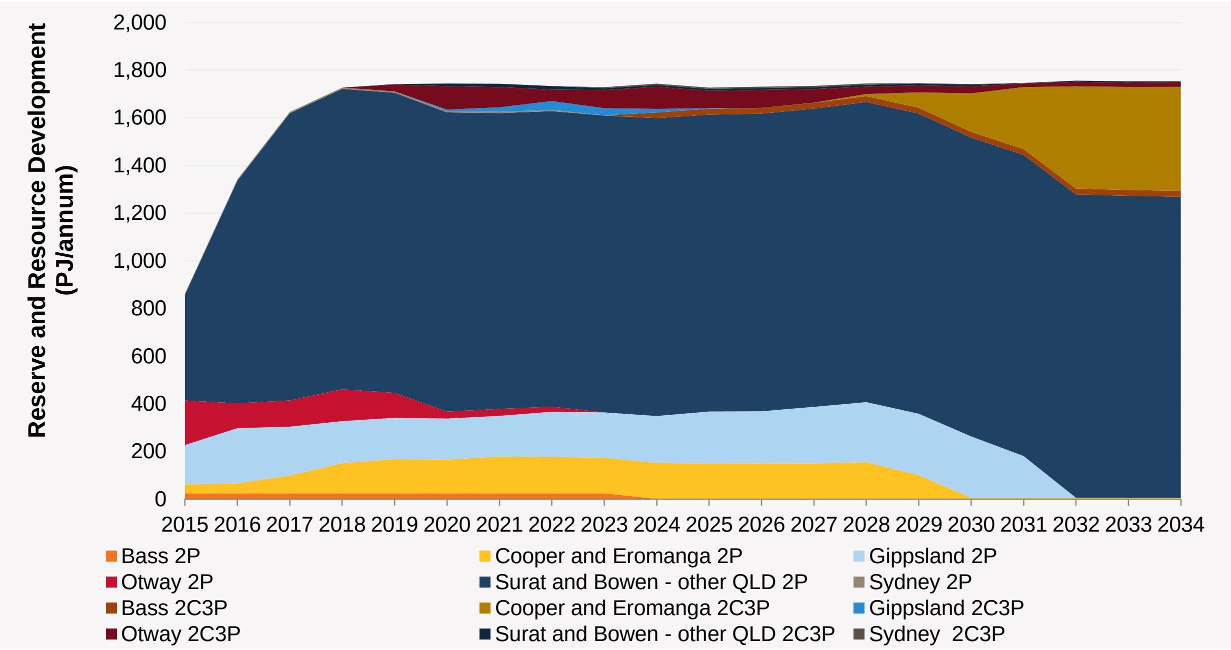
3.1.1 Supply Gaps

No supply gaps are forecast in the low scenario.

3.1.2 Reserve Development

The status of reserves in the low scenario, over the 20-year study period, is shown in Figure 10.

Figure 10 Low scenario reserve consumption and reserve and resource development



As in the medium scenario, the lower-cost southern offshore conventional basins (Bass, Otway and Gippsland) are consumed first, however, due to lower consumption forecasts, reserves, (such as in the Gippsland basin) are fully consumed later than in the medium scenario.

Table 4 shows the dates at which existing reserves are fully consumed, and new reserves and resources are developed, in the low scenario.

Table 4 Reserve development for the low scenario

	Date Consumed	Date Developed
Proven and Probable Reserves		
Bass	2024	-
Cooper and Eromanga	Not fully consumed	-
Gippsland	2031	-
Otway	2019	-
Surat and Bowen	Not fully consumed	-
Sydney	2023	-
Probable Reserves and Contingent Resources		
Bass	-	2024
Cooper and Eromanga	-	2028
Gippsland	-	2031
Otway	-	2019
Surat and Bowen	-	2020
Sydney	-	2023

3.2 High Scenario

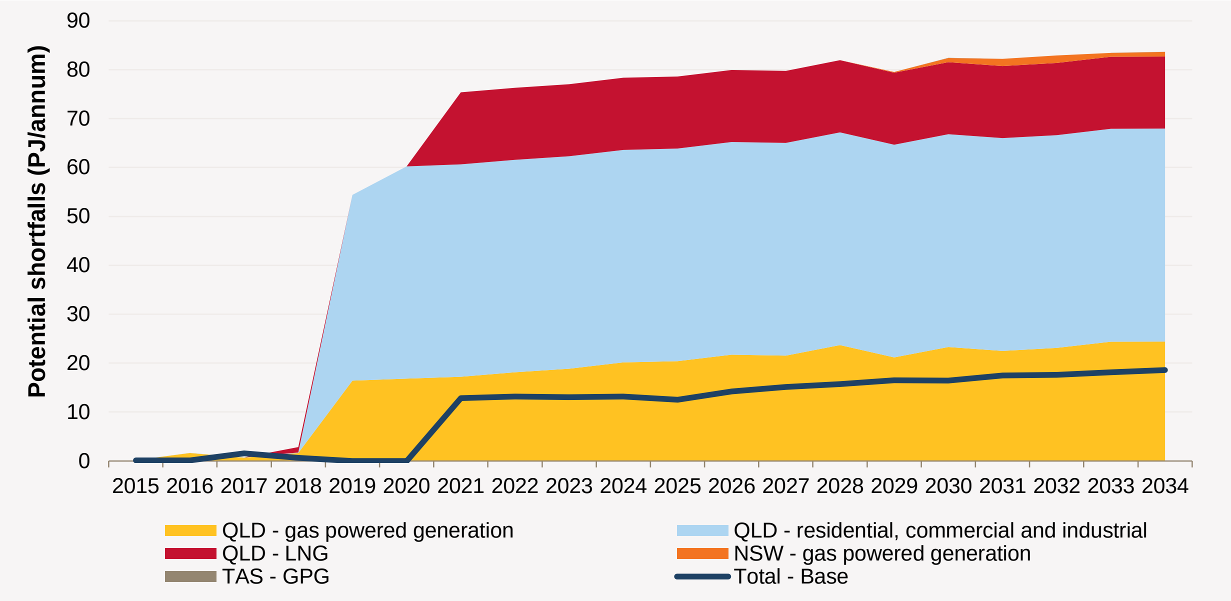
Overall, high consumption forecasts are 477 PJ per year higher by 2034 than in the medium scenario. The key drivers for this are:

- The high demand scenario including an extra LNG train at Gladstone, which increases overall LNG export demand from 1,425 PJ to 1,770 PJ per year.
- Lower gas prices, a higher rate of new connections (due to higher population growth) and no federal energy efficiency savings beyond current programs.
- More optimistic operating forecasts due to favourable economic conditions, higher gross domestic product (GDP) growth, higher commodity prices, lower gas prices, lower exchange rates and modest plant expansion.
- Lower gas prices and faster growth in electricity consumption, resulting in higher use of GPG in the NEM, and therefore slower decline in GPG gas consumption.

3.2.1 Supply Gaps

As shown in Figure 11, total forecast supply gaps are much larger (about 1,025 PJ more) than in the medium scenario.

Figure 11 Projected supply gaps, high scenario



The increased forecast supply gap in Queensland under a high scenario from 2018–34 assumes a seventh LNG train that contributes to forecast annual gas consumption increase of 477 PJ, compared to the medium scenario.

Medium scenario results indicate that gas market capacity is close to meeting the demand of six LNG trains. This means that under the high scenario, major gas network upgrades would be required to provide enough capacity for an extra LNG train.

3.2.2 Reserve Development

The status of reserves in the high scenario, over the 20-year study period, is shown in Figure 12.

Table 5 shows the dates at which existing reserves are fully consumed, and new reserves and resources are developed, in the high scenario.

Figure 12 High scenario reserve consumption and reserve and resource development

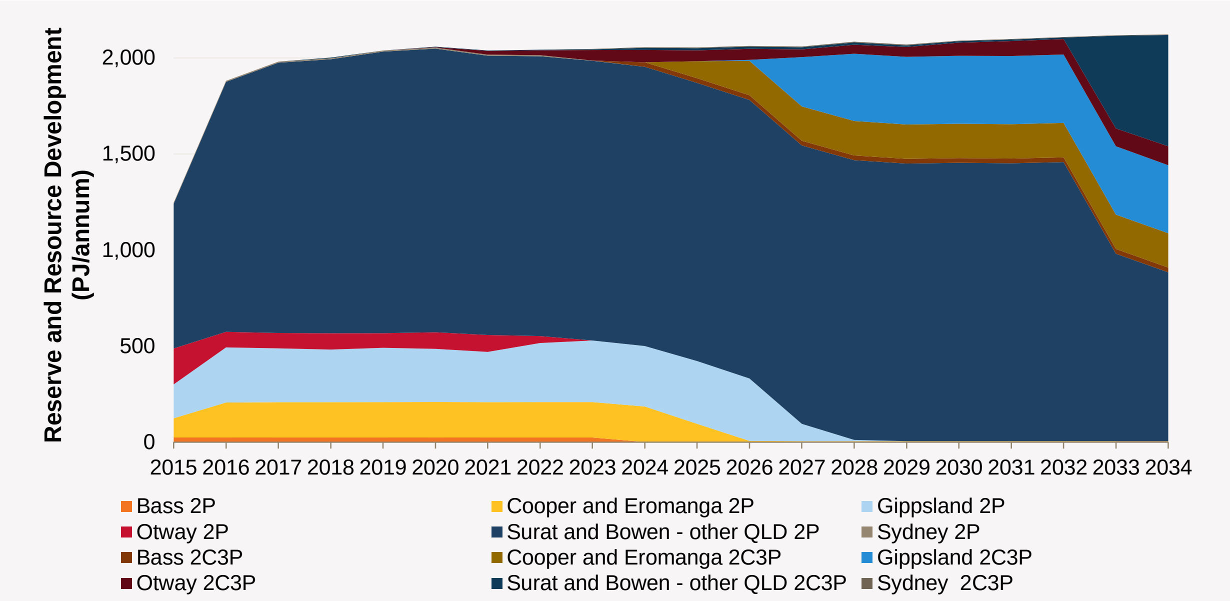


Table 5 Reserve development for the high scenario

	Date Consumed	Date Developed
Proven and Probable Reserves		
Bass	2024	-
Cooper and Eromanga	Not fully consumed	-
Gippsland	2027	-
Otway	2021	-
Surat and Bowen	Not fully consumed	-
Sydney	2023	-
Probable Reserves and Contingent Resources		
Bass	-	2024
Cooper and Eromanga	-	2025
Gippsland	-	2026
Otway	-	2021
Surat and Bowen	-	2020
Sydney	-	2023

MEASURES AND ABBREVIATIONS

Units of measure

Abbreviation	Unit of measure
PJ	Petajoule
TJ	Terajoule

Abbreviations

These terms are used in the 2015 GSOO, Attachment A, Attachment B and/or the GSOO Methodology document.

Abbreviation	Expanded name
AEMO	Australian Energy Market Operator
APLNG	Australia Pacific LNG
CGP	Carpentaria Gas Pipeline
EGP	Eastern Gas Pipeline
GDP	gross domestic product
GLNG	Gladstone LNG
GPG	Gas powered generation
GSOO	Gas Statement of Opportunities
LMP	Longford to Melbourne Pipeline
LNG	Liquefied Natural Gas
MAPS	Moomba to Adelaide Pipeline
MSP	Moomba to Sydney Pipeline
NQGP	North Queensland Gas Pipeline
QCLNG	Queensland Curtis LNG
QGP	Queensland Gas Pipeline
QLD	Queensland
RBA	Reserve Bank of Australia
RBP	Roma to Brisbane Pipeline
SEA Gas	South East Australia Gas Pipeline
SWP	South West Pipeline
SWQP	South West Queensland Pipeline
TGP	Tasmanian Gas Pipeline
WTS	Western Transmission System

GLOSSARY

These terms are used in the 2015 GSOO, Attachment A, Attachment B, and/or the GSOO Methodology document.

Term	Definition
1-in-2 peak day	The 1-in-2 peak day demand projection has a 50% probability of exceedance (POE). This projected level of demand is expected, on average, to be exceeded once in two years. Also known as the 50% peak day.
1-in-20 peak day	The 1-in-20 peak day demand projection (for severe weather conditions) has a 5% probability of exceedance (POE). This is expected, on average, to be exceeded once in 20 years. Also known as the 95% peak day.
1C contingent resources	Low estimate of contingent resources.
2C contingent resources	Best estimate of contingent resources.
3C contingent resources	High estimate of contingent resources.
1P reserves	A low-side estimate of quantities of gas that are reasonably certain to be recoverable in future under existing economic and operating conditions. Also known as proved gas reserves.
2P reserves	The sum of proved-plus-probable estimates of gas reserves. The best estimate of commercially recoverable reserves. Often used as the basis for reports to share markets, gas contracts, and project economic justification.
3P reserves	The sum of proved, probable, and possible estimates of gas reserves.
Gas Bulletin Board (GBB)	A website **(**www.gbb.aemo.com.au**)** managed by AEMO that provides information on major interconnected gas processing facilities, gas transmission pipelines, gas storage facilities, and demand centres in eastern and south-eastern Australia. Also known as the National Gas Market Bulletin Board or simply the Bulletin Board.
gas powered generation (GPG)	Where electricity is generated from gas turbines (combined-cycle gas turbine (CCGT) or open-cycle gas turbine (OCGT)).
lateral	A pipeline branch.
linepack	The pressurised volume of gas stored in the pipeline system. Linepack is essential for gas transportation through the pipeline network each day, and as a buffer for within-day balancing.
liquefied natural gas (LNG)	Disconnection of electricity customer load. Natural gas that has been converted into liquid form for ease of storage or transport.
LNG train	A unit of gas purification and liquefaction facilities found in a liquefied natural gas plant.
peak day	Over the course of a season (winter or summer), the day on which maximum gas demand occurs.
peak shaving	Meeting a demand peak using injections of vaporised liquefied natural gas (LNG).
possible reserves	Estimated quantities that have a chance of being discovered under favourable circumstances. ‘Possible, proved, and probable’ reserves added together make up 3P reserves.
probability of exceedance (POE)	Refers to the probability that a forecast electricity maximum demand figure will be exceeded. For example, a forecast 10% probability of exceedance (POE) maximum demand will, on average, be exceeded only 1 year in every 10.
probable reserves	Estimated quantities of gas that have a reasonable probability of being produced under existing economic and operating conditions. Proved-plus-probable reserves added together make up 2P reserves.
production	In the context of defining gas reserves, gas that has already been recovered and produced.
prospective resources	Gas volumes estimated to be recoverable from a prospective reservoir that has not yet been drilled. These estimates are therefore based on less direct evidence.
proved resources	Estimated quantities of gas that are reasonably certain to be recoverable in future under existing economic and operating conditions. Also known as 1P reserves.
proved-plus-probable	See 2P reserves.
reservoir	In geology, a naturally occurring storage area that traps and holds oil and/or gas.
reserves	Gas resources that are considered to be commercially recoverable and have been approved or justified for commercial development.
resources	See contingent resources and prospective resources.

Term	Definition
shale gas	Gas found in shale layers that cannot be economically produced using conventional oil and gas industry techniques. See unconventional gas.
unconventional gas	Gas found in coal seams, shale layers, or tightly compacted sandstone that cannot be economically produced using conventional oil and gas industry techniques.
within-day balancing	The balancing of supply and demand during the gas day by use of scheduled injections and depletion of system linepack. Liquefied natural gas (LNG) is used as an additional supply if linepack is predicted to fall below the minimum level required for system security.