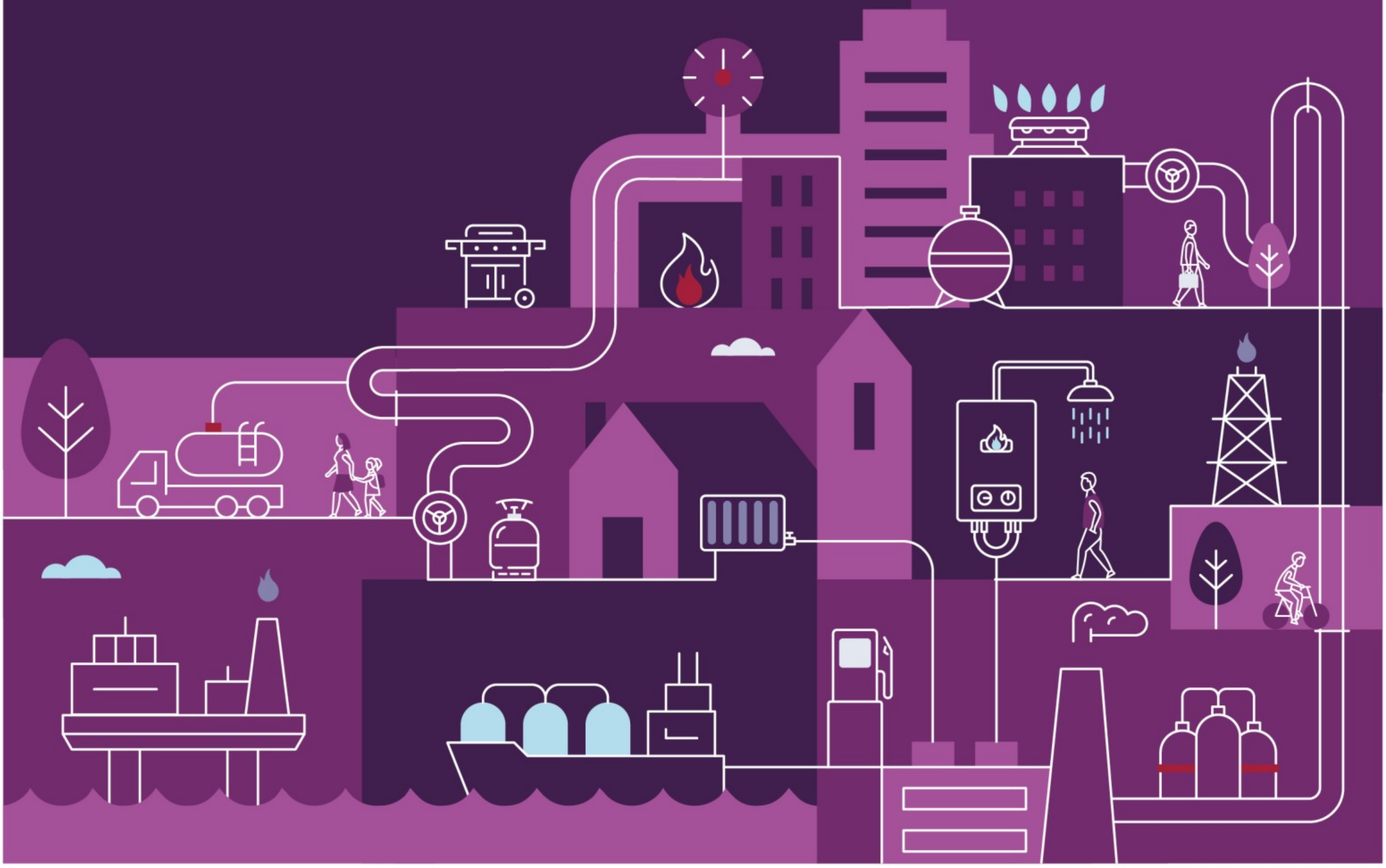
Gas Supply Adequacy Methodology Information Paper

March 2023

For the 2023 Gas Statement of Opportunities for eastern and south-eastern Australia



Important notice

Purpose

AEMO has prepared this document to provide information about the methodology and assumptions used to produce gas supply adequacy forecasts for the 2023 Gas Statement of Opportunities under the National Gas Law and Part 15D of the National Gas Rules.

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1 Introduction

This document describes the methodology and assumptions used to assess supply adequacy for the 2023 *Gas Statement of Opportunities* (GSOO)[1].

The GSOO reports on the adequacy of gas supply to meet maximum daily demand and annual consumption over a 20-year outlook period across the Australian jurisdictions other than Western Australia. The adequacy assessment is performed using a model of gas supply and demand (gas model) that includes representations of:

- Existing, committed, and proposed new and expanded gas processing facilities.
- Existing, committed, and proposed new and expanded gas transmission pipelines.
- Existing, committed, and proposed new and expanded gas storage facilities.
- Gas reserves and resources.
- Gas consumption forecasts for residential, commercial, and industrial customers, gas generation (in previous reports this was referred to as gas-powered generation [GPG]), and liquefied natural gas (LNG) exports.
- Alternative supply options including LNG receipt terminals.

The GSOO model accommodates the provisions of the Australian Domestic Gas Security Mechanism (ADGSM).

The gas model balances daily supply and demand at least cost, by considering daily and annual gas reserve and resource availability, and pipeline and processing infrastructure constraints.

Key outputs of the gas model include daily pipeline flows, gas production, and potential shortfalls.

The analysis is repeated for a range of scenarios and sensitivities, as outlined in the 2023 GSOO, to determine the robustness of outcomes to changes in modelled assumptions. Specific detail on scenarios used in the 2023 GSOO is available in the GSOO report.

1.1 Shared assumptions with other AEMO publications

The GSOO is part of a comprehensive suite of forecasting publications published by AEMO, an overview of which is shown in **Figure 1**.

The GSOO is an integrated component within the forecasting function of AEMO, and coordination across these publications ensures maximum internal consistency and allows robust insights across the energy landscape to be compiled. As an example, the methodologies used in determining the long-term evolution of the National Electricity Market (NEM) provided by AEMO's *Integrated System Plan* (ISP) are applied by the GSOO in forecasting expected gas consumption from gas generation.

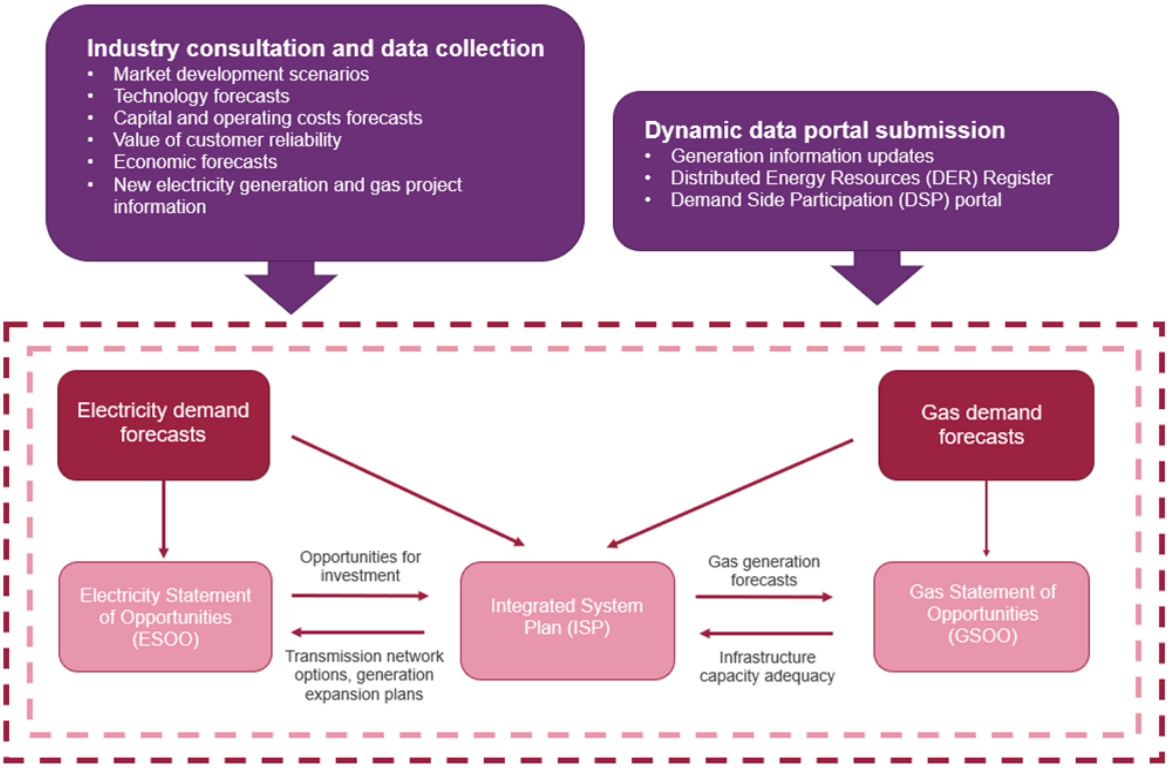
The GSOO also complements the *Victorian Gas Planning Report* (VGPR)[2]. Where appropriate, the GSOO and VGPR may share common assumptions.

[1] At https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo.

[2] At https://www.aemo.com.au/energy-systems/gas/gas-forecasting-and-planning/victorian-gas-planning-report.

AEMO specifically seeks to align inputs and assumptions across its different forecasting and planning documents published. These are available on AEMO's website[3] and provide additional relevant background to GSOO data and modelling assumptions.

Figure 1 AEMO's major long-term forecasting publications



1.2 Supporting material

A suite of resources has been published on the AEMO website to support the content in this methodology document and the 2023 GSOO report and can be found in **Table 1**.

Table 1 Links to other supporting information

Source	Website address
2023 GSOO inputs and information from survey of gas industry participants (for updated processing capacity of each facility used in the GSOO)	https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo
2023 Gas Demand Forecasting Methodology	
Archive of previous GSOO reports	
GSOO Procedures	
National Electricity and Gas Forecasting Portal (AEMO Forecasting Portal)	http://forecasting.aemo.com.au
Gas Bulletin Board (GBB)	https://www.aemo.com.au/energy-systems/gas/gas-bulletin-board-gbb
2022 *Integrated System Plan*	https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

[3] At http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Inputs-Assumptions-and-Methodologies.

2 Gas model

2.1 Model description

The GSOO model is an energy supply model that simulates daily gas supply and demand balances over the 20-year timeframe. The model uses linear programming techniques to calculate the least-cost gas supply to demand centres, subject to different infrastructure and operational constraints:

- The direction and capacity of the pipeline network to deliver gas to demand centres.
- The capacity of gas processing facilities to deliver sufficient gas into the pipeline network.
- The capacity and availability of storage facilities to store excess gas for later injection into the pipeline network.
- The availability of reserves and resources to maintain processing throughput.
- Annual or daily production limitations from each field or group of fields and LNG import terminals.

The model computes energy balances at all levels of a gas system from reservoirs, basins or terminals to the demand centres, in each gas network node and time period, and supplies energy services at minimum total system cost. Outputs consist of gas production (usually in terajoules a day [TJ/d]), pipeline flows (usually in TJ/d), and potential shortfalls (usually in petajoules [PJ]), among other things.

The linear programming formulation for the model is given by:

For each day and year,

Minimize: NPV $\left(\sum_{supply\ options} operation\ cost + \sum_{pipelines} operation\ cost + \sum_{processing\ units} operation\ cost + \sum_{storage\ facilities} operation\ cost + \sum_{demand\ centers} shortfall\ penalty \right)$

Subject to:

- Energy system balance
- Supply/demand balance at each node
- Pipeline capacity constraints
- Production/supply capacity constraints
- Gas storage capacity constraints

The gas model does not explicitly model pipeline pressure constraints, pipeline gas transportation agreements, or intra-day flows.

The gas model does not calculate the optimum pipeline or field expansion projects to ensure all gas shortfalls are eliminated; instead, the GSOO studies the adequacy of existing, committed, anticipated and uncertain projects to meet the future gas needs of consumers, as specified by the scenarios and sensitivities under analysis, and informed by participant surveys and data submissions.

2.2 Data sources

AEMO uses a variety of sources to prepare the inputs to the gas model, as shown in **Table 2**.

Table 2 Key inputs and the related data sources for the gas model

Input	Source
Demand projections	AEMO Forecasting Portal, at http://forecasting.aemo.com.au.
Capacity of reserves and resources	Gas industry participants, and publicly available data (in case of lack of data, Rystad Energy estimates), available at https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo)
Production costs	Rystad Energy and publicly available data Rystad Energy data available at https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo
Transmission costs	Gas industry participants and publicly available data
Pipeline, processing, storage facility capabilities and daily rates	Gas industry participants Gas Bulletin Board (GBB), and publicly available data GBB available at: http://gbb.aemo.com.au/
Annual and daily field production limits	Gas industry participants, and internal AEMO analysis

2.2.1 Gas industry participants survey

AEMO surveys gas industry participants to obtain detailed gas information including:

- Processing facility capacities, and potential or committed future expansions.
- Pipeline capacities, and potential or committed future expansions.
- LNG facility capacities, and potential or committed future expansions.
- Gas project developments (including reserves).
- Storage facility capacities and potential or committed future developments.

For the 2023 GSOO, this information is up to date as of December 2022, although AEMO endeavours to incorporate more up-to-date information (where practical and material) to the analysis.

Collated results from the survey of gas industry participants are available on AEMO's website[4].

Annual and maximum daily field production forecasts are also obtained from gas industry participants for use in the gas supply adequacy modelling, but are confidential in nature, and are not published unless suitably aggregated to de-identify participant information.

An example GSOO survey can be found on AEMO's website[5].

2.3 Model implementation

2.3.1 Gas network

Capacities from existing transmission and processing infrastructure, as well as publicly announced infrastructure augmentations, are used to determine total gas network capacity to facilitate supply.

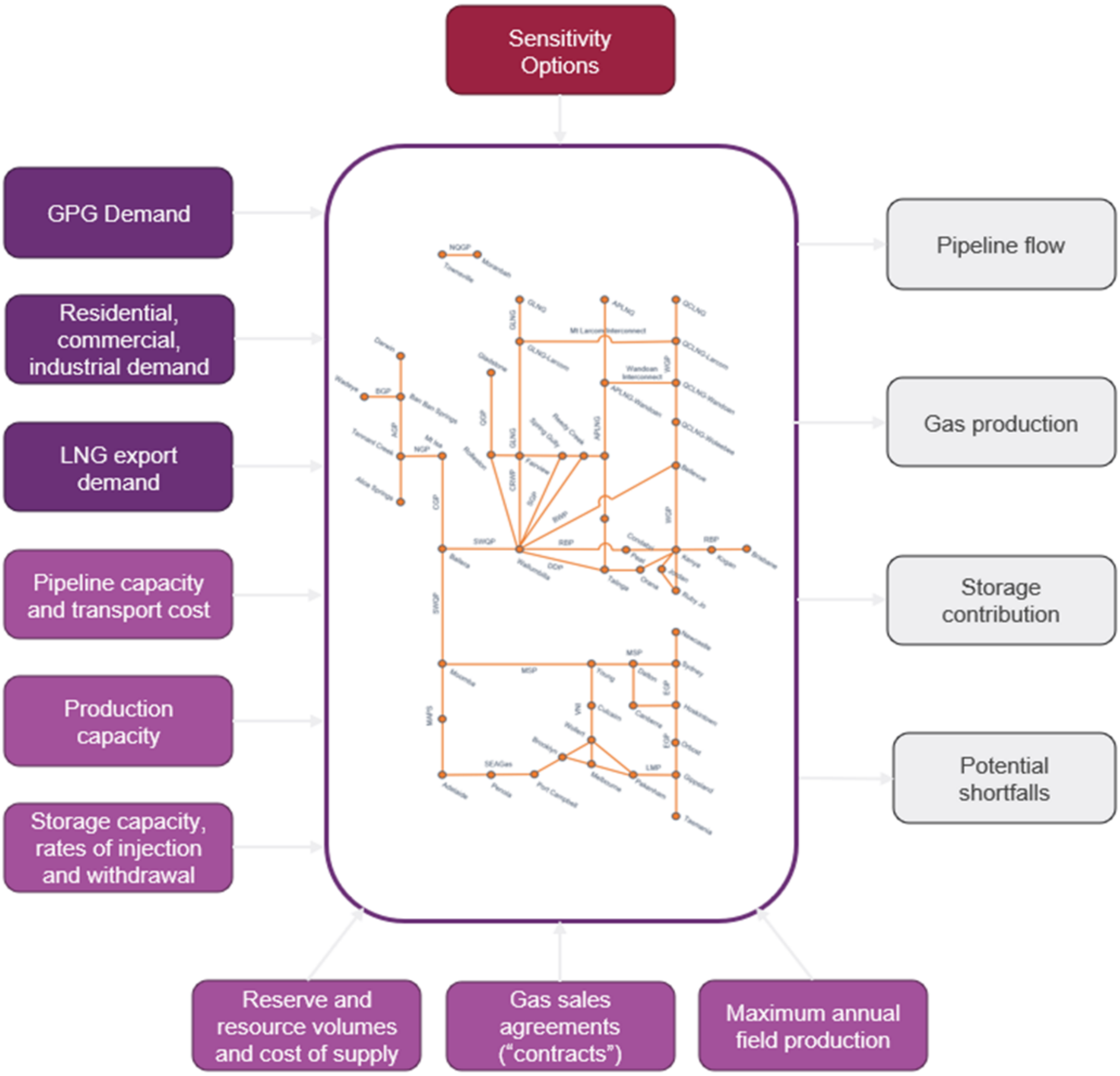
[4] See 2023 Gas Processing, Transmission, and Storage Facilities in 2023 GSOO supply input data files, at https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo.

[5] See https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo.

Infrastructure augmentations may be treated as either certain to progress and included in the base modelling, or more uncertain and studied as sensitivities.

A representation of the gas model, with its inputs and outputs, is shown in **Figure 2**.

Figure 2 Model inputs and outputs

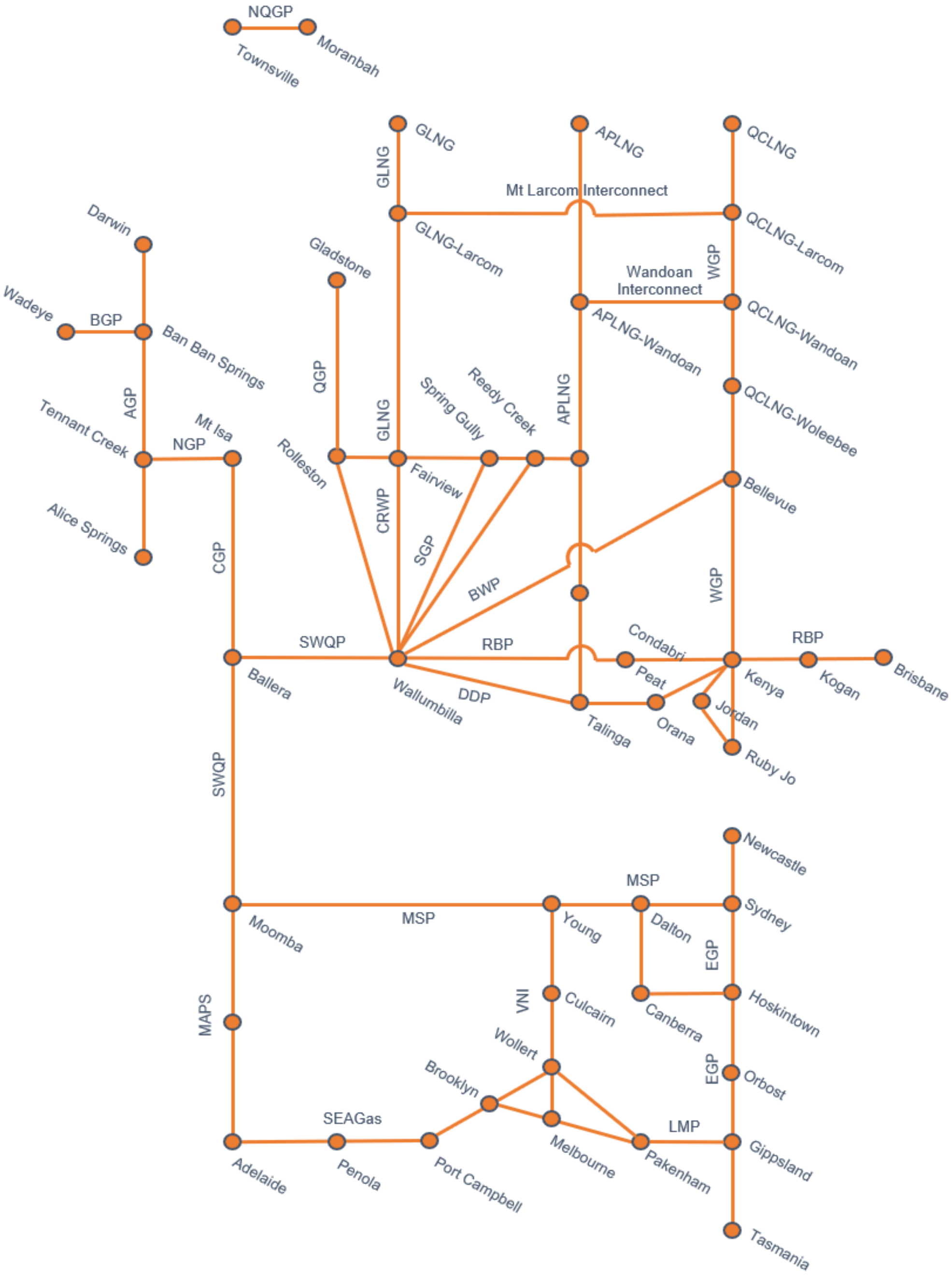


The gas network is represented by a series of connected nodes. At each node, gas may be injected into or withdrawn from the network where production facilities and loads are connected respectively.

Connections between nodes define paths which gas can flow between. Together, nodes and their associated connections define a topology. The topology of the gas model, shown in **Figure 3**, is designed to capture key features of the physical gas network such as pipelines, storages and producing fields. In the 2023 GSOO, the Northern Territory was included in the topology for the first time.

In many cases, a connection (or series of connections) represents an actual pipeline. Pipeline transmission costs are considered in the gas model optimisation to ensure that, where possible, gas flow paths are realistic.

Figure 3 Gas model topology for 2023 GSOO



See the pipeline abbreviations list at the end of this report for full pipeline names.

2.3.2 Gas fields and basins

The gas model represents fields and basins as quantities of gas supply connected at a specific location in the gas model topology, able to be produced by a particular processing facility or facilities.

A modelled field or basin may represent a single field, or an aggregation of fields. The decision as to whether a field is modelled as a specific single field, an aggregation of fields, or at overall basin level is based on the level of information available, whether from publicly available sources, stakeholder surveys or consultant advice. To reduce model complexity, if the level of information is available regarding individual field formations, but the granularity does not impact the modelled solution, the fields may be aggregated to reduce model complexity.

Reserves and resources

In the gas model, reserves and resources are consumed over the GSOO outlook period based on estimates of annual and daily supply availability, assuming 100% conversion to production is possible if required, considering demand levels, maximum available production, and production cost.

Gas supply to consumers relies on continued investment to identify, prove, and then exploit gas reserves and resources. AEMO's production forecasts rely heavily on surveys of producers to determine the available quantities of gas, the plans for extraction, and the capability and capacity of the gas processing plant. When forecasting gas production, uncertainties on both technical and commercial grounds must be considered.

To allow consistent comparison of the supply chain, AEMO applies the following project classifications:

- **Existing and committed** – gas fields and production facilities that are already operating or have obtained all necessary approvals, with implementation ready to commence or already underway.
- **Anticipated** – developers consider the project to be justified on the basis of a reasonable forecast of commercial conditions at the time of reporting, and reasonable expectations that all necessary approvals (such as regulatory approvals) will be obtained and final investment decision (FID) made.
- **Uncertain** – these projects are at earlier stages of development or face challenges in terms of commercial viability or approval.

These classifications are aligned with the Society of Petroleum Engineers – Petroleum Resource Management System (PRMS) project maturity sub-classes[6]. For the 2023 GSOO, the *Development Pending* project maturity sub-class was reassigned to the *Uncertain* category to ensure consistency with the project classifications used in the VGPR. This had little impact on the classification of production projects for the 2023 GSOO.

Under this classification structure, each project represents a specific investment decision, with an associated quantity of recoverable gas reserves and resources, that may be more, or less, certain.

Gas developments are categorised according to the level of technical and commercial uncertainty associated with recoverability. These uncertainties could include securing finance, obtaining government approvals, negotiating contracts, overcoming geological challenges, or the quality/purity of the gas.

The following categories are applied across the industry:

- A gas **reserve** is a quantity of gas expected to be commercially recovered from known accumulations. When estimating the existing, committed, and anticipated gas reserves, the best estimate values are quoted as "proven and probable" (**2P**) reserves. When probabilistic methods are used, there should be at least a 50% probability that the quantities actually recovered will equal or exceed the sum of estimated proved plus probable reserves.
- Gas **resources** are defined as less certain, and potentially less commercially viable sources of gas. When estimating these uncertain resources, the best estimate of contingent resources (**2C**) is used.
- More broadly, there are also **prospective resources**, which are estimated volumes associated with undiscovered accumulations of gas. These resources are highly speculative and have not yet been proven by drilling.

[6] Following stakeholder consultation, these classifications were implemented in the 2020 GSOO.

Further detail about reserve and resource quantities can be found in the Petroleum Resource Management System (PRMS)[7].

Annual field production limits

The gas model satisfies demand by allocating remaining reserves and resources on a least cost basis by considering cost of production together with the cost of transporting the gas to the demand location subject to physical market constraints.

AEMO uses production forecasts provided by industry participants to provide an upper limit for the amount of gas capable of extraction out of each field or group of fields for each year. Where forecasts are unavailable in the long term, AEMO considers that a natural decline in production rate will occur for each category of reserves or resource, based on historical performance, and supplied forecast data.

Production limits are defined for existing, committed, anticipated, and uncertain projects, where they are included in a relevant case.

Gas fields, processing facilities and cost of production

Gas production at processing facilities is determined by the gas model at a daily resolution. At each daily step, a modelled processing facility may supply gas up to its processing capacity. The gas model reflects any seasonality in production capability for the fields and facilities.

Each reserve and resource category of each field has a separate production cost, with the cost becoming more expensive in the order of:

- 2P developed reserves.
- 2P undeveloped reserves.
- 2C resources.
- Prospective resources.

The cost of each tranche of gas at each field is directly related to the geological and economical complexities of that specific field, and as such, the 2C resources at one location may be less expensive than the 2P developed reserves at another location, for example.

This cost is applied to every unit of gas produced by the associated processing facility.

Each processing facility[8] in the gas model may be associated with one or more fields.

2.3.3 LNG import terminals

In modelling LNG import terminals, AEMO optimises operation of these facilities, with all other gas facilities, on a least-cost basis, considering the technical limits of the plant, or shipment limitations, at daily and/or annual granularity.

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[7] See https://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf.

[8] Similar to previous GSOO publications, the Ballera processing facility has not been included in the 2023 GSOO. Gas flowing through the Ballera facility is not incremental to gas processed at the Moomba processing facility. The inclusion of both facilities would result in duplication of processing capacity as gas flowing through Ballera has been captured in the Moomba processing facility.

2.3.4 Storage

The gas model optimises gas storage operation considering the rate and cost of injection into and withdrawal from a storage facility, as well as storage depth. The injection and withdrawal behaviour of each storage facility is optimised to meet local peak demand fluctuations at least cost.

The gas model also aims to replenish annual storage inventory to ensure that storage levels at the beginning of each year are the same by the end of the year and stored gas is available for future years.

2.3.5 Pipelines

The GSOO model considers all major pipelines shown in **Figure 3**. At each daily step, a modelled pipeline may flow up to its daily capacity limitation, which may limit production from upstream facilities. In cases that capacity of pipeline significantly changes across winter and non-winter seasons, such variations are also included in the modelling upon available data from surveys. Flow is optimised by taking into account transport cost – or pipeline tariffs – on each pipeline in the modelled system.

AEMO considers pipeline capacity to be static in most cases; for more complicated pipeline systems, such as the Victorian Declared Transmission System (DTS), this broad assumption leads to inaccurate pipeline flows. To better reflect the dynamic operation of the Victorian DTS and operational issues inherent in sending gas between Melbourne and Port Campbell, the gas model implements a dynamic pipeline capacity for the South West Pipeline (SWP). The dynamic treatment considers:

- The SWP transportation capacity towards Melbourne increases as DTS demand increases.
- The SWP transportation capacity from Melbourne towards Port Campbell is at its maximum on days of low DTS demand and decreases as DTS demand increases.

See the 2023 VGPR[9] for more detailed information on the SWP capacity limitations.

The GSOO model also includes additional constraints in the model which are reflective of operational limitations on maximum pipeline capacities due the relative dynamic interactions between Moomba to Sydney Pipeline (MSP) laterals (Young to Sydney and Young to Culcairn) based on the enhanced data received via surveys.

2.3.6 Distribution and transmission losses

Distribution and transmission losses are reflected in the customer demand by adjusting the demand with the loss amount (see 2023 *Gas Demand Forecasting Methodology Information Paper*[10]). They are therefore not directly included in the supply adequacy model.

2.3.7 Daily demand profile development

The gas model applies daily demand profiles developed from forecasts of all demand sectors within the regions covered by this GSOO.

For more information about the development of the forecasts for each demand sector and the key assumptions used, refer to the Gas Demand Forecasting Methodology Information Paper for the 2023 GSOO[10].

[9] At https://www.aemo.com.au/energy-systems/gas/gas-forecasting-and-planning/victorian-gas-planning-report. See Section 6.

[10] See 2023 Gas Statement of Opportunities Methodology – Demand Forecasting, at https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo.

Abbreviations and glossary

Abbreviations

Abbreviation	Expanded name
ADGSM	Australian Domestic Gas Security Mechanism
AEMO	Australian Energy Market Operator
DTS	Declared Transmission System
FID	Final Investment Decision
GBB	Gas Bulletin Board
GSOO	Gas Statement of Opportunities
ISP	Integrated System Plan
LNG	Liquefied Natural Gas
NEM	National Electricity Market
NPV	Net Present Value
VGPR	Victorian Gas Planning Report

Pipeline abbreviations

Abbreviation	Expanded name
AGP	Amadeus Gas Pipeline
BGP	Bonaparte Gas Pipeline
BWP	Berwyndale Pipeline
CGP	Carpentaria Gas Pipeline
CRWP	Comet Ridge to Wallumbilla Pipeline
DDP	Darling Downs Pipeline
EGP	Eastern Gas Pipeline
LMP	Longford to Melbourne Pipeline
MAPs	Moomba to Adelaide Pipeline System
MSP	Moomba to Sydney Pipeline
NGP	Northern Gas Pipeline
NQGP	Northern Queensland Gas Pipeline
QGP	Queensland Gas Pipeline
RBP	Roma Brisbane pipeline
SEA Gas Pipeline	South Eastern Australia Gas Pipeline
SGP	Spring Gully Pipeline
SWP	South West Pipeline
SWQP	South West Queensland Pipeline
TGP	Tasmania Gas Pipeline
VNI	Victoria Northern Interconnect
WGP	Wallumbilla to Gladstone Pipeline

Glossary

Term	Definition
2C resources	Best estimate of contingent resources – equivalent to 2P, except for one or more contingencies or uncertainties currently impacting the likelihood of development. Can move to 2P classification once the contingencies are resolved.
2P reserves	The sum of proved and 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.
adequacy	Sufficient gas supply to meet demand in a given day and/or year.
annual consumption	Gas consumption reported for a given year.
contingent resources	Gas resources that are known but currently considered uncommercial based on once or more uncertainties (contingencies) such as commercial viability, quantities of gas, technical issues, or environmental approvals.
demand	Capacity or gas flow on an hourly or daily basis, or the electrical power requirement met by generating units.
developed reserves	Gas supply from existing wells.
Gas Bulletin Board (GBB)	A website (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 Natural Gas Services Bulletin Board or the Bulletin Board.
Gas generation	The generation of electricity using gas as a fuel for turbines, boilers, or engines.
liquefied natural gas (LNG)	Natural gas that has been converted into liquid form for ease of storage or transport.
probable reserves	Estimated quantities of gas that have a reasonable probability of being produced under existing economic and operating conditions. Proved and probable reserves added together make up 2P reserves.
peak demand	The highest demand day in a year or season.
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 than other categories.
proved and probable	See 2P reserves.
proved reserves	Estimated quantities of gas that are reasonably certain to be recoverable in future under existing economic and operating conditions. Also known as 1P reserves.
reservoir	In geology, a naturally occurring storage area that traps and holds oil and/or gas. Iona UGS is also referred to as a reservoir for gas storage.
reserves	Reserves are quantities of gas which are anticipated to be commercially recovered from known accumulations
resources	More uncertain and less commercially viable than reserves. See contingent resources and prospective resources.
undeveloped reserves	Gas supply from wells yet to be drilled.