

# Gas Supply Adequacy Methodology Information Paper

**April 2020**

For the 2020 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 supply adequacy forecasts for the 2020 Gas Statement of Opportunities under the National Gas Law and Part 15D of the National Gas Rules.

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## VERSION CONTROL

Version	Release date	Changes
1	21/04/2020	Initial release

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# 1. Introduction

This document describes the methodology and assumptions used to assess supply adequacy for the 2020 Gas Statement of Opportunities (GSOO)<sup>1</sup>.

The GSOO reports on the adequacy of eastern and south-eastern Australian gas markets to supply maximum daily demand and annual consumption over a 20-year outlook period. The adequacy assessment is performed using a model of gas supply and demand (gas model) that includes representations of:

- Reserves and resources.
- 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 consumption forecasts for residential, commercial, and industrial customers, gas-powered generation (GPG), and liquefied natural gas (LNG) exports.

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 gas supply contract commitments, 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 2020 GSOO, to determine the robustness of outcomes to changes in modelled assumptions. Specific detail on scenarios used in the 2020 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 GPG.

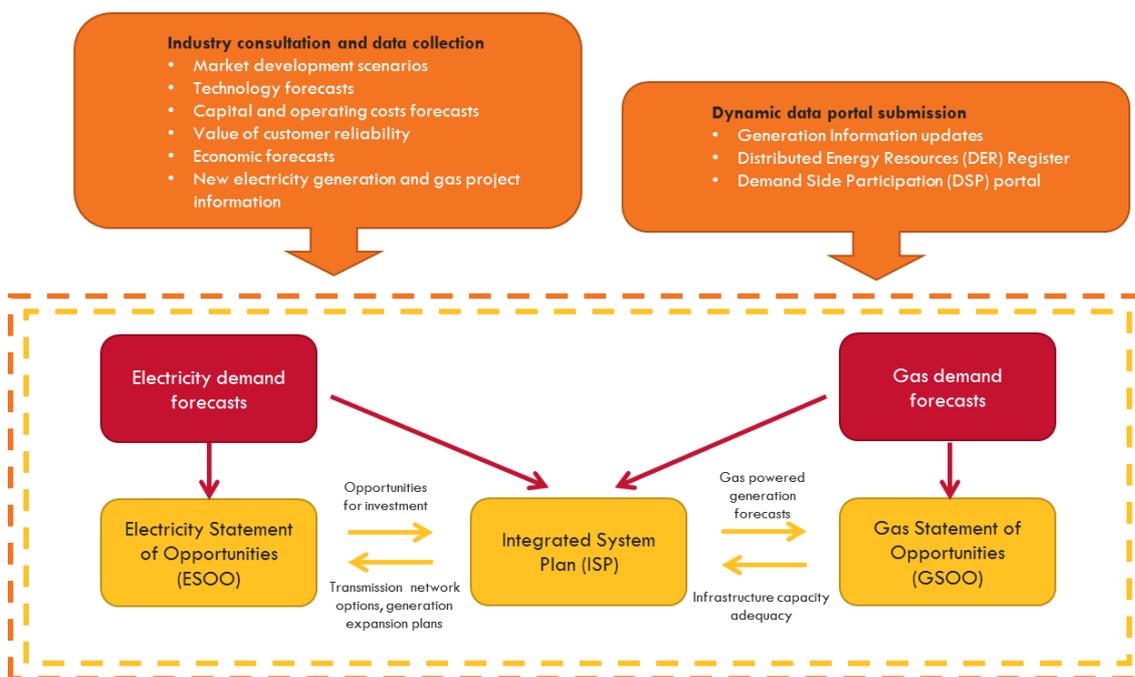
AEMO publishes methodology documents to support all major planning publications. These are available on AEMO's website<sup>2</sup> and provide additional relevant background to GSOO data and modelling assumptions.

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<sup>1</sup> AEMO. 2020 Gas Statement of Opportunities. Available: <http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities>.

<sup>2</sup> Forecasting methodologies are available for each publication, and centralised at the following address: <http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Inputs-Assumptions-and-Methodologies>.

**Figure 1 AEMO's major 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 2020 GSOO report and can be found in Table 1.

**Table 1 Links to other supporting information**

Source	Website address
2020 GSOO inputs and stakeholder survey information (for updated processing capacity of each facility used in the GSOO)	<a href="http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities">http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities</a>
2020 Gas Statement of Opportunities methodology – demand forecast	<a href="http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities">http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities</a>
Archive of previous GSOO reports	<a href="http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities">http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities</a>
National Electricity and Gas Forecasting Portal (AEMO Forecasting Portal)	<a href="http://forecasting.aemo.com.au">http://forecasting.aemo.com.au</a>
Gas Bulletin Board (GBB)	<a href="https://www.aemo.com.au/energy-systems/gas/gas-bulletin-board-gbb">https://www.aemo.com.au/energy-systems/gas/gas-bulletin-board-gbb</a>
2020 Draft Integrated System Plan	<a href="https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp">https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp</a>

# 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 supplies of gas to enable delivery 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, and
- Annual production limitations from each field or group of fields.

The model computes energy balances at all levels of a gas system from reservoirs or basins to the demand centres, supplies energy services at minimum total system cost, and balances gas commodity in each gas network node and time period. Outputs consist of gas productions, pipeline flows, and potential shortfalls.

The linear programming formulation for the model is given by:

For each day and year,

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

Subject to:

- Energy system balance
- Supply/demand balance
- Nodal capacity balance
- Pipeline capacity constraints
- Production 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 impact of a range of different expansions as sensitivities, without commenting on which may be the best or most cost-effective solution.

## 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
Capacity of reserves and resources	Core Energy Group and gas industry participants
Production costs	Core Energy Group and gas industry participants
Transmission costs	Gas industry participants. Where data was not provided and/or was considered confidential, AEMO used data supplied by Core Energy Group.
Pipeline, processing, storage facility capabilities and daily rates	Gas industry participants. Where data was not provided and/or was considered confidential, AEMO used data supplied by Core Energy Group.
Annual and daily field production limits	Core Energy Group, gas industry participants, and internal AEMO analysis.

### 2.2.1 Gas industry participants survey

AEMO surveyed 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.

This information is up to date as of December 2019, although AEMO endeavoured to incorporate more up-to-date information where practical.

Collated results from the survey of gas industry participants are available on AEMO's website<sup>3</sup>.

Annual and maximum daily field production forecasts were also obtained from gas industry participants for use in the gas supply adequacy modelling, but given the confidential nature of this data, AEMO will not make this data publicly available.

## 2.3 Model implementation

### 2.3.1 Gas network

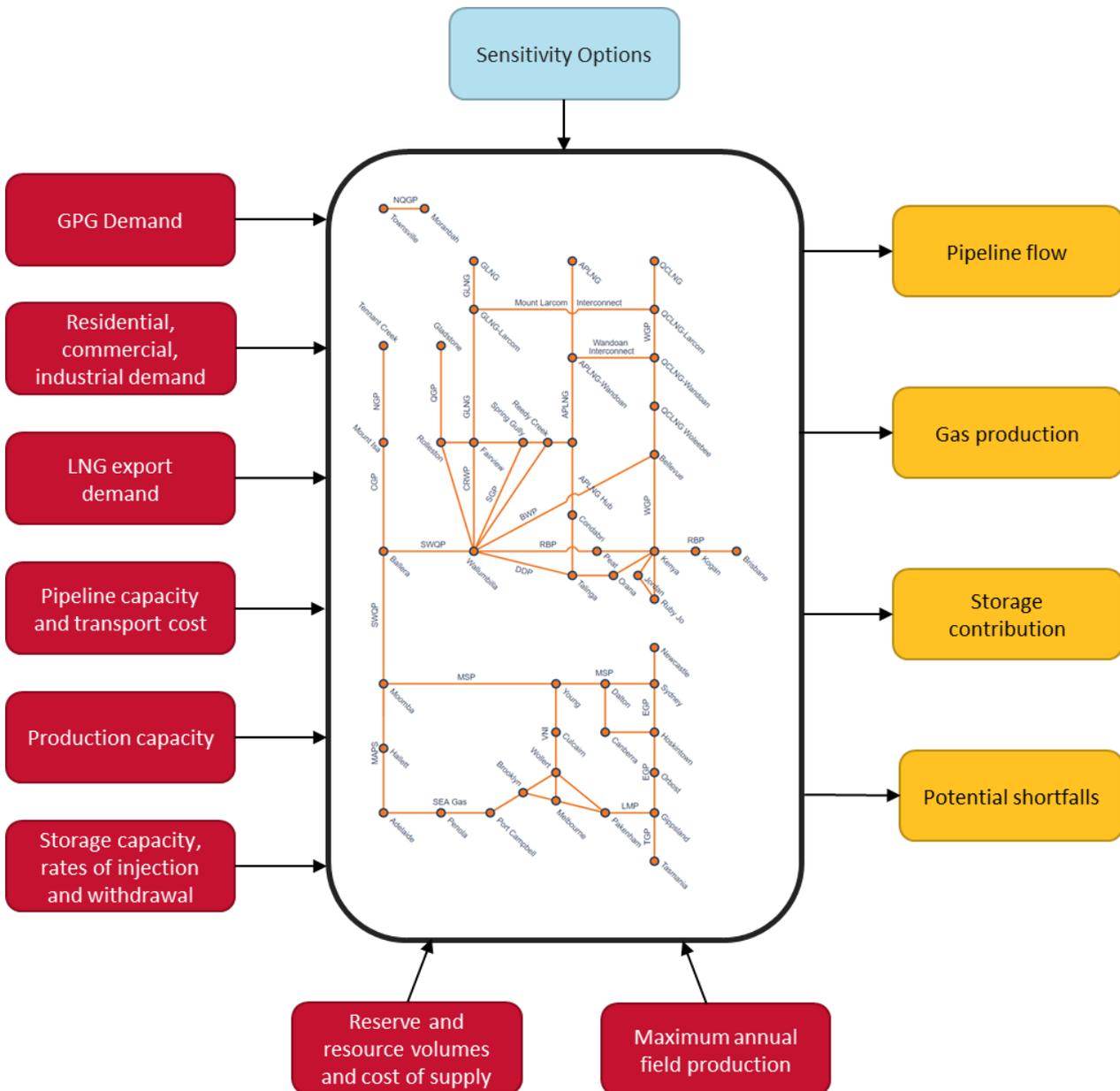
Capacities from existing transmission and processing infrastructure, as well as publicly announced infrastructure augmentations are used to determine total gas network capacity to facilitate supply.

<sup>3</sup> AEMO. 2019 Gas Processing, Transmission, and Storage Facilities, available at <http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities>.

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

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

**Figure 2 Model inputs and outputs**

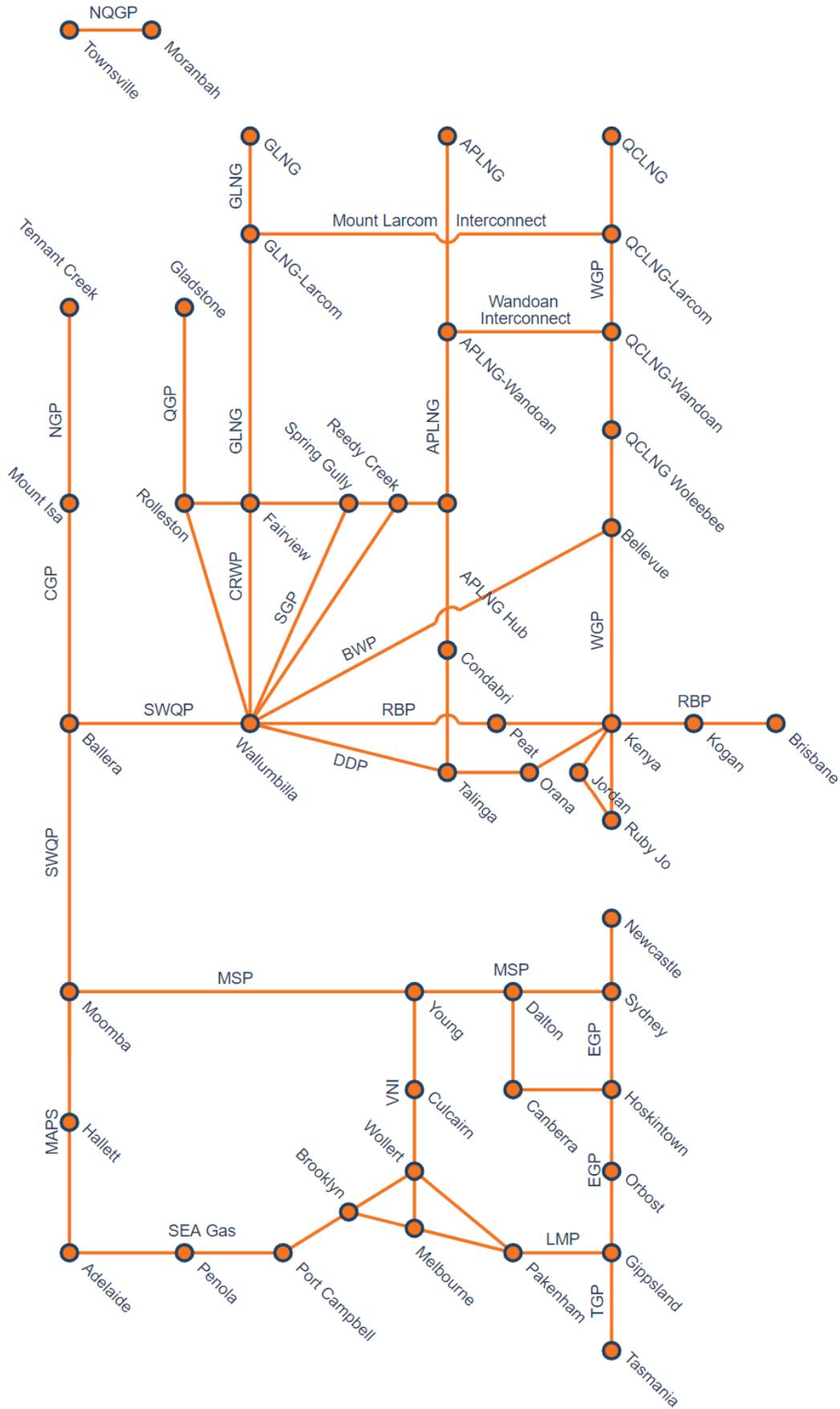


The eastern and south-eastern gas network is represented by a series of connected nodes. At each node, gas may be injected into or withdrawn from the network where production facilities and loads are connected respectively.

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 many cases, a connection (or series of connections) represents an actual pipeline. Pipeline transmission costs are considered in the gas model optimisation.

Figure 3 Gas model topology for 2020 GSOO



### 2.3.2 Gas fields and basins

The gas model represents field and basin 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 correspond to:

- A real-world field (for example, Minerva or Longtom).
- An aggregation of fields (for example, the Casino, Henry and Netherby fields are represented by a single field in the gas model).

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 are aggregated to a meaningful level.

#### Reserves and resources

In the gas model, reserves and resources are consumed over the 20-year outlook period based on estimates of annual supply availability, assuming 100% conversion to production is possible if required. In determining the rate of field depletion, the model considers the maximum production from each field, contract commitments, demand requirements and the cost of production.

The reserves and resources categorisations considered by the 2020 GS00 are 2P developed reserves, 2P undeveloped reserves, 2C contingent resources, and Prospective resources.

Further detail about reserve and resource quantities can be found in the Petroleum Resource Management System (PRMS)<sup>4</sup>.

The probability of gas existing in the ground and being considered commercially viable is not the only uncertainty related to future production. AEMO has further considered the level of certainty around whether projects will proceed to develop the identified volumes of reserves or resources.

For the 2020 GS00, AEMO has considered the following definitions:

- **Committed projects** – all necessary approvals have been obtained and implementation is ready to commence or is underway. Committed projects consist of 2P reserves (developed and undeveloped).
- **Anticipated projects** – 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 decisions made. Anticipated projects typically include 2P undeveloped reserves and selected 2C resources.
- **Uncertain projects** – these projects are more uncertain or at early stages of development. Uncertain projects include uncertain 2C contingent and prospective resources that are accessible by existing pipeline and processing infrastructure.

Under this classification, a project represents a specific investment decision, with an associated quantity of recoverable reserves and resources that may be more, or less, certain. As explained in the PRMS Guidelines, “a project may, for example, constitute the development of a single reservoir or field, or an incremental development in a producing field, or the integrated development of a group of several fields and associated facilities with a common ownership”.

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<sup>4</sup> See [https://www.spe.org/industry/docs/PRMS\\_Guidelines\\_Nov2011.pdf](https://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf).

### 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 has used production forecasts provided by industry participants to provide an upper limit for the amount of gas expected out of each field or group of fields for each year. Where forecasts are unavailable in the long term, AEMO considered that sufficient development and exploration occurs such that rates of gas production are maintained to the end of the outlook period.

AEMO separately assessed the production limits for three cases:

- Existing and committed projects only
- Existing, committed and anticipated projects
- Existing, committed, anticipated and uncertain projects.

### Gas fields and processing facilities

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.

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 contingent 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<sup>5</sup> in the gas model may be associated with one or more fields.

### 2.3.3 Storage

The gas model optimises gas storage operation after allowing for the cost for both injection into and withdrawal from a storage facility. 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.

### 2.3.4 Pipelines

AEMO considers all major pipelines shown in Figure 3. At each daily step, a modelled pipeline may flow up to its daily capacity limitation. Flow is optimised by taking into account transport cost – or pipeline tariffs – on each pipeline in the modelled system.

Pipeline linepack is considered by setting upper and lower limits that the pipeline volume must stay between.

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<sup>5</sup> Similar to previous GSOO publications, the Ballera processing facility has not been included in the 2020 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.

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, the GSOO model implements a dynamic pipeline capacity for the South West Pipeline (SWP) to reflect the operational issues inherent in sending gas between Melbourne and Port Campbell.

- 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 2019 Victorian Gas Planning Report (VGPR)<sup>6</sup> for more detailed information on the SWP capacity limitations.

### 2.3.5 Transmission losses

The gas model captures gas losses along the pipeline network in addition to customer demand for gas. This accounted for up to 1% of total demand each year.

### 2.3.6 Daily demand profile development

AEMO developed daily demand profiles for all demand sectors included in the gas model.

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 2020 GSOO<sup>7</sup>.

#### **Industrial, commercial and residential demand**

AEMO developed a daily reference profile for each GSOO demand centre, using historical data from either the Victorian DTS data (for Victorian demand only), flow data provided by pipeline operators (where available), or the Gas Bulletin Board.

The daily reference profile was then applied to annual consumption and maximum demand forecasts for the 20-year outlook period. This produced 20 years of daily demand for each residential, commercial, and industrial demand load.

#### **GPG demand**

Electricity market modelling simulations were used to produce half-hourly GPG generation data for the 20-year outlook period. AEMO combined this half-hourly generation data with estimates of fuel efficiency parameters for GPG<sup>8</sup>, to develop gas consumption values for each GPG in each half hour of the outlook period, which was then summed to a daily total for use in the gas supply model. Further information about electricity market modelling can be found on AEMO's website<sup>9</sup>.

#### **LNG export demand**

AEMO developed a daily reference profile for LNG export load, using the daily load profile from the Gas Bulletin Board of each of the three LNG projects for the most recent 12 months. This load profile applied annual demand forecasts for the three LNG projects of QCLNG, APLNG, and GLNG, to develop daily profiles over 20 years for each of the three Curtis Island LNG projects.

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<sup>6</sup> 2019 Victorian Gas Planning Report, Section 5.2. Available at: <http://aemo.com.au/Gas/National-planning-and-forecasting/Victorian-Gas-Planning-Report>

<sup>7</sup> Demand Forecasting Methodology Information Paper, available at <https://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities>.

<sup>8</sup> Available in the 2019 Input and Assumptions workbook, available at [https://aemo.com.au/-/media/files/electricity/nem/planning\\_and\\_forecasting/inputs-assumptions-methodologies/2019/2019-input-and-assumptions-workbook-v1-3-dec-19.xlsx?la=en](https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2019/2019-input-and-assumptions-workbook-v1-3-dec-19.xlsx?la=en).

<sup>9</sup> AEMO, *Market Modelling Methodologies*, August 2019. Available at [https://aemo.com.au/-/media/files/electricity/nem/planning\\_and\\_forecasting/inputs-assumptions-methodologies/2019/market-modelling-methodology-paper.pdf?la=en](https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2019/market-modelling-methodology-paper.pdf?la=en)

# Pipelines

<b>Abbreviation</b>	<b>Expanded name</b>
<b>BWP</b>	Berwyndale Pipeline
<b>CGP</b>	Carpentaria Gas Pipeline
<b>CRWP</b>	Comet Ridge to Wallumbilla Pipeline
<b>DDP</b>	Darling Downs Pipeline
<b>EGP</b>	Eastern Gas Pipeline
<b>LMP</b>	Longford to Melbourne Pipeline
<b>MAPs</b>	Moomba to Adelaide Pipeline System
<b>MSP</b>	Moomba to Sydney Pipeline
<b>NGP</b>	Northern Gas Pipeline
<b>NQGP</b>	Northern Queensland Gas Pipeline
<b>QGP</b>	Queensland Gas Pipeline
<b>SEA Gas Pipeline</b>	South Eastern Australia Gas Pipeline
<b>SGP</b>	Spring Gully Pipeline
<b>SWP</b>	South West Pipeline
<b>SWQP</b>	South West Queensland Pipeline
<b>TGP</b>	Tasmania Gas Pipeline
<b>VNI</b>	Victoria – New South Wales interconnect
<b>WGP</b>	Wallumbilla to Gladstone Pipeline

# Measures and abbreviations

## Units of measure

Abbreviation	Unit of measure
PJ	Petajoules
TJ	Terajoules
TJ/d	Terajoules per day

## Abbreviations

Abbreviation	Expanded name
ADGSM	Australian Domestic Gas Security Mechanism
AEMO	Australian Energy Market Operator
APLNG	Australia Pacific LNG
DTS	Declared Transmission System
FID	Final Investment Decision
GBB	Gas Bulletin Board
GLNG	Gladstone LNG
GPG	Gas-powered generation
GSOO	Gas Statement of Opportunities
ISP	Integrated System Plan
LNG	Liquefied Natural Gas
NEM	National Electricity Market
NPV	Net Present Value
QCLNG	Queensland Curtis LNG
VGPR	Victorian Gas Planning Report

# Glossary

Term	Definition
<b>2C contingent resources</b>	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.
<b>2P reserves</b>	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.
<b>annual consumption</b>	Gas consumption reported for a given year.
<b>contingent resources</b>	Gas resources that are known but currently considered uncommercial based on one or more uncertainties (contingencies) such as commercial viability, quantities of gas, technical issues, or environmental approvals.
<b>demand</b>	Capacity or gas flow on an hourly or daily basis, or the electrical power requirement met by generating units.
<b>developed reserves</b>	Gas supply from existing wells.
<b>Gas Bulletin Board (GBB)</b>	A website ( <a href="http://gbb.aemo.com.au">gbb.aemo.com.au</a> ) 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.
<b>gas-powered generation (GPG)</b>	The generation of electricity using gas as a fuel for turbines, boilers, or engines.
<b>linepack</b>	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.
<b>liquefied natural gas (LNG)</b>	Natural gas that has been converted into liquid form for ease of storage or transport.
<b>probable reserves</b>	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.
<b>production</b>	In the context of defining gas reserves, gas that has already been recovered and produced.
<b>prospective resources</b>	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.
<b>proved and probable</b>	See 2P reserves.
<b>proved reserves</b>	Estimated quantities of gas that are reasonably certain to be recoverable in future under existing economic and operating conditions. Also known as 1P reserves.

<b>Term</b>	<b>Definition</b>
<b>reservoir</b>	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.
<b>reserves</b>	Reserves are quantities of gas which are anticipated to be commercially recovered from known accumulations
<b>resources</b>	More uncertain and less commercially viable than reserves. See contingent resources and prospective resources.
<b>undeveloped reserves</b>	Gas supply from wells yet to be drilled.