Gas Supply Adequacy Methodology

June 2018

For the 2018 Gas Statement of Opportunities

Important notice

PURPOSE

AEMO has prepared this document to provide information about methodology and assumptions used to produce the 2018 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	29/06/2018	
1.1	27/08/2018	Correction to Table 1, amending the available supporting information.

Contents

Tables

Figures

1. Introduction

This document describes the methodology and assumptions used to assess supply adequacy for the 2018 Gas Statement of Opportunities (GSOO).[1]

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 supply and demand (gas model) that includes representations of:

- Reserves and resources.
- Gas supply contracts.
- 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 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 2018 GSOO, to determine the robustness of outcomes to changes in modelled assumptions. These scenarios are in alignment with those used in AEMO's Integrated System Plan (ISP)[2]. Specific detail on scenarios used in the 2018 GSOO is available in the GSOO report, available on AEMO's website[3].

1.1 Shared assumptions with other AEMO publications

The GSOO is part of a comprehensive suite of AEMO's forecasting publications, 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 maximise internal consistency. As an example, the long-term evolution of the National Electricity Market (NEM) provided by AEMO's ISP is used by the GSOO in forecasting expected gas consumption from GPG.

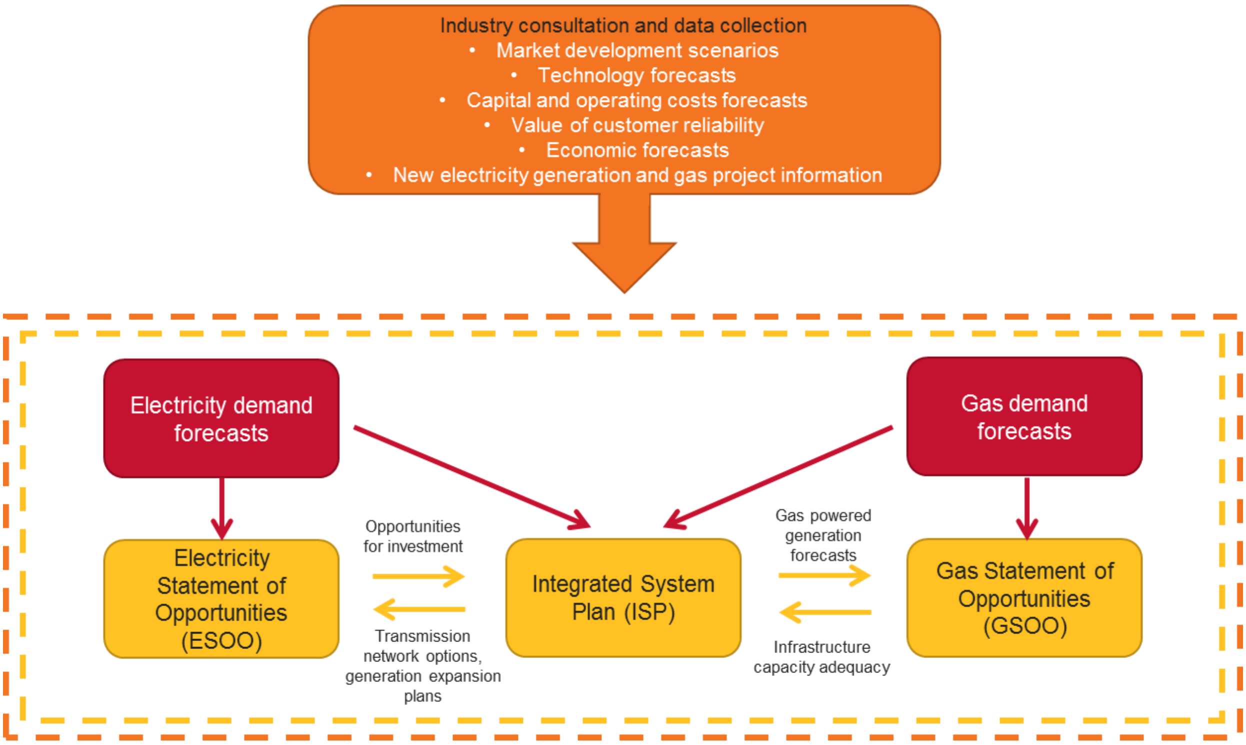
AEMO publishes methodology documents to support all major planning publications. These are available on AEMO's website and provide additional relevant background to GSOO data and modelling assumptions.

[1] AEMO. *2018 Gas Statement of Opportunities*. Available: http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

[2] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan

[3] https://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities

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 2018 GSOO report, and can be found in Table 1.

Table 1 Links to other supporting information

Source	Website address
2018 GSOO inputs and stakeholder survey information (for updated processing capacity of each facility used in the GSOO)	http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities
2018 Gas Statement of Opportunities methodology – demand forecast	http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities
Archive of previous GSOO reports	http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities
National Electricity and Gas Forecasting Portal (AEMO Forecasting Portal)	http://forecasting.aemo.com.au
Gas Bulletin Board	http://gbb.aemo.com.au

2. Gas model

2.1 Data sources

Table 2 shows key sources for the gas supply adequacy model inputs.

Table 2 Key sources for gas supply adequacy model input data

Input	Source
Demand	AEMO Forecasting Portal
Contracts	Core Energy Group
Reserves and resources	Core Energy Group and gas industry participants
Production costs	Core Energy Group
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 field production limits	Core Energy Group and gas industry participants.

2.1.1 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 6 April 2018, although AEMO has 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.[4]

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.

2.2 Assessing adequacy

2.2.1 Minimising the cost to supply forecast demand

The GSOO gas model is formulated as a transportation problem (a type of linear program focused on optimising transportation and resource allocation), that simulates daily gas market supply and demand conditions over the 20-year outlook period.

It calculates optimum production and flow by minimising the cost to supply forecast daily demand, subject to:

- The capability 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 availability of reserves and resources to maintain processing throughput,
- Annual production limitations from each field or group of fields, and
- Contract commitments for gas producers.

[4] AEMO. 2018 Gas Processing, Transmission, and Storage Facilities. Available: http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

The formulation is given by:

Minimize: NPV (Operations Costs + Fixed Costs + Production Costs + Transmission Costs + Processing Costs + Storage Costs)

Subject to:

- Energy system balance
- Pipeline capacity constraints
- Supply/demand balance
- Nodal capacity balance
- 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.

2.2.2 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 2018 GSOO are 2P developed reserves, 2P undeveloped reserves, 2C contingent resources and Prospective resources.

Further detail about reserve quantities used in the 2018 GSOO is available on AEMO's website.[5]

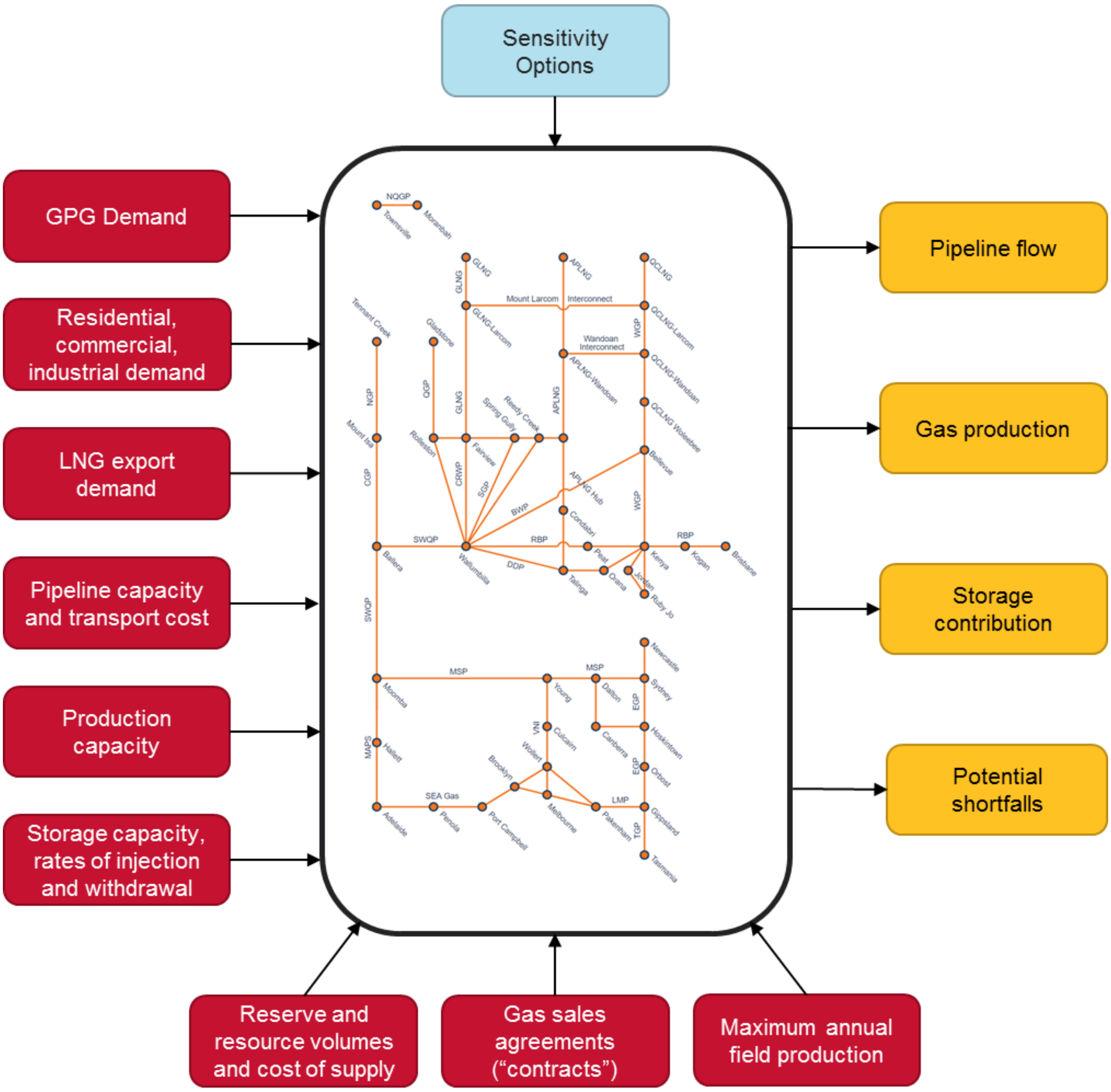
2.2.3 Total gas network capacity

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.

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

[5] Available at: http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

Figure 2 Model inputs and outputs

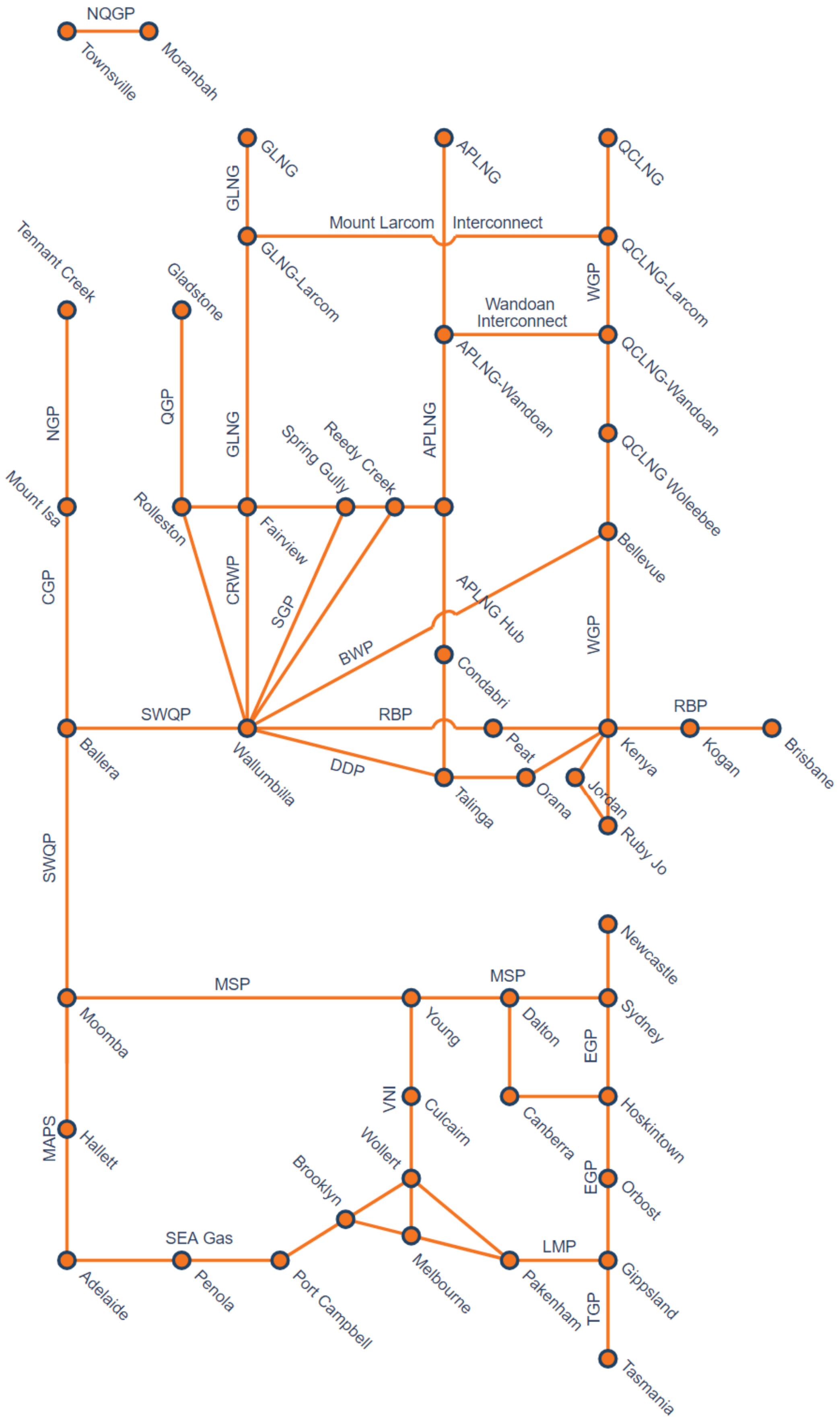


The eastern and south-eastern gas network is represented by a series of connected nodes. At each node, gas may be injected into or withdrawn from the network where production facilities and loads are connected respectively.

Connections between nodes define paths which gas can flow between. Together, nodes and their associated connections define a topology. The topology of the 2018 GSOO 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 2018 GSOO



2.3 Supply contracts and annual field production limits

AEMO includes the supply quantities of wholesale gas contracts (contracted demand) in the gas model, which drives field deliverability and better represents actual gas production.

The gas model satisfies uncontracted 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 between 2019 and 2022. After this point, AEMO considered two different futures:

- That sufficient development and exploration occurs such that rates of gas production from 2022 are maintained to the end of the outlook period, and
- That there is insufficient development and exploration to prevent the depletion of existing southern gas basins, resulting in only 15% of southern contingent and prospective resources able to be brought to market to the end of the outlook period.

Low production from northern fields was not separately considered in the 2018 GSOO, as these conditions are explicitly considered in the GSOO's Weak demand scenario, where demand LNG exports is unable to be maintained as the economic conditions are unfavourable for the continual drilling and exploration of new CSG wells.

2.4 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.

Similar to the 2017 GSOO, the Ballera processing facility has not been included in the 2018 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.

Each processing facility in the gas model may be associated with one or more fields. In the gas model, a field is any defined accumulation of gas with a specific uniform extraction cost. 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).

2.5 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.

2.6 Demand

2.6.1 Demand prioritisation

AEMO's modelling assumes that:

- Minimum contracted LNG demand will be satisfied as LNG export producers prioritise their sales commitments to international consumers under long-term contracts.
- Available production beyond LNG minimum contracted quantities is prioritised to domestic consumers, to reflect the impact of the Heads of Agreement[6] with the east coast LNG consortia, subject to deliverability constraints
- Further production capacity is available for LNG spot sales.

Projected shortfalls will therefore impact supply to non-contracted LNG sales first before impacting domestic demand (industrial, commercial, and residential customers and GPG).

2.6.2 Daily demand profile development

AEMO developed a daily demand profile for all demand sectors that were 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 *2018 Gas Statement of Opportunities methodology – demand forecast paper for the 2018 GSOO*.[7]

Industrial, commercial and residential demand

AEMO developed a daily reference profile for each GSOO demand centre, using historical data from either the Victorian Declared Transmission System data (for Victorian demand only), flow data provided by pipeline operators (where available), or the Gas Bulletin Board. The reference data was based on flows observed in the 2013-14 financial year, selected so to be consistent with the ISP modelling outcomes.

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 hourly GPG generation data for the 20-year outlook period. This market modelling is consistent with the expansion and dispatch expectations of the 2018 ISP. AEMO combined this hourly generation data with estimates of fuel efficiency parameters for GPG[8], to develop gas consumption values for each GPG in each hour of the outlook period, which was then summed to a daily total for use in the gas supply model.

LNG export demand

AEMO developed a daily reference profile, 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 was applied to the 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.

2.6.3 Transmission losses

The GSOO also considered gas losses along the transmission network in addition to customer demand for gas. This accounted for up to 1% of total demand each year.

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[6] See https://industry.gov.au/resource/UpstreamPetroleum/AustralianLiquefiedNaturalGas/Documents/Heads-of-Agreement-The-Australian-East-Coast-Domestic-Gas-Supply.pdf.

[7] *2018 Gas Statement of Opportunities methodology – demand forecast*, available at: https://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

[8] Available in the ISP assumptions workbook: http://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2018/2018-Integrated-System-Plan--Modelling-Assumptions--v22.xlsx

3. Infrastructure changes from 2017 GSOO

The information in Table 3 show revisions to the 2018 GSOO model's topology as compared to the 2017 GSOO and 2017 GSOO Update. The Inner Ring Main and Eastern Outer Ring Main pipelines though existing in 2017, have been implemented into the 2018 GSOO model to better reflect flow constraints around Melbourne and the DWGM. The Western Outer Ring Main is a project being developed by APA, and is expected to come online from 2021.

Table 3 Modelling topology revision – 2018 GSOO compared to 2017 GSOO and 2017 GSOO Update

Pipeline	Forward capacity (TJ/d)	Reverse capacity (TJ/d)
Inner Ring Main Pipeline	158	260
Eastern Outer Ring Main Pipeline	450	150
Western Outer Ring Main Pipeline	450	250

The 2018 GSOO reflects notable pipeline and storage capacity changes since the 2017 GSOO and 2017 GSOO Update, shown in Table 4.

Table 4 Infrastructure upgrade summary – 2018 GSOO compared to 2017 GSOO and 2017 GSOO Update

Pipeline	New capacity (TJ/d)	Increase (TJ/d)[9]
Iona Underground Gas Storage	435	45
Moomba to Adelaide Pipeline System (MAP)	241	4
VIC-NSW Interconnect (VNI)	150 (Reverse)	25
Queensland Gas Pipeline (QGP)	142	-7
Roma - Brisbane Pipeline (RBP)	211	-22

[9] Negative values indicate capacity decrease

MEASURES AND ABBREVIATIONS

Units of measure

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

Abbreviations: General

Abbreviation	Expanded name
AEMO	Australian Energy Market Operator
APLNG	Australia Pacific LNG
DWGM	Declared Wholesale Gas Market
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

Pipelines

Abbreviation	Expanded name
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
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
WGP	Wallumbilla to Gladstone Pipeline

Glossary

Term	Definition
2C contingent 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.
annual consumption	Gas consumption reported for a given year.
coal seam gas (CSG)	Gas found in coal seams that cannot be economically produced using conventional oil and gas industry techniques. Also referred to in industry sources as coal seam methane (CSM) or coal bed methane (CBM).
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-powered generation (GPG)	The generation of electricity using gas as a fuel for turbines, boilers, or engines.
hydraulic fracturing	Hydraulic fracturing, also called fraccing or fracking, is a method of increasing the extraction of oil and gas from reservoirs, and more recently coal seam gas, by injecting fluid under high pressure to fracture wells or coal seams.
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)	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.
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.
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.