GSOO METHODOLOGY

METHODOLOGY FOR THE GAS STATEMENT OF OPPORTUNITIES

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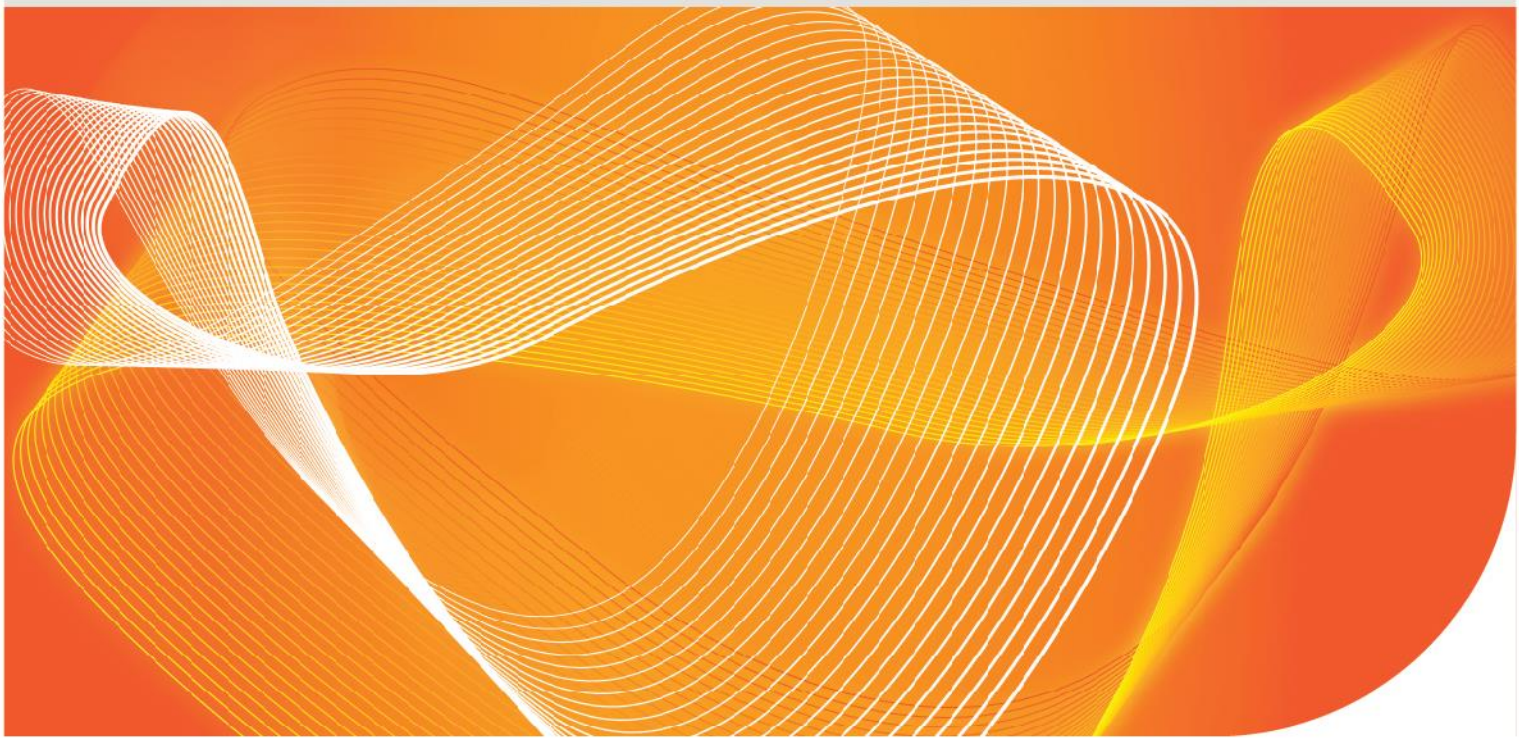

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about the methodology and assumptions used by AEMO to develop its 2017 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	9/3/2017	

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CHAPTER 1. INTRODUCTION

This document describes the methodology and assumptions used to develop the *2017 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, as forecast in AEMO's *National Gas Forecasting Report* (NGFR).[2]

The gas model attempts to balance daily supply and demand at least cost, by considering 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 2017 GSOO, to determine the robustness of outcomes to changes in modelled assumptions.

1.1 Shared assumptions with other AEMO publications

The GSOO is part of a comprehensive suite of AEMO's planning and forecasting publications, an overview of which is shown in Figure 1.

The publication cycle begins with the annual *National Electricity Forecasting Report* (NEFR), which produces electricity demand forecasts for each region in the National Electricity Market (NEM). AEMO's *National Transmission Network Development Plan* (NTNDP) then provides a strategic assessment of how forecast electricity demand will be met.

A key output from this report is forecast GPG gas demand, which is also a key input for AEMO's NGFR in forecasting total gas demand.

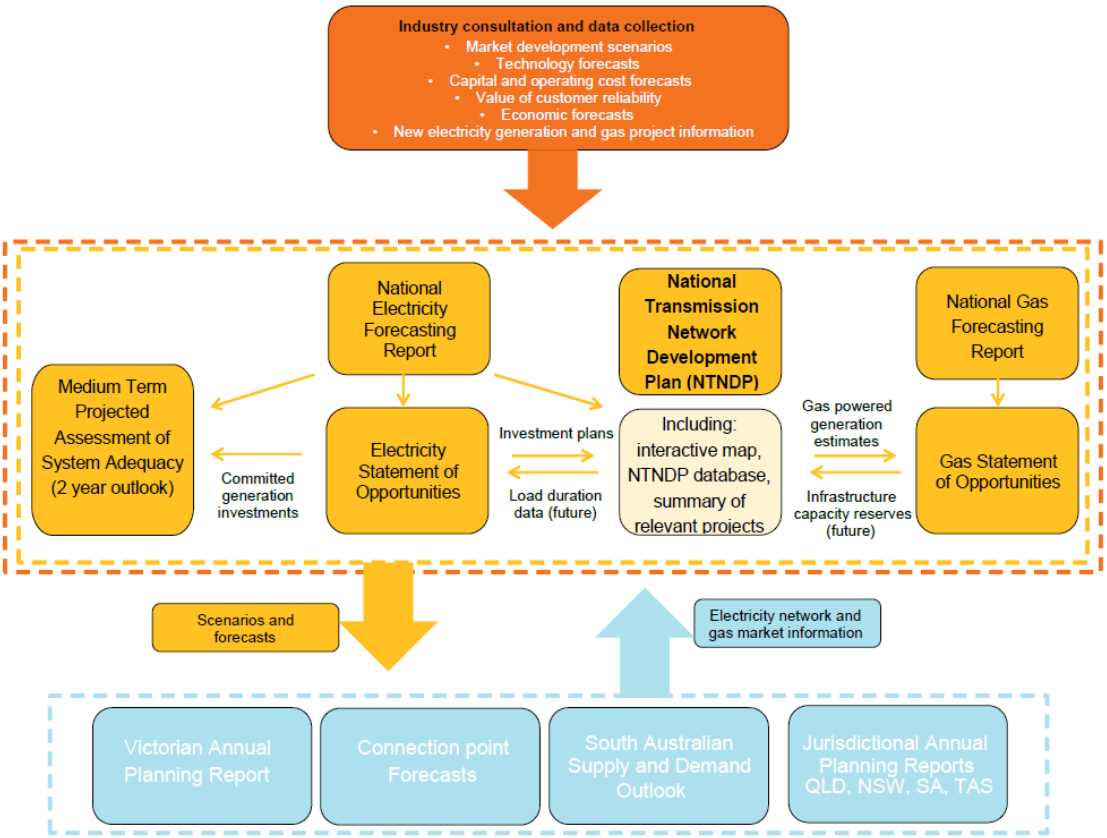
The GSOO is the final report in the planning publication cycle, and uses total forecast gas demand from the NGFR as a key input.

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

[1] AEMO. *2017 Gas Statement of Opportunities*. Available: http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

[2] AEMO. *2016 National Gas Forecasting Report*. Available: http://www.aemo.com.au/Gas/National-planning-and-forecasting/National-Gas-Forecasting-Report.

Figure 1 AEMO's planning and 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 2017 GSOO report.

Table 1 Links to other supporting information

Source	Website address
2017 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
2017 GSOO Supply-Demand modelling output files	http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities
2016 National Gas Forecasting Report	http://www.aemo.com.au/Gas/National-planning-and-forecasting/National-Gas-Forecasting-Report
Archive of previous GSOO reports	http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities

CHAPTER 2. GAS MODEL

2.1 Data sources

Table 2 shows key sources for the gas model inputs.

Table 2 Key sources for gas model input data

Input	Source
Demand	AEMO 2016 NGFR
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	Gas Bulletin Board 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 31 December 2016, although AEMO has endeavoured to incorporate more recent information where practical.

Collated results from the survey of gas industry participants are available on AEMO's website.[3]

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, from 2017 to 2036.

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.
- Contract commitments for gas producers.

[3] AEMO. 2017 Gas Processing, Transmission, and Storage Facilities. Available: http://www.aemo.com.au/Gas/National-planning-and-forecasting/Gas-Statement-of-Opportunities.

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 depletion, the model considers both contract commitments and the cost of production.

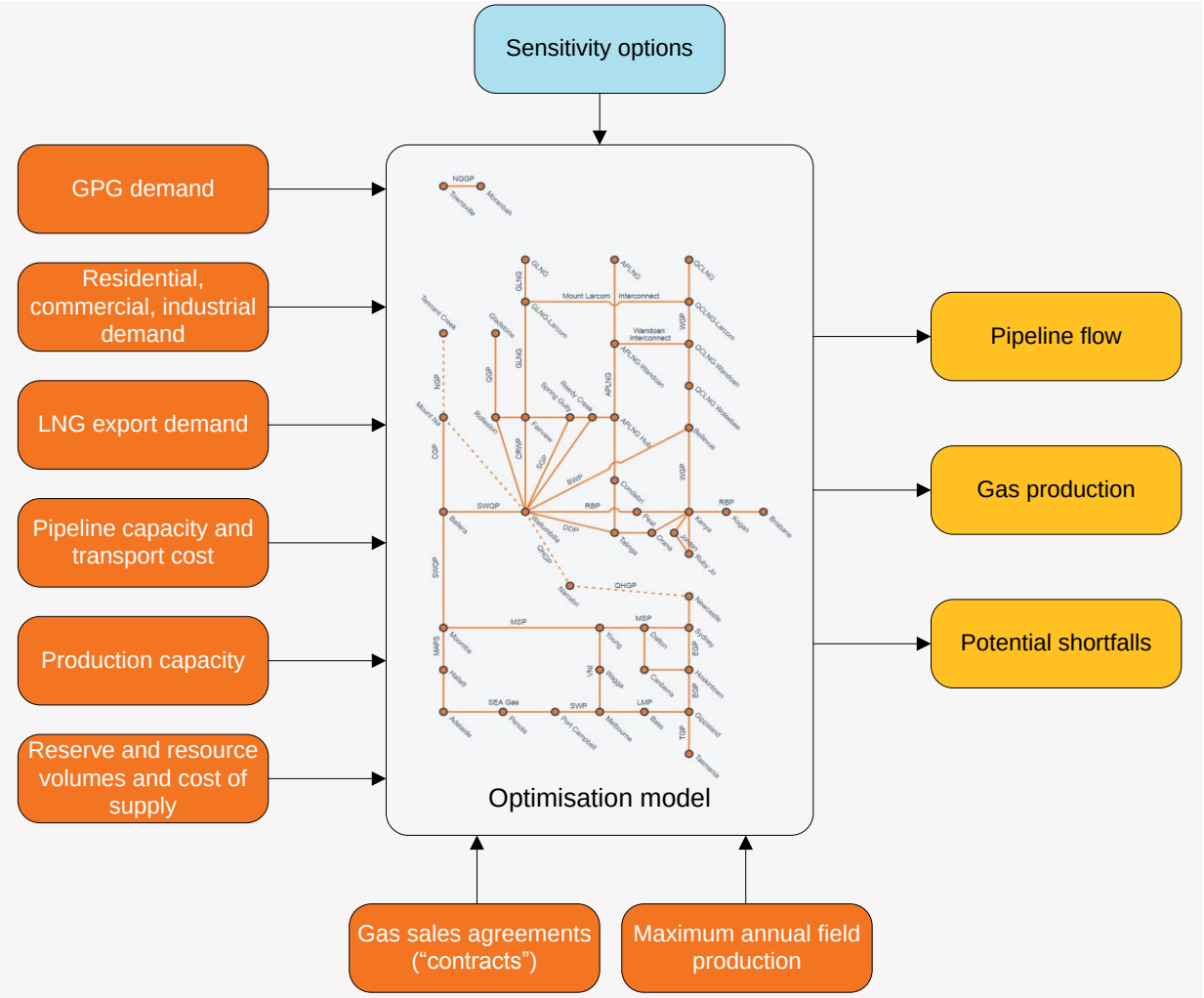
Further detail about reserves quantities used in the 2017 GSOO is available on AEMO's website.[4]

2.2.3 Total gas network capacity

Capacities from existing transmission and processing infrastructure and 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.

Figure 2 Model inputs and outputs



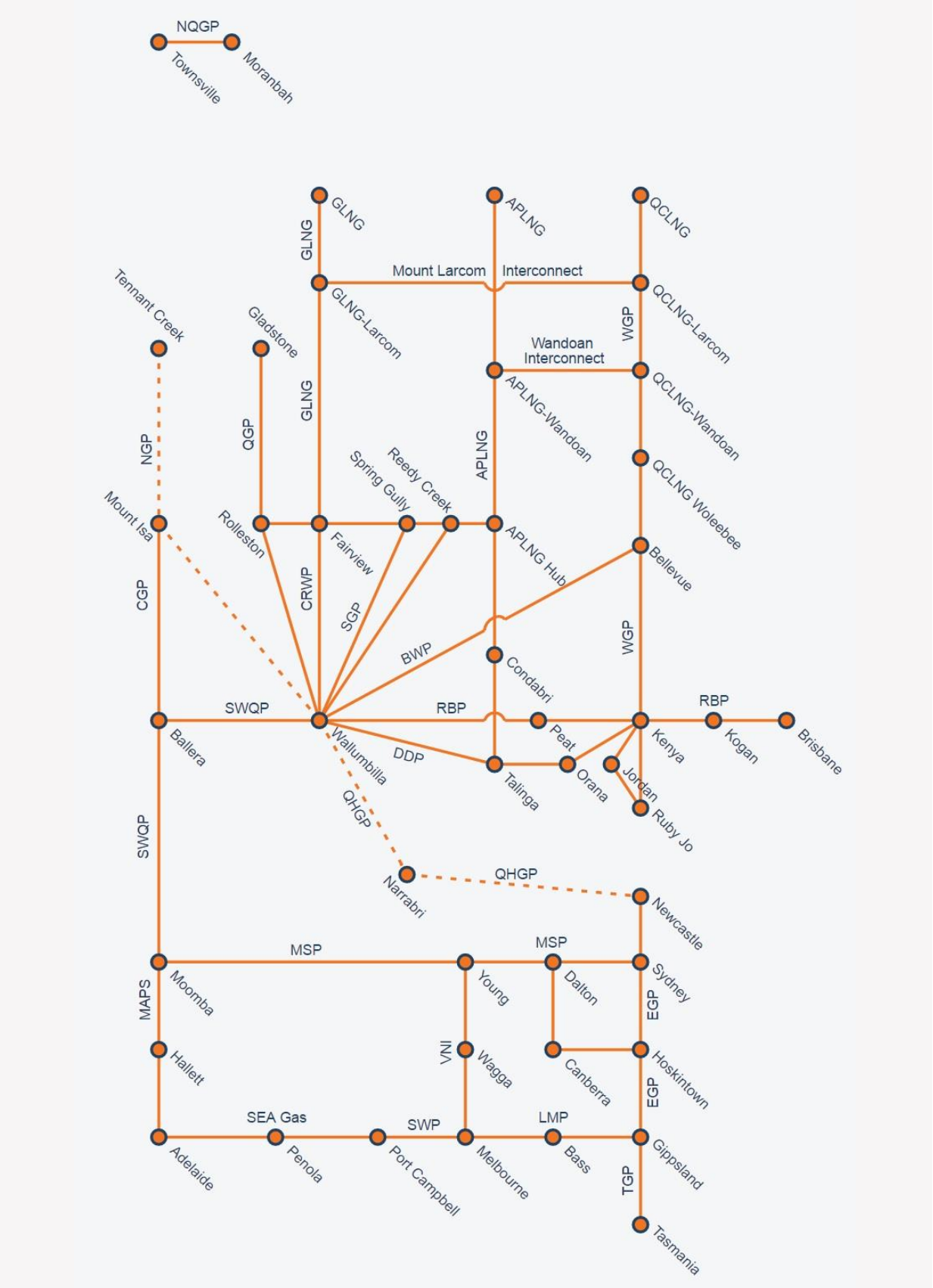
The eastern and south-eastern gas network is represented by a series of connected nodes. At each node, gas may be injected into or withdrawn from the network, or flow may be redirected.

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

Connections between nodes define paths over which gas can flow. Together, nodes and their connections define a topology. The topology used for modelling in the 2017 GSOO, shown in Figure 3, is designed to capture key features of the physical gas network.

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 2017 GSOO



2.3 Supply contracts and annual field production limits

AEMO includes publicly announced 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.

AEMO has also used Gas Bulletin Board (GBB)[5] data to calibrate maximum field deliverability to ensure that forecast annual production aligns with historical information. Where insufficient historical production information was available, AEMO has assumed that fields are capable of operating continuously at the stated maximum capacities of their processing facilities. If these fields do not deliver to rated capacities, GSOO results will vary accordingly.

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 field has a separate production cost. This cost is applied to every unit of gas produced by the associated processing facility.

The Ballera processing facility has not been included in the 2017 GSOO (not included in the 2016 GSOO but included in the 2015 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.

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 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, although the model allows the storage facilities to not meet the refilling target if the alternative is shortfalls.

[5] The GBB (gbb.aemo.com.au) provides information on major interconnected gas processing facilities, gas transmission pipelines, gas storage facilities, and demand centres in eastern and south-eastern Australia.

2.6 Demand

2.6.1 Demand prioritisation

AEMO's modelling assumes that:

- LNG demand will be satisfied as LNG export producers prioritise their gas portfolios to fulfil sales commitments under long-term contracts.
- Projected shortfalls will therefore impact supply to the domestic market (industrial, commercial, and residential customers and GPG).
- GPG is the lowest priority sector in the domestic market, on the basis that, if gas was unavailable for electricity generation, another fuel type (such as coal-fired or hydro generation) could be substituted. This assumption is likely to be increasingly challenged as the electricity supply demand balance tightens.

For more information about the development of each class of demand and the key assumptions used, refer to the *2016 NGFR Forecasting Methodology Information Paper*.[6]

2.6.2 Daily demand profile development

AEMO developed a daily demand profile for all demand sectors that were included in the gas model.

Industrial, commercial and residential demand

AEMO developed a daily reference profile, using historical data from either the Gas Bulletin Board, Victorian Declared Transmission System data (for Victorian demand only), or flow data provided by pipeline operators (where available). The reference data was based on flows observed in 2010, selected as a typical year from analysis of historical flows over the range of available data.

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 model simulations were used to produce hourly GPG generation data for the 20-year outlook period. AEMO combined this hourly generation data with estimates of the GPG heat rates, to develop gas consumption values for each GPG in each hour of the outlook period.

LNG export demand

AEMO used the daily load profile of the Queensland Curtis LNG (QCLNG) Pipeline as a proxy for daily LNG export demand for all three LNG projects. This load profile was applied to the annual demand forecasts for QCLNG, APLNG, and GLNG, to develop daily profiles over 20 years for each of the three Curtis Island LNG projects.

Each 365-day profile commenced at different intervals throughout the year, so that peak demand days don't occur simultaneously on the same day.

2.6.3 Transmission losses

The GSOO also considered gas losses along the transmission network in addition to NGFR demand. This accounted for up to 14 PJ each year.

[6] AEMO. *2016 National Gas Forecasting Report – Methodology Information Paper*. February 2017. Available: http://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/NGFR/2016/Forecasting-Methodology-Information-Paper---2016-NGFR.pdf.

CHAPTER 3. INFRASTRUCTURE CHANGES FROM 2016

The 2017 GSOO reflects notable pipeline capacity changes since the 2016 GSOO, shown in Table 3.

Table 3 Pipeline upgrade summary – 2017 GSOO compared to 2016 GSOO

Pipeline	New capacity (TJ/d)	Increase/decrease (TJ/d)
Gladstone LNG (GLNG) Pipeline	1430	30
South West Pipeline (SWP) to Port Campbell	102	-27
Wallumbilla to Gladstone Pipeline (previously QCLNG pipeline)	1588	58

Similarly, processing facility capacity has been reassessed since the 2016 GSOO. Table 4 shows facilities where new capacity has been installed, or existing capacity has been upgraded.

Table 4 Changes to processing facility capacity – 2017 GSOO compared to 2016 GSOO

Processing facility	New capacity (TJ/d)	Increase (TJ/d)
Combabula	300	75
Condabri	540	115
Orana	200	5
Reedy Creek	180	30
Taloona	60	5
Total increase		**230**

MEASURES AND ABBREVIATIONS

Units of measure

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

Abbreviations

Abbreviation	Expanded name
AEMO	Australian Energy Market Operator
APLNG	Australia Pacific LNG
CGP	Carpentaria Gas Pipeline
GBB	Gas Bulletin Board
GLNG	Gladstone LNG
GPG	Gas-powered generation
GSOO	Gas Statement of Opportunities
LNG	Liquefied Natural Gas
QCLNG	Queensland Curtis LNG
SWP	South West Pipeline

GLOSSARY

These terms are used in the *2017 GSOO Methodology Document* and the *2017 Gas Statement of Opportunities* report.

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.
black system	Defined in Chapter 10 of the National Electricity Rules as "the absence of voltage on all or a significant part of the transmission system or within a region during a major supply disruption affecting a significant number of customers".
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.
curtailment	The interruption of a customer's supply of gas at its delivery point that occurs when AEMO intervenes or issues an emergency direction in Victoria.
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.
inertia	Produced by synchronous generators, inertia dampens the impact of changes in power system frequency, resulting in a more stable system. Power systems with low inertia experience faster changes in system frequency following a disturbance, such as the trip of a generator.
intermittent generation	Electricity generation, such as wind farms and solar photovoltaic (PV), whose supply varies throughout the day and is not readily predictable.
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.

Term	Definition
Rate of Change of Frequency (RoCoF)	When a contingency results in a supply demand imbalance in the electricity power system, system frequency will begin to deviate from the standard 50 Hz. High RoCoF levels make it increasingly difficult to manage frequency disturbances, because responses to correct the imbalance must operate more rapidly to arrest the frequency change, and may not operate quickly enough to prevent a cascading trip of load or generation, and, in extreme cases, widespread supply disruption.
reliability	The ability of the power system to supply adequate power to satisfy customer demand, allowing for credible supply, pipeline, generation, and transmission network contingencies.
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.
security	Security of supply is a measure of the power system's capacity to continue operating within defined technical limits, even in the event of the disconnection of a major electricity power system element such as an interconnector or large generator, or disruption of gas supply.
synchronous generation	Synchronous generators (most coal, gas and hydro generators) produce power through directly connected alternating current machines, rotating at a speed synchronised to power system frequency. These generators produce inertia and dynamic voltage to support a more stable power system.
thermal generation	Thermal generation produces electrical power from heat energy, fuelled mainly by coal and natural gas, and to a lesser extent by wood waste and geo-thermal resources. These generators are synchronous.
undeveloped reserves	Gas supply from wells yet to be drilled.