THE UNIVERSITY OF MELBOURNE

Melbourne Energy Institute

MEI*network*22
Seminar #2

Gas markets and gas retailing

Speaker: Mr Matthew Clemow,
Australian Energy Market Operator

Moderator: Professor Michael Brear,
Melbourne Energy Institute

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MEI*network*22 Seminar Series

Seminar topic	Month
Conventional and unconventional natural gas - Mr Steve Henzell, Advisian	10 May
Gas markets and gas retailing - Mr Matthew Clemow, Australian Energy Market Operator	7 June
Liquefied natural gas and export - Ms Carolyn Au, Shell	5 July
Natural gas and hydrogen transmission and distribution	August
Green hydrogen as an alternative to natural gas	September
Blue hydrogen as an alternative to natural gas	October
Options for hydrogen export	November

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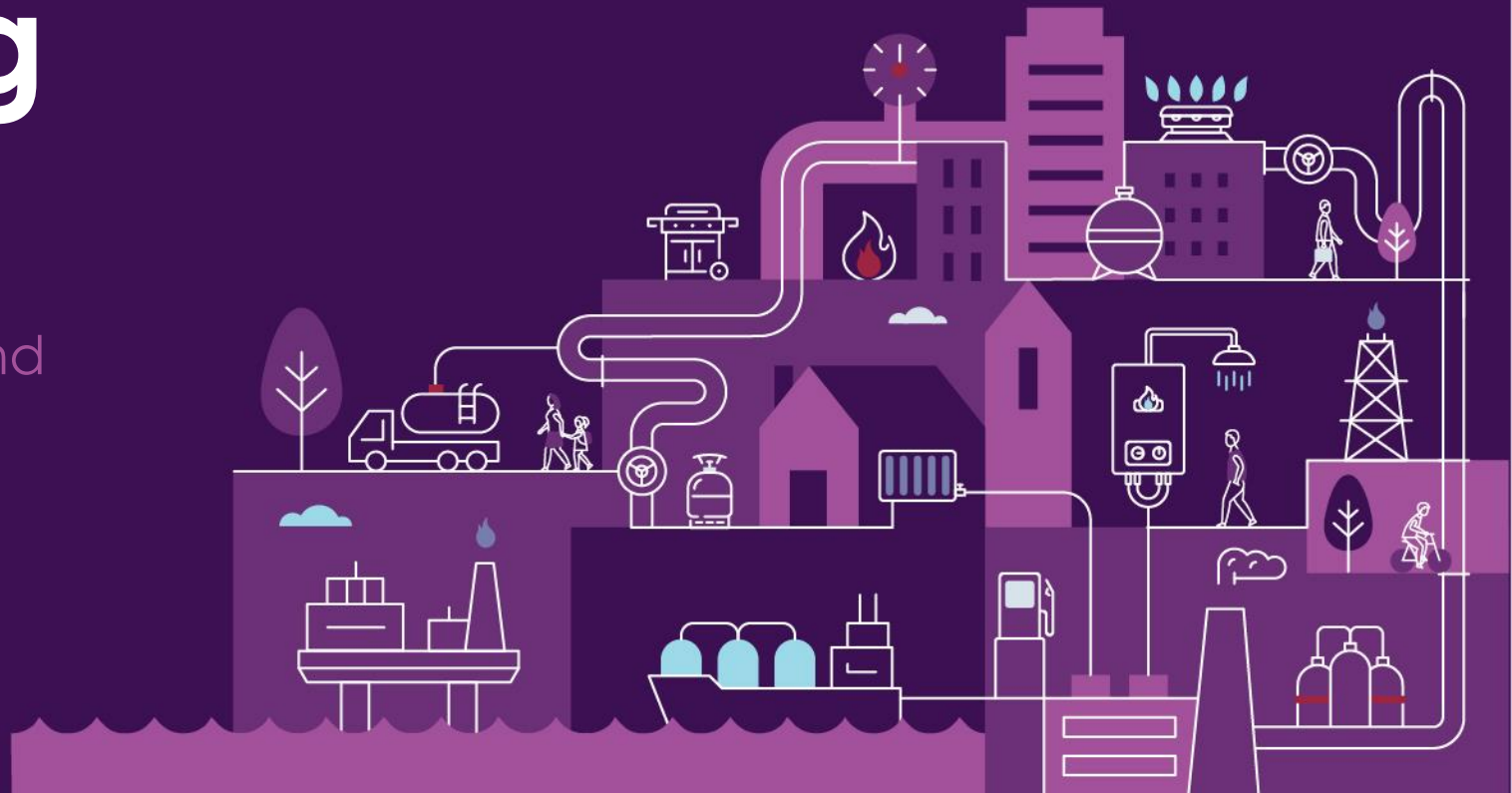
Gas Markets and Gas Retailing

Matthew Clemow

Group Manager – Gas Markets and System Operations

7 June 2022



Part 1

- AEMO and Markets Overview
- AEMO Wholesale Gas Markets
- Gas Metering
- Gas Retail Market
- Gas Planning / Supply Shortfall
- Additional Supply Projects

Part 2

- Victorian Operations Overview
- Demand Forecasting and Operating Challenges
- Market Intervention Case Study
- Emergency Management

AEMO and Markets Overview

AEMO Roles

- AEMO is the Australian independent energy market and system operator
- Commenced in eastern Australia on 1 July 2009, with Western Australia joining on 1 October 2015 (formed through the amalgamation of state based operators)

Electricity

- Operates the National Electricity Market (NEM) power system, the South West Interconnected System in WA, including scheduling the wholesale electricity markets
- Electricity planning documents including Integrated System Plan, Electricity Statement of Opportunities, Victorian Annual Planning Report

Gas

- Operation Wholesale and Retail Gas Markets
- Gas Bulletin Board(s)
- Gas planning documents including Gas Statement of Opportunities, Victorian Gas Planning Report

AEMO operates on a cost recovery basis through fees paid by participants

AEMO is a public private partnership:

60%
Government owned

40%
Industry members

Governance Structure

National Gas Law	National Gas Rules		Procedures
Energy National Cabinet Reform Committee (ENCRC) and the Energy Ministers' Meeting (EMM) • Energy policy and direction setting **Energy Security Board (ESB)** • Whole of system oversight through the energy transition	AEMC • Market development adviser • Makes and administers National Gas Rules and codes of conduct	AUSTRALIAN ENERGY REGULATOR • Monitors conduct and enforces compliance with the applicable Rules and Procedures. • Economic regular for covered assets	AEMO AUSTRALIAN ENERGY MARKET OPERATOR • Operates gas wholesale markets • Operates gas retail markets • Makes and administers gas market Procedures

What is natural gas?

- Typically 90%+ Methane (CH_4) molecules
- Naturally occurring
  - Like oil, is a 'fossil fuel', generally believed to be formed from pre-historic life.
- May be pressurised or liquified for storage
- Natural Gas does not smell, an odorant is added to make it smell to help detect leaks
- $CH_4 + 2\ O_2$ -> $CO_2 + 2\ H_2O$ + ENERGY
- One standard cubic metre (35.315 cubic feet) =>

Approx. 38.5 MJ (depending on heating value)

- 1,000 MJ = 1 Gigajoule (GJ),
  - average Melbourne household uses 63 GJ/year
  - average Sydney household uses 26 GJ/year
- 1,000 GJ = 1 Terajoule (TJ)
  - Victoria uses over 1,000 TJ per day in winter
- 1,000 TJ = 1 Petajoule (PJ)
  - Exports from Gladstone ~4 PJ per day

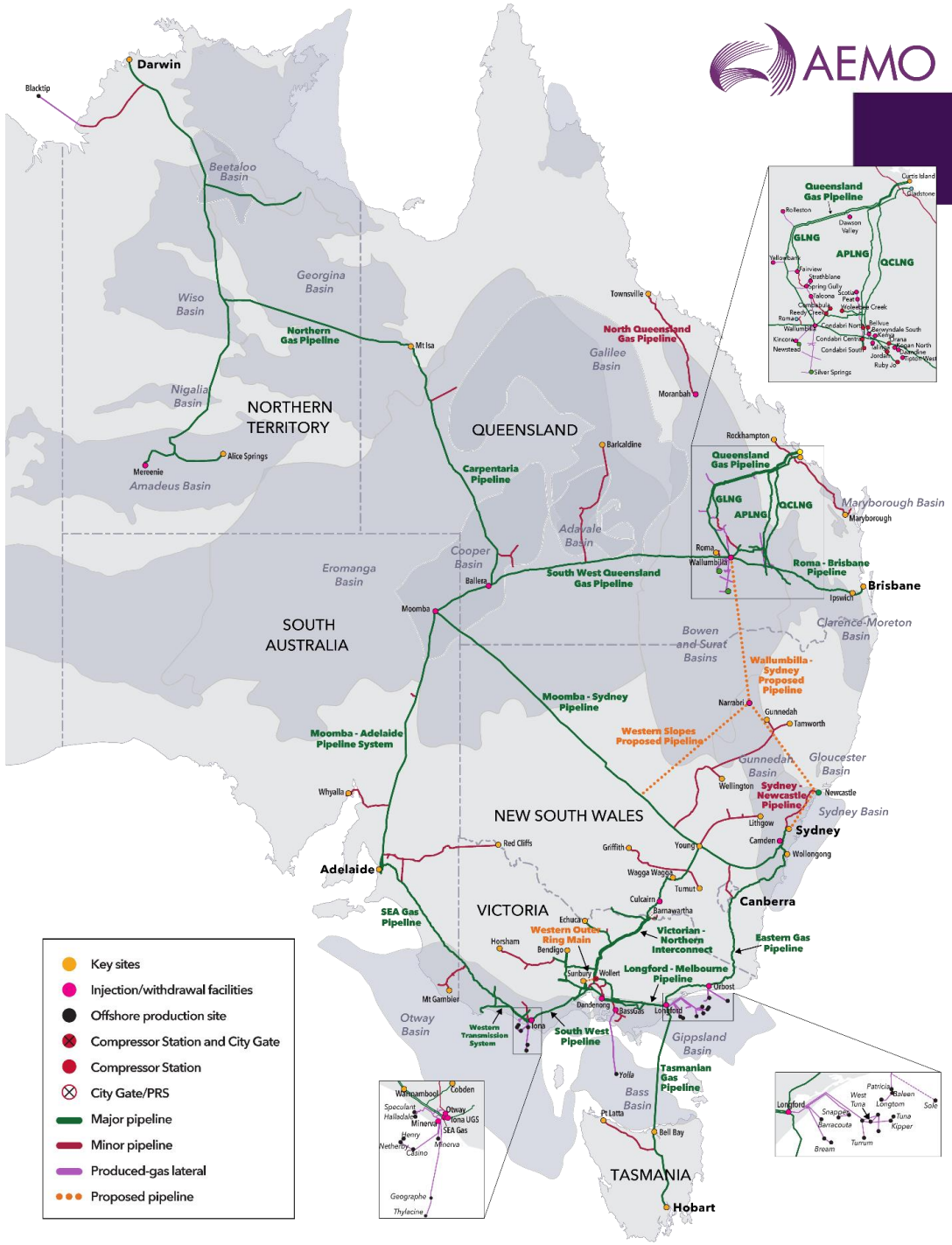
*Australian Energy Update 2017, Commonwealth Department of Environment and Energy

East Coast Gas Markets

No Single Overall Gas Market:

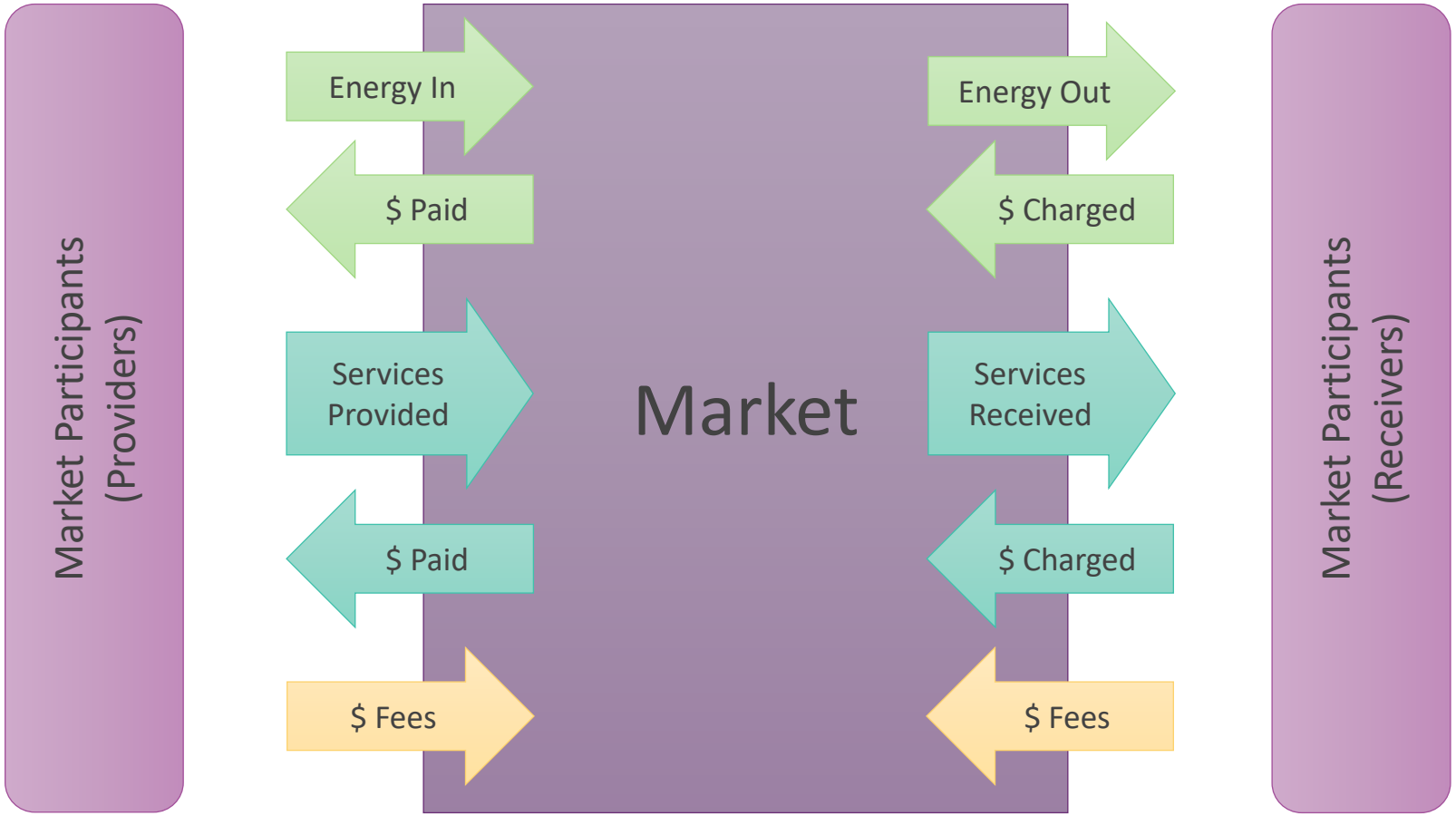
- Victorian Declared Wholesale Gas Market (DWGM)
- Short Term Trading Markets (STTM) at three hubs:
  - Adelaide
  - Brisbane
  - Sydney
- Gas Supply Hubs (GSH)
  - Wallumbilla
  - Moomba
- Pipeline Capacity Trading (PCT)
- Pipeline Capacity Day Ahead Auctions (DAA)
- Gas Retail Markets (Vic and Qld only)

No AEMO Wholesale Gas Markets in Western Australia

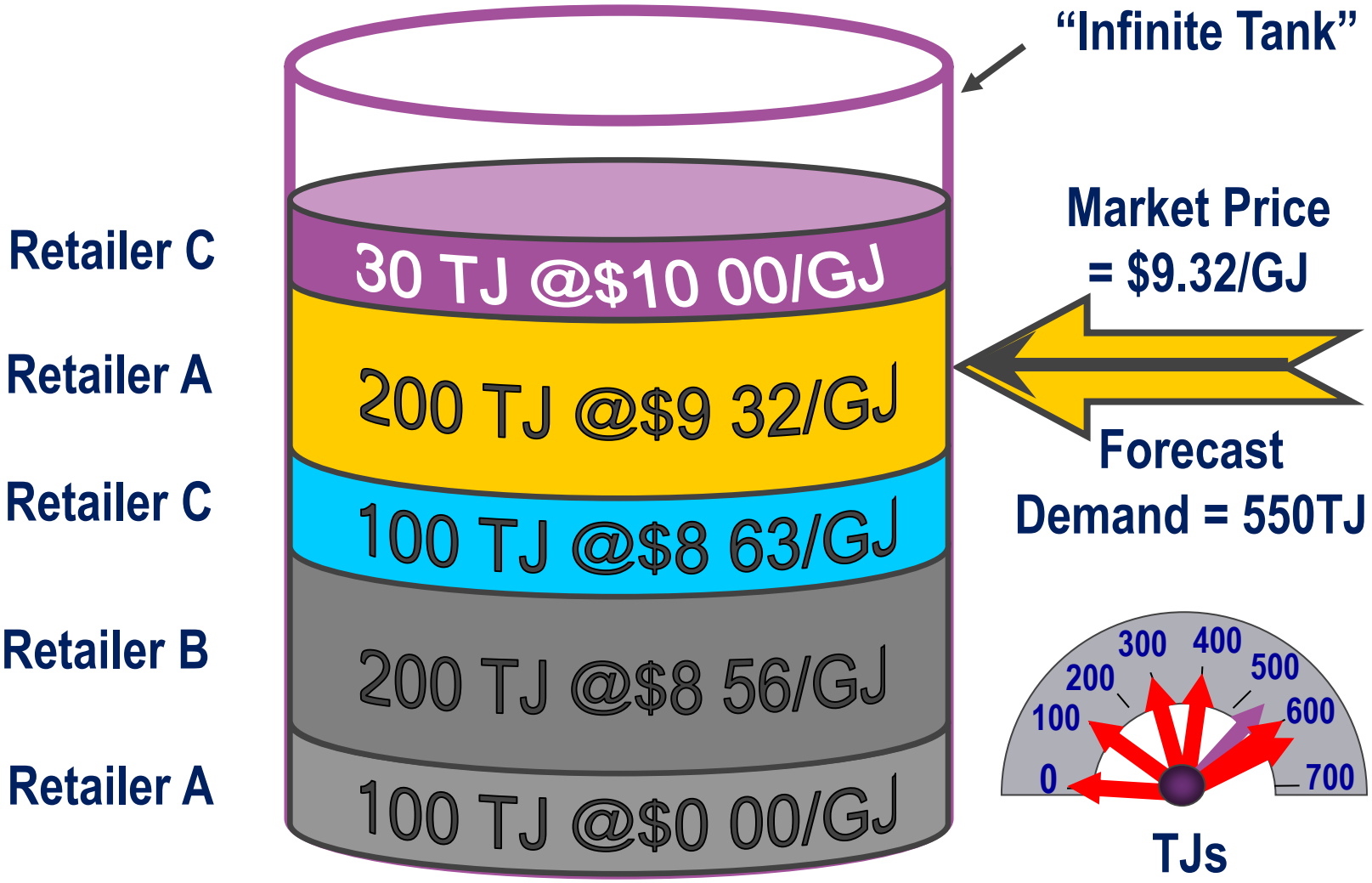


Energy markets

All AEMO's energy markets work in the same way…

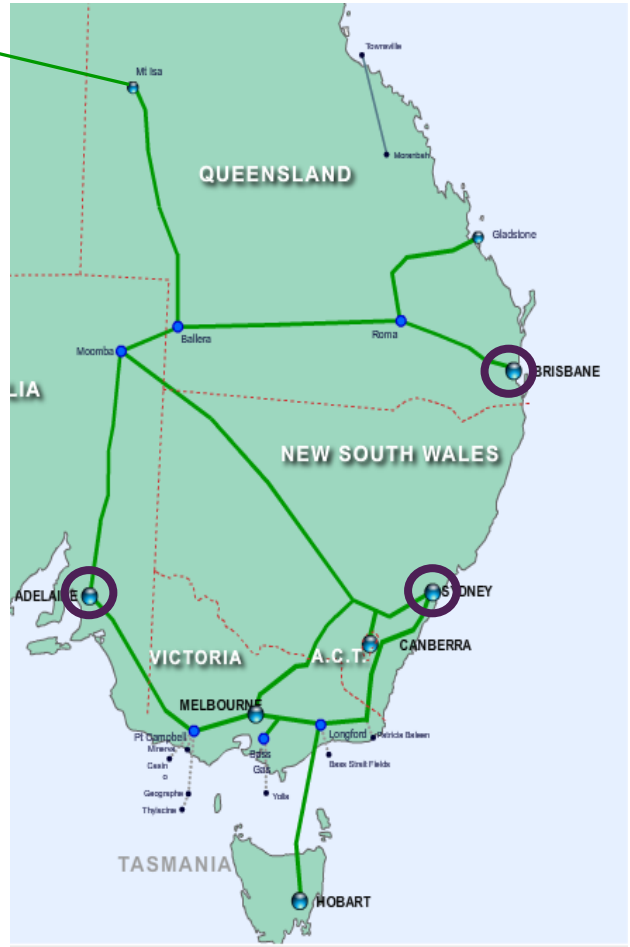


Determining Market Price



AEMO Wholesale Gas Markets

Short Term Trading Markets (STTM)



Short Term Trading Markets

The Short Term Trading Markets (STTM) were designed to facilitate short term gas trading between gas shippers and users as a demand hub. STTM hubs currently operate in Adelaide, Brisbane and Sydney.

145 PJ
Annual consumption for Adelaide, Brisbane and Sydney STTM hubs

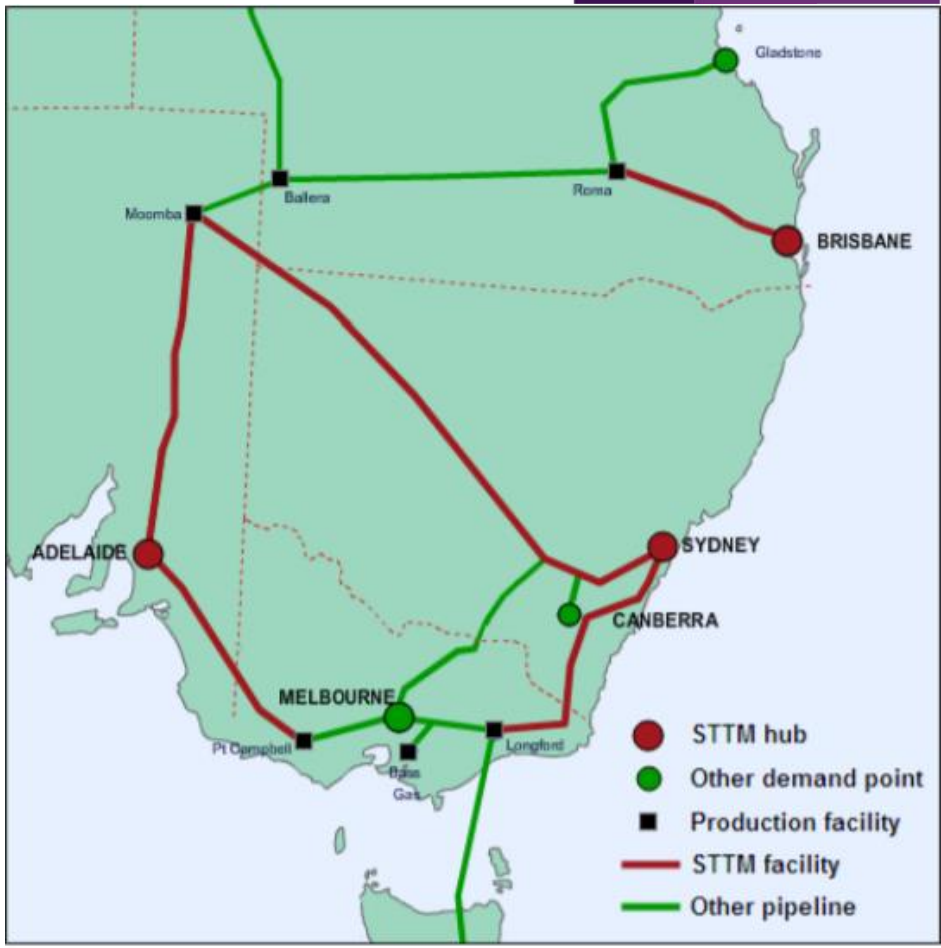
$1.3 billion
Value of all gas scheduled in the market (ex-ante)

40
Market participants

- Established in 2010 to facilitate trading at demand hubs.
- Hubs in Sydney, Adelaide, and Brisbane
- Daily market designed to provide transparent market information
- All gas flow through the hub is traded in the STTM
- Participants can choose to buy gas on the spot market
- Hubs operate independently of each other but operate under the same rules

STTM - Roles

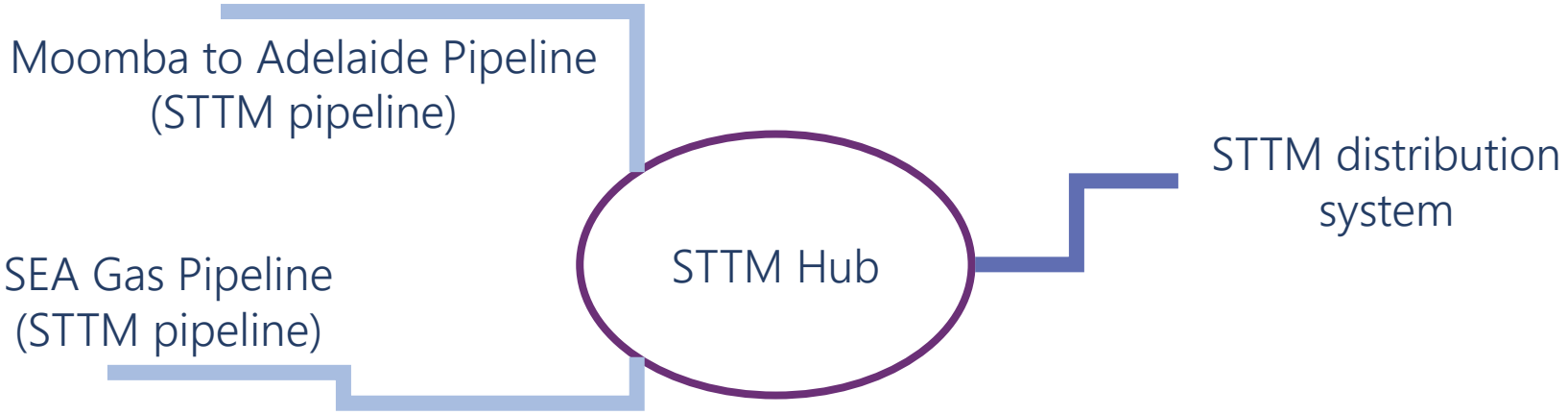
AEMO	Market Participants	Service Providers / Asset owners
• Market operator • Coordinates Contingency Gas in response to a market shortfall	• Contract for supply of gas from producers, or can purchase from the spot market (STTM) • Forecast their gas demand – place bids for this demand • Nominate directly with facility operators (pipelines, production and storage)	• Pipelines • Production Facilities • Storage Facilities • Allocation Agents • Operate and manage own assets based on nominations from customers (shippers) who are scheduled by the market (STTM). • Curtailment / Emergency Management



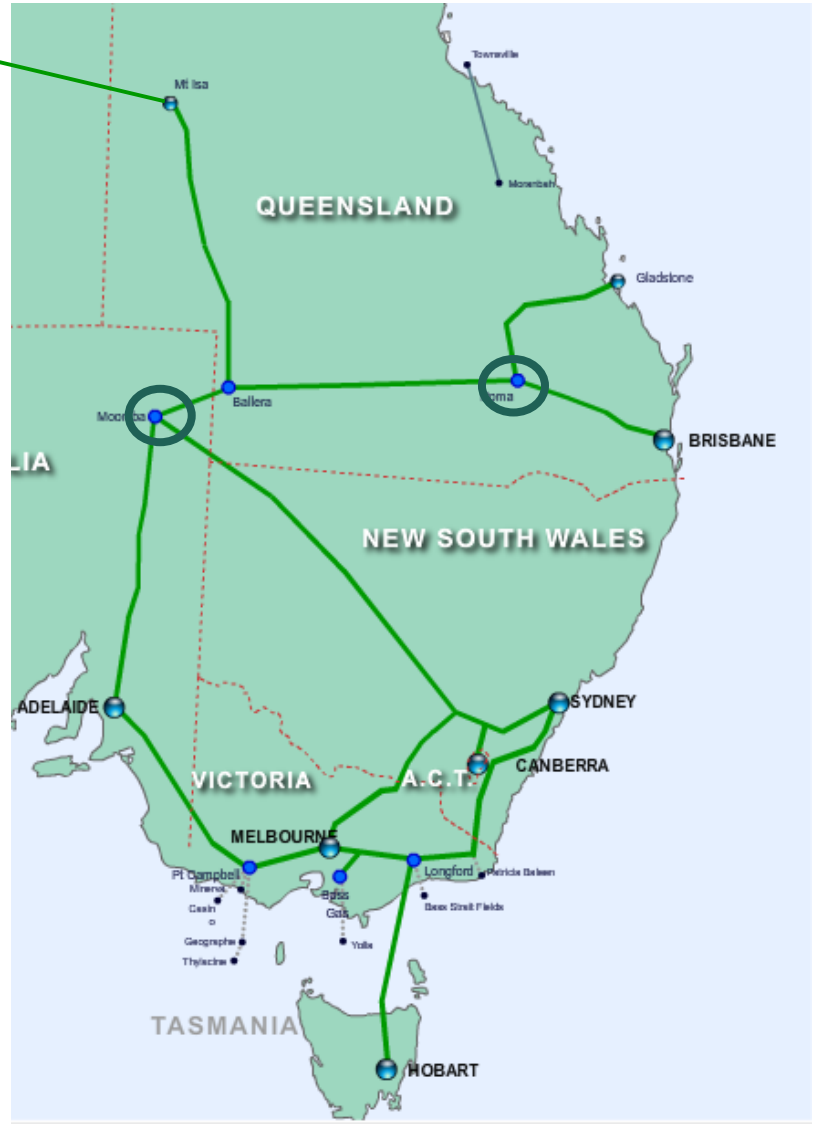
Key market concepts

- All gas flowing into the hub is traded through the STTM
- Ex Ante schedule: bids and offers from market participants scheduled by 12:30pm prior to the Gas Day with consideration of pipeline capacity.
- Market participants nominate directly with pipeline operators (by ~4:00pm)
- Intra-day balancing: market operator service (MOS) for flow variations
- Ex Post schedule: after the gas day has finished, ex post schedule and price published for balancing compared to what actually happened.

EXAMPLE:
The STTM representation of facilities: Adelaide



Gas Supply Hub (GSH)



Gas Supply Hub

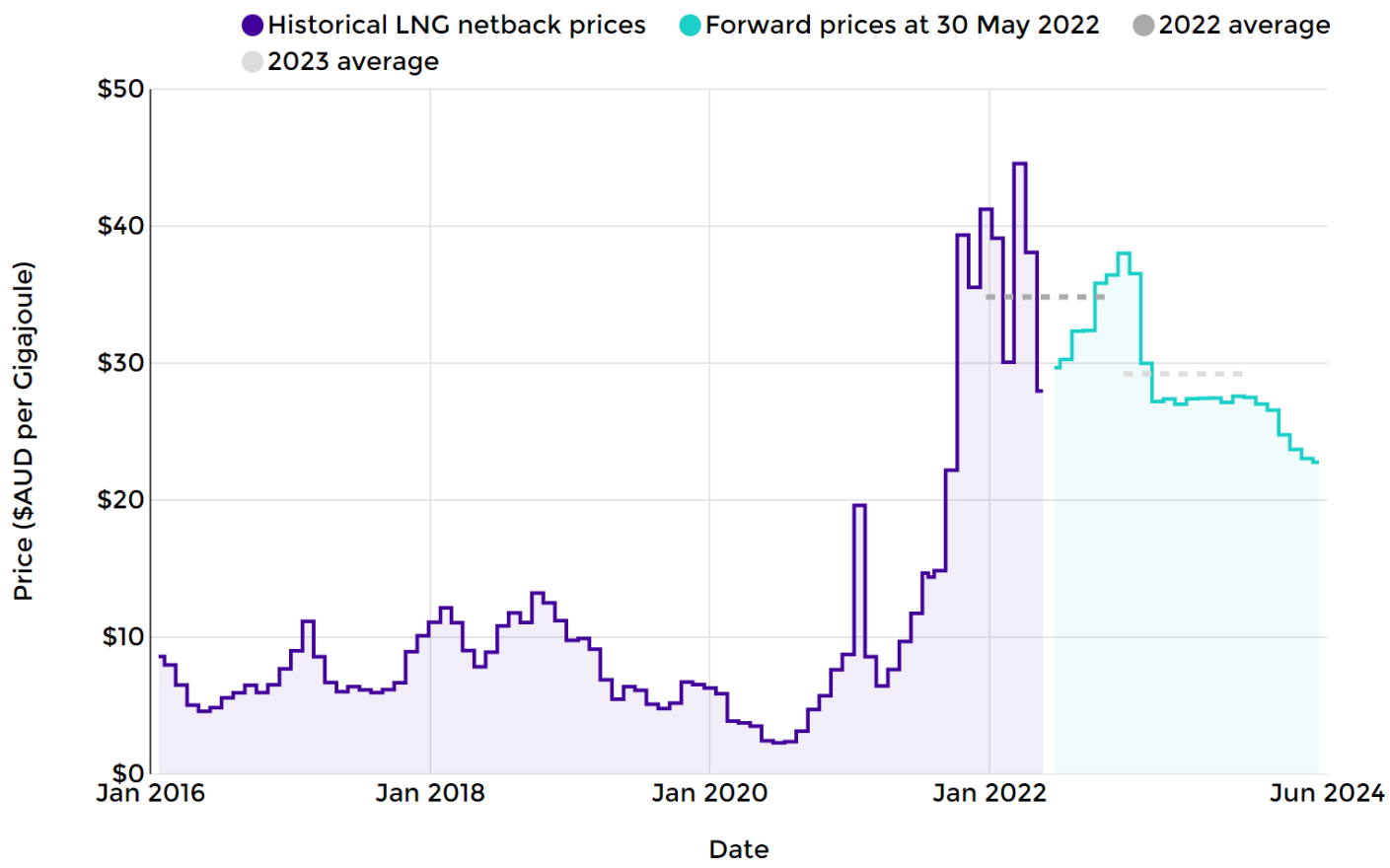
The Gas Supply Hub is a wholesale market that supports the efficient trade and movement of gas between regions, enhancing gas trading transparency and setting a reference price for participants. Gas Supply Hubs operate at Wallumbilla and Moomba.

1,917	16.4 PJ	$147.6 million	16
Number of trades	Quantity of gas traded	Market value traded	Trading participants

- Voluntary market established in 2014.
- The GSH is an exchange for the wholesale trading of natural gas, to enable improved wholesale trading for east cost and southern markets affected by liquefied natural gas (LNG) exports in QLD.
- Through an electronic platform, GSH participants can trade standardised, short-term physical gas products at pipelines connecting at Wallumbilla and Moomba.

International Price Impacts on GSH

- High international LNG prices has resulted in high Queensland LNG netback prices and limited gas supply from Queensland to the southern states since late 2021.
- Reduced LNG Netback pricing is anticipated during winter 2022 although prices are likely to remain high due to international events.

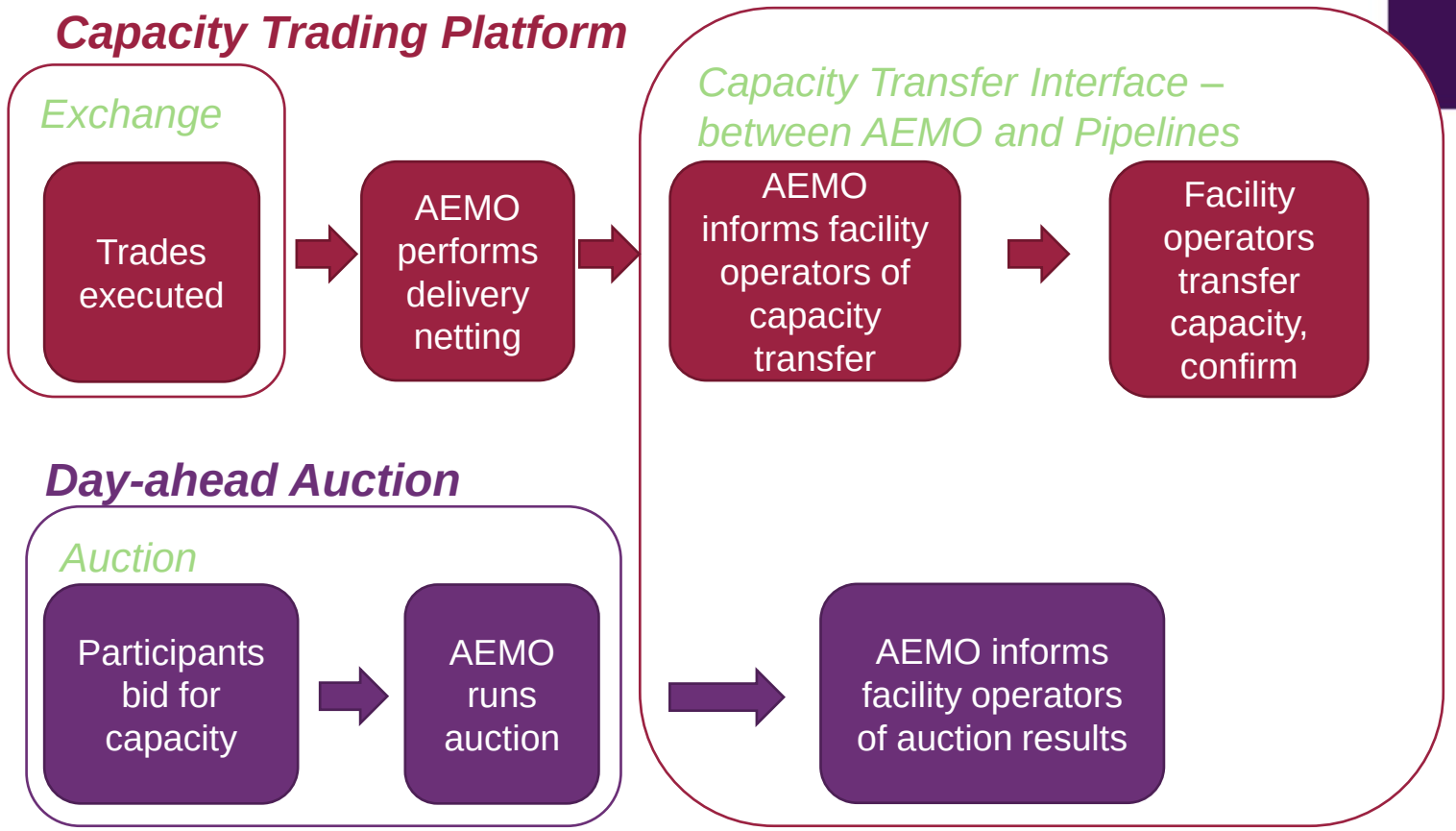


Source: ACCC Gas inquiry 2017-2025 LNG netback price series – 1 June 2022
https://www.accc.gov.au/regulated-infrastructure/energy/gas-inquiry-2017-2025/lng-netback-price-series

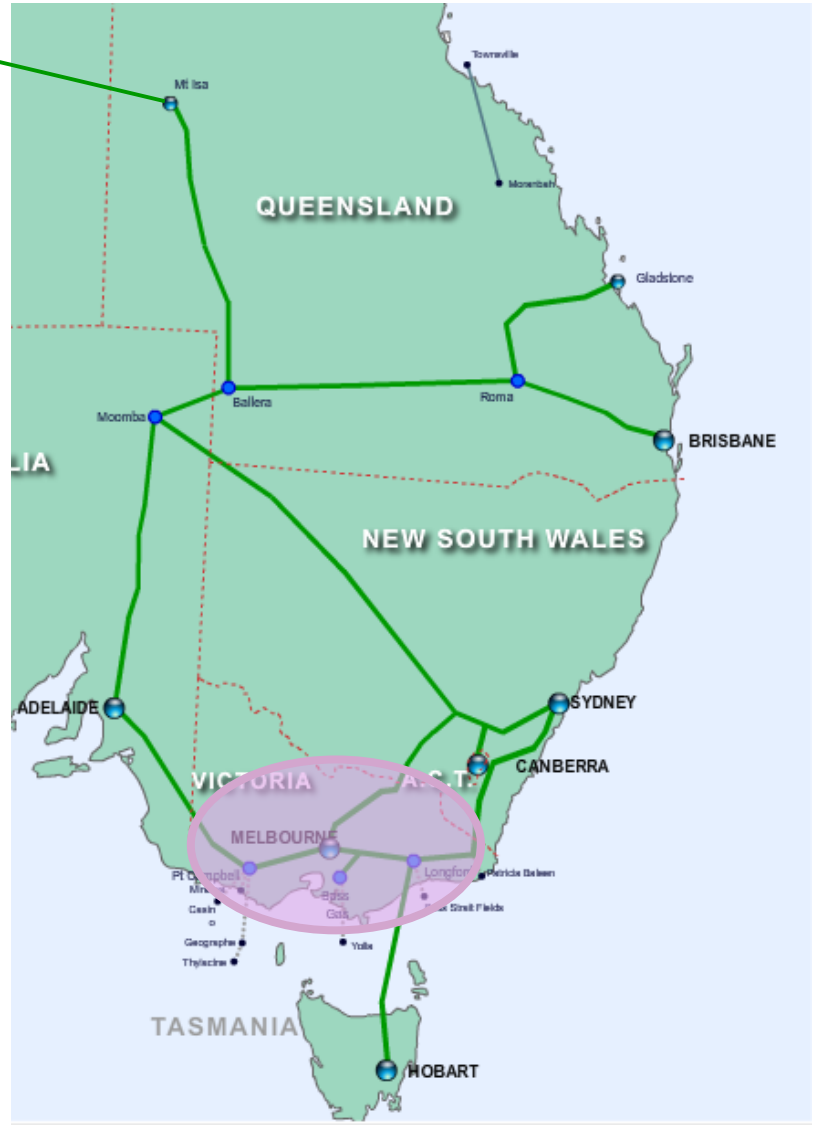
CTP and DAA Overview

Established 1 March 2019 to facilitate trading of unused transportation capacity on gas pipelines and compression facilities.

- Capacity trading platform (CTP)
  - Provides an exchange for participants to trade firm pipeline capacity between one another
  - Continuous trading between 9am and 7pm each day
- Day ahead auction (DAA)
  - Daily auction for contracted but unnominated (unutilised) pipeline capacity at 5pm



Declared Wholesale Gas Market



Declared Wholesale Gas Market

The Declared Wholesale Gas Market (DWGM) was established to enable competitive and dynamic trading on injections and withdrawals from the Victorian Gas Declared Transmission System.

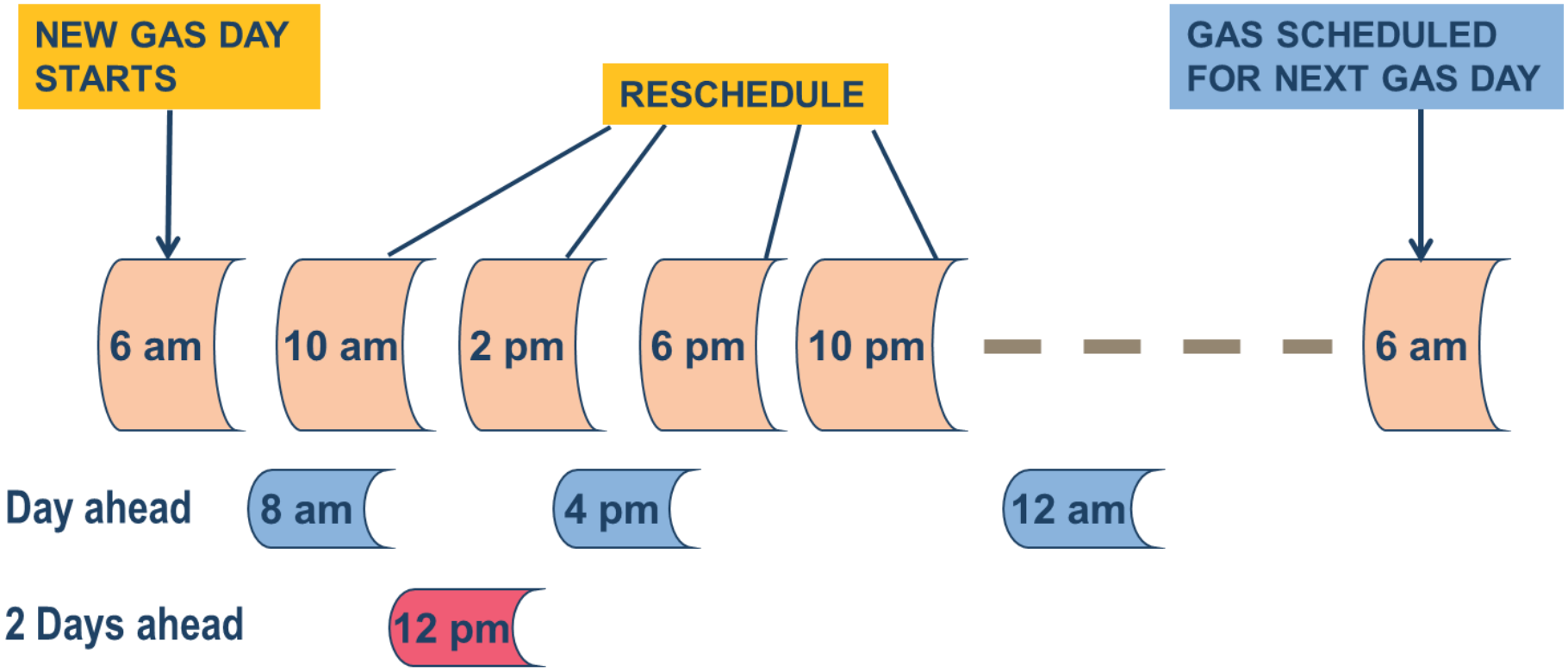
204 PJ	10 PJ	$2.2 billion	59
Total annual consumption	Gas-Powered Generation consumption	Value of all gas scheduled in the market	Market participants

- Established in 1999 to enable competitive trading of gas within the Victorian Gas Declared Transmission System (DTS).
- Market designed to manage intra-day gas demand changes due to weather changes and gas generation
- Victoria has the highest residential gas use in Australia of about 2 million customers
  - Mostly small customers below 10TJ per year
  - Only ~800 customers use 10 TJ per year or more
- Highest daily demand 1,308 TJ

DWGM - Roles

AEMO	Market Participants	Service Providers / Asset owners
• Market and system operator • Emergency Management in the DTS • Provide planning information to market (Victorian Gas Planning Report [VGPR])	• Contract for supply of gas from producers and storage providers • Or can purchase from the spot market (DWGM) • Forecast their gas demand • Inject gas per DWGM schedule to supply their customers	• DTS owner (DTSSP) • Production Facilities • Storage Facilities • Interconnected Pipelines • Distributors • Allocation Agents

DWGM Scheduling Times



- All market quantities for the Gas Day at traded at the 6:00 am “Beginning of Day” scheduled
- Updated market quantities are traded 4 hourly to cover deviations from forecast demand and scheduled flows into and out of the market
- “Ad hoc” schedules in response to a Threat to System Security

Gas Markets Summary

Market	Location	Type	Mandatory / Voluntary	Max Price $/GJ	Min Price $/GJ
Declared Wholesale Gas Market (DWGM)	Victorian Declared Transmission System	Commodity (Market Carriage)	Mandatory (Gross)	800	0
Short Term Trading Market (STTM)	Brisbane, Sydney and Adelaide	Commodity (Hub)	Mandatory (Gross)	400	0
Gas Supply Hub (GSH)	Wallumbilla, Moomba	Commodity	Voluntary (Net)	999*	-100
Day Ahead Auction (DAA)	Most east coast pipelines	Capacity	Voluntary (Auction) (mandatory for capacity to be made available)	50*	0
Capacity Trading Platform (CTP)	Most east coast pipelines	Capacity	Voluntary (Net)	1,000*	0

*max price in voluntary markets for “fat-finger” error, rather than price cap

Gas Metering

Wholesale Gas Metering

Accurate Gas Metering is required to settle the gas markets

Gas meters measure gas flow not energy

1. Measured flow is converted to a Standard Volume, which is defined as the volume of gas at Standard Conditions (1 atmosphere and 15°C).

Standard Volume (V) = Flow (F) x Pressure Correction Factor (PCF)

2. The energy content (or Heating Value) of the gas is determined using a gas chromatograph based on the composition of the gas.

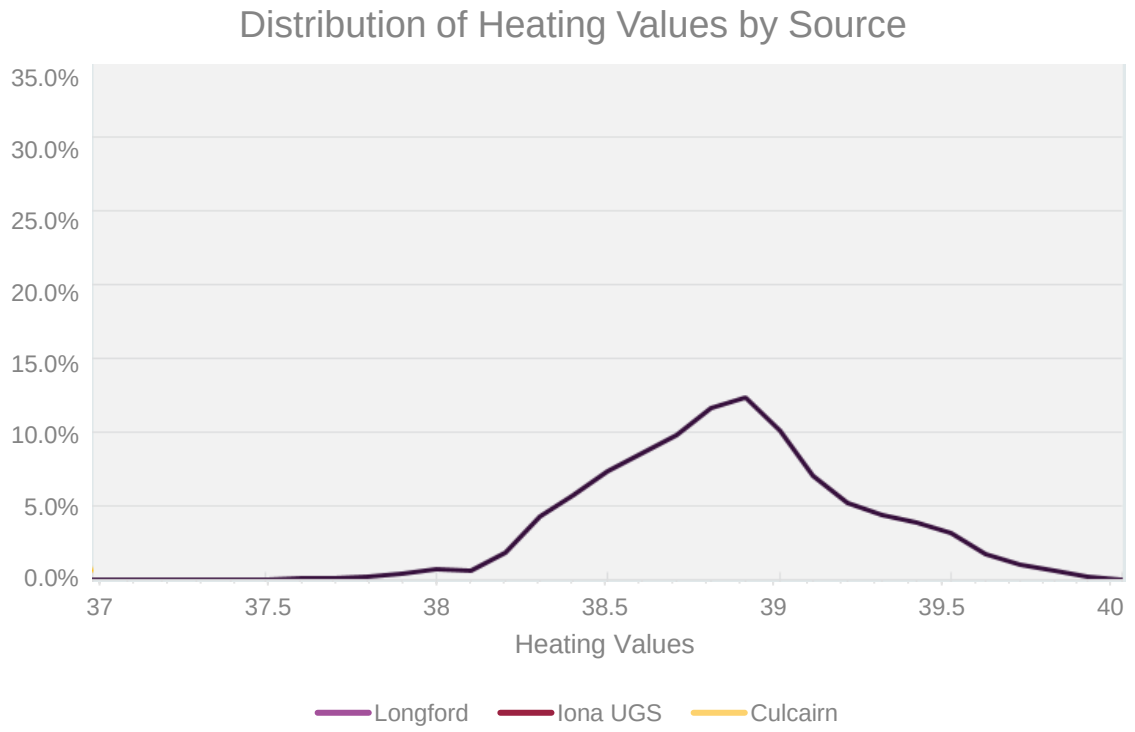
3. Energy is calculated using the following formula:

Energy = Heating Value (HV) x Standard Volume (V)

= Heating Value x Pressure Correction Factor x Flow

Heating Value variability by source

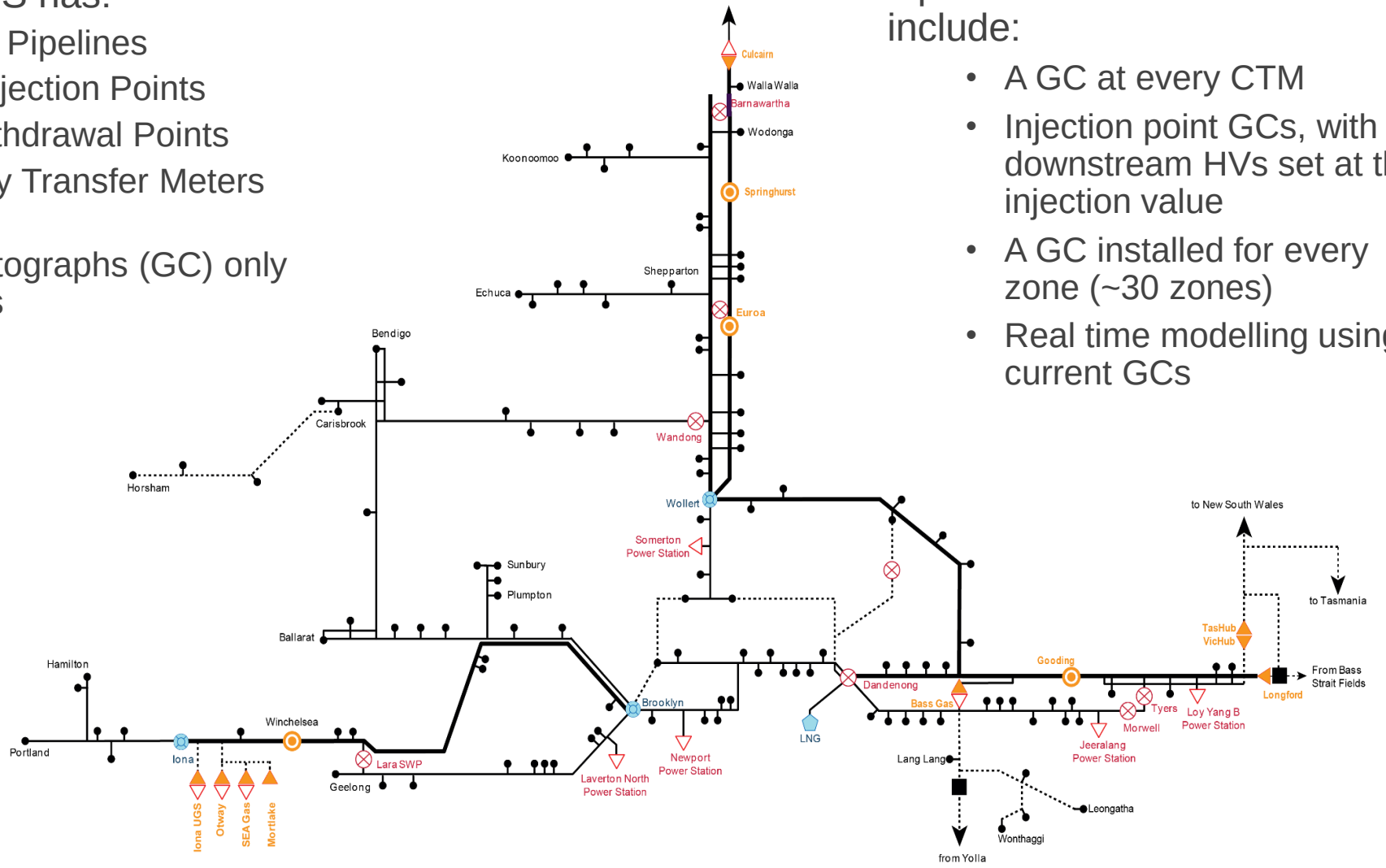
- Heating value of Longford varies due to the large number of offshore gas fields, three processing trains, and ability to vary ethane content.
- Culcairn heating value displays a bimodal curve due to coal seam gas supply during winter. Culcairn is also a withdrawal point so DTS pipeline is bidirectional.
- Iona underground gas storage plant delivers more consistent HV gas into the DTS due to drier gas fields.
- Otway Gas Plant can supply higher HV gas.
- Iona is a usually a withdrawal point outside of winter unless demand is high and/or Longford is reduced.



Options for measuring Heating Value

The Victorian DTS has:

- Bi-directional Pipelines
- 10 System Injection Points
- 6 System Withdrawal Points
- ~170 Custody Transfer Meters (CTM)
- Gas Chromatographs (GC) only at major sites



Options for HV determination include:

- A GC at every CTM
- Injection point GCs, with all downstream HVs set at the injection value
- A GC installed for every zone (~30 zones)
- Real time modelling using current GCs

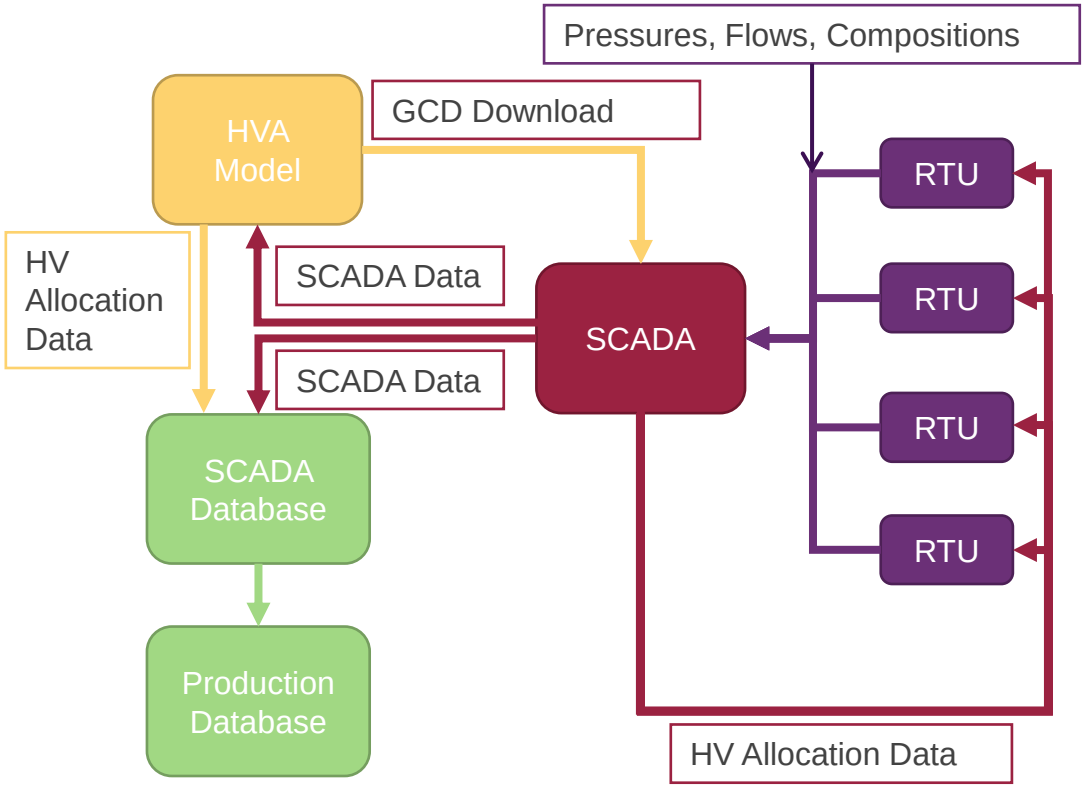
Heating Value Allocation Model

- System developed in 2018
- The model was built using DNV Synergi Pipeline Simulator
- Utilises SCADA flows, pressures and gas quality data, the system calculates the Heating Value in real time
- In progress system enhancement to track off-specification gas in the DTS

RTU – Remote Terminal Unit (field meter or GC)

SCADA – Supervisory control and data acquisition

GCD – Gas Composition Data



Gas Quality Guidelines

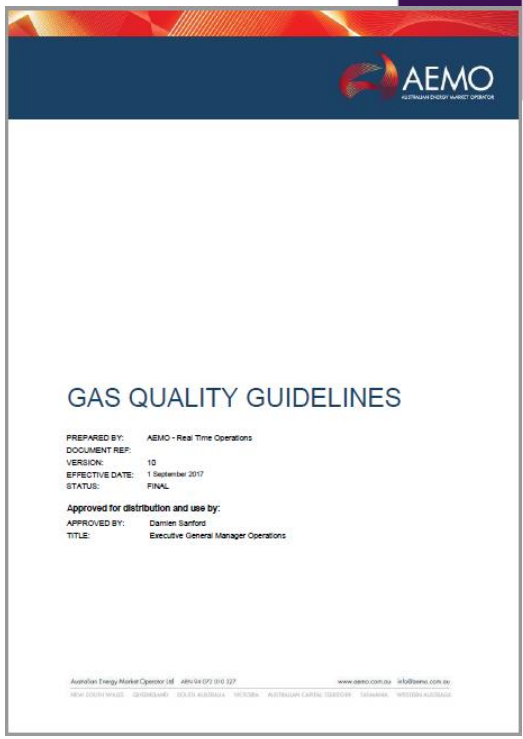
Balance risks to public safety by the supply of off-specification gas, with the risks to public safety associated with curtailment of the injection, subsequent system disruption and re-lights within the premises of gas consumers.

Gas Safety Act 1997

Section 32(c) – manage and operate to minimise, as far as 'practicable', the hazards and risks to the safety of the public and customers arising from interruptions to the supply of gas and the reinstatement of an interrupted gas supply; and

Section 33 - ensure that, as far as 'practicable', the gas which it conveys meets the prescribed standards of 'quality'.

		Low					High			
Parameter	Units	Curtail	Mitigate	Notify	Confirm		Confirm	Notify	Mitigate	Curtail
Initial response time[b]	minutes	30	30	10	10		10	10	30	30
Wobbe	MJ/m^3	44	45	46	47		51.5	52	52.5	53.5
Heating Value	MJ/m^3	–	–	–	–		41.8	42.3	42.6	43.0
Hydrocarbon dewpoint	^{0}C	–	–	–	–		1	2	3	5
Water content	mg/m^3	–	–	–	–		65	73	93	105
Hydrogen sulphide	mg/m^3	–	–	–	–		4.5	5.7	5.8	10
Mercaptan sulphur	mg/m^3	–	–	–	–		4.5	5	10	– [c]
Total sulphur	mg/m^3	–	–	–	–		45	50	100	200
Temperature	^{0}C	–10 2 hrs	–2 24 hrs	2	3		45	50	55	60
Oxygen	Mol%	–	–	–	–		0.15	0.20	2.0	5.0
Total inerts	Mol%	–	–	–	–		6.5	7.0	7.2	7.5
Odorant	mg/m^3	2.0 2 hrs	4.0	6.0	6.5		14.5	15	24	– [d]



Gas Retail Market

Gas Retail Market

- AEMO's gas retail markets allow licensed retailers to sell natural gas to residential and business customers in New South Wales, the Australian Capital Territory, Queensland, South Australia, Victoria and Western Australia.
- Provides over 5 million gas consumers with the ability to contract for the supply of gas with any licensed retailer of their choice, and facilitates the interactions between industry participants required to support efficient operation of the markets.
- The gas retail markets are operated according to a set of processes, responsibilities and obligations that AEMO administers; AEMO also provides the systems to facilitate interactions between industry participants.

Gas Retail Market Services

There are four primary gas retail market services that AEMO administers:

- Delivery Point Management – managing the customer transfer for gas delivery points and the associated market data between retailers, and between retailers and distribution businesses.
- Balancing, Allocation and Reconciliation Management – managing the daily allocation of gas usage to retailers to enable settlement of gas supply contracts, transmission and distribution use of system contracts.
- Procedure Change Management – managing further development and improvement of the Procedures governing the operation of the retail gas markets under the auspices of the NGL and NGR and the Retail Market Procedures (WA) and Energy Coordination Act (WA)
- Operating the central IT systems that facilitate retail market services.

Retailer of Last Resort (RoLR)

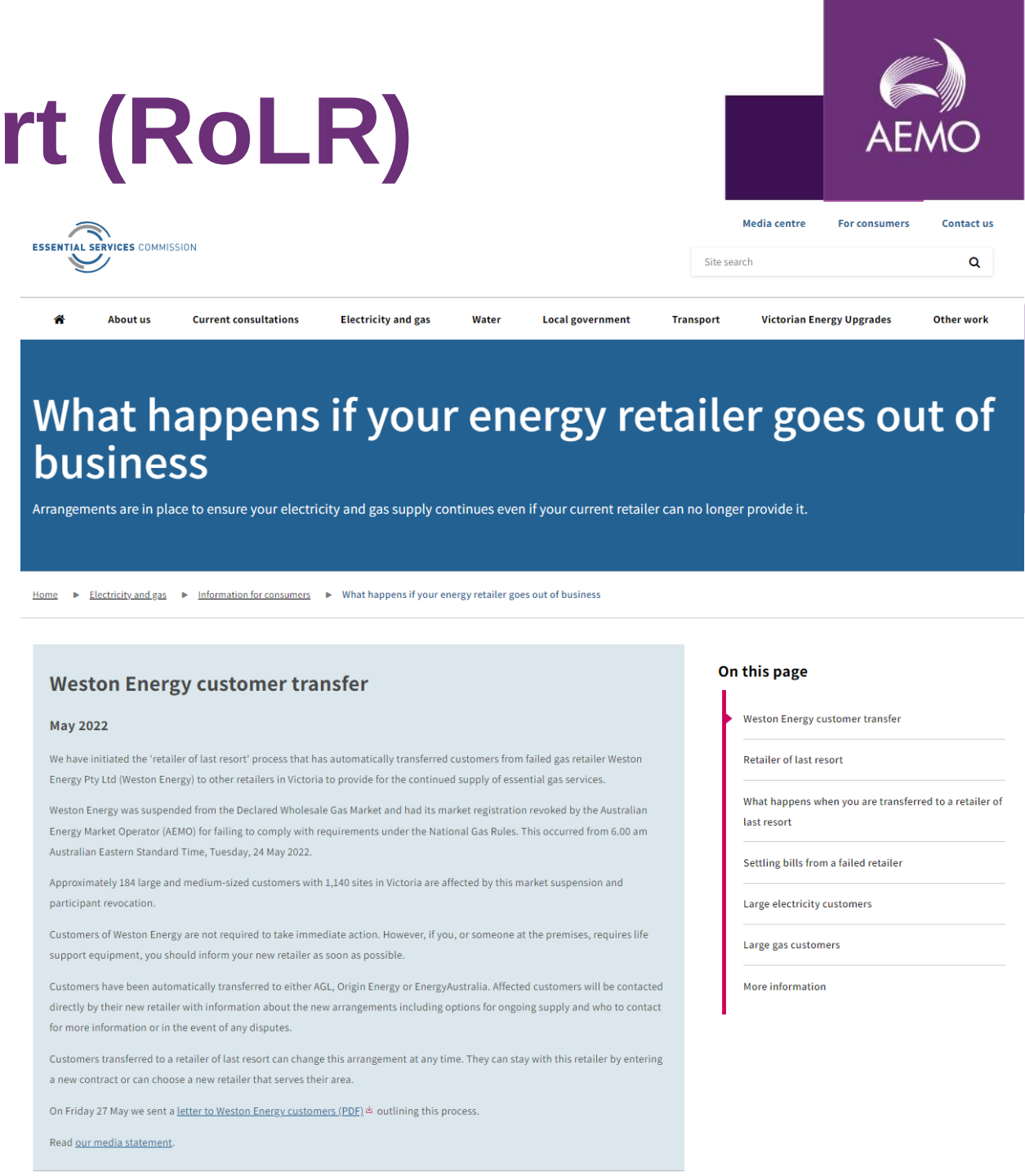
The Retailer of Last Resort mechanism provides customers with a gas and electricity retailer when their current retailer is unable to. In Victoria, this could occur if:

- The Essential Services Commission revokes the energy retailer's licence; or
- The retailer does not have sufficient funds to purchase electricity or gas from the wholesale market and has their right to do so suspended or revoked AEMO.

The gas retailers of last resort in Victoria are:

- AGL for AusNet Distribution gas networks
- EnergyAustralia for Australian Gas Networks
- Origin Energy for Multinet Gas Networks

AEMO processes the customers' transfer to their new retailer.



ESSENTIAL SERVICES COMMISSION

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What happens if your energy retailer goes out of business

Arrangements are in place to ensure your electricity and gas supply continues even if your current retailer can no longer provide it.

Home ▸ Electricity and gas ▸ Information for consumers ▸ What happens if your energy retailer goes out of business

Weston Energy customer transfer

May 2022

We have initiated the 'retailer of last resort' process that has automatically transferred customers from failed gas retailer Weston Energy Pty Ltd (Weston Energy) to other retailers in Victoria to provide for the continued supply of essential gas services.

Weston Energy was suspended from the Declared Wholesale Gas Market and had its market registration revoked by the Australian Energy Market Operator (AEMO) for failing to comply with requirements under the National Gas Rules. This occurred from 6.00 am Australian Eastern Standard Time, Tuesday, 24 May 2022.

Approximately 184 large and medium-sized customers with 1,140 sites in Victoria are affected by this market suspension and participant revocation.

Customers of Weston Energy are not required to take immediate action. However, if you, or someone at the premises, requires life support equipment, you should inform your new retailer as soon as possible.

Customers have been automatically transferred to either AGL, Origin Energy or EnergyAustralia. Affected customers will be contacted directly by their new retailer with information about the new arrangements including options for ongoing supply and who to contact for more information or in the event of any disputes.

Customers transferred to a retailer of last resort can change this arrangement at any time. They can stay with this retailer by entering a new contract or can choose a new retailer that serves their area.

On Friday 27 May we sent a letter to Weston Energy customers (PDF) outlining this process.

Read our media statement.

On this page

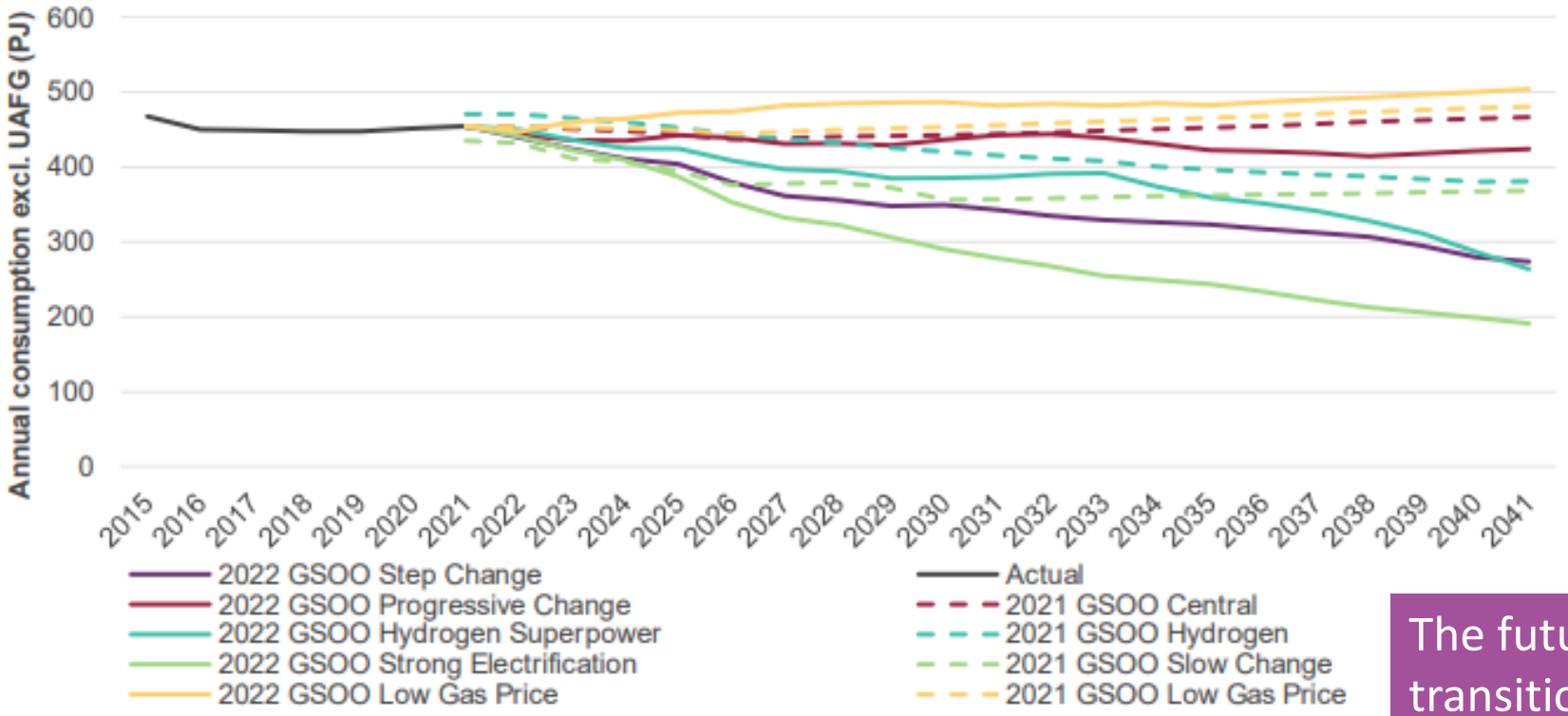
- Weston Energy customer transfer
- Retailer of last resort
- What happens when you are transferred to a retailer of last resort
- Settling bills from a failed retailer
- Large electricity customers
- Large gas customers
- More information

Gas Heating Value – Hydrogen

- AEMO's Retail Market Procedure and the Victorian Gas Distribution System Code currently require that a uniform "State-wide Heating Value" is used for billing customers connected to a gas distribution network.
- Hydrogen produces over 2.5 times the energy per kg combusted vs. the energy per kg of natural gas (Higher Heating Value of 142 MJ/kg vs. 52 MJ/kg for natural gas), but it is much less dense (fewer kg per standard cubic metre) – so a greater volume of hydrogen is needed to deliver the same energy.
- A 10% hydrogen blend could result in metered quantities being over-estimated by approx. 8% if the uniform State-wide Heating Value is used to determine the energy delivered.
- Upgrades to heating value calculations and measurements will be necessary for hydrogen blending, as well as retail metering system changes to manage different heating values.
- Revision to Retail Market Procedure and the Victorian Gas Distribution System Code to allow for zonal or localised heating values.
- DWGM changes to recognise market supply points in distribution networks.

Gas Planning / Supply Shortfall

Domestic consumption outlook (excluding gas generation)



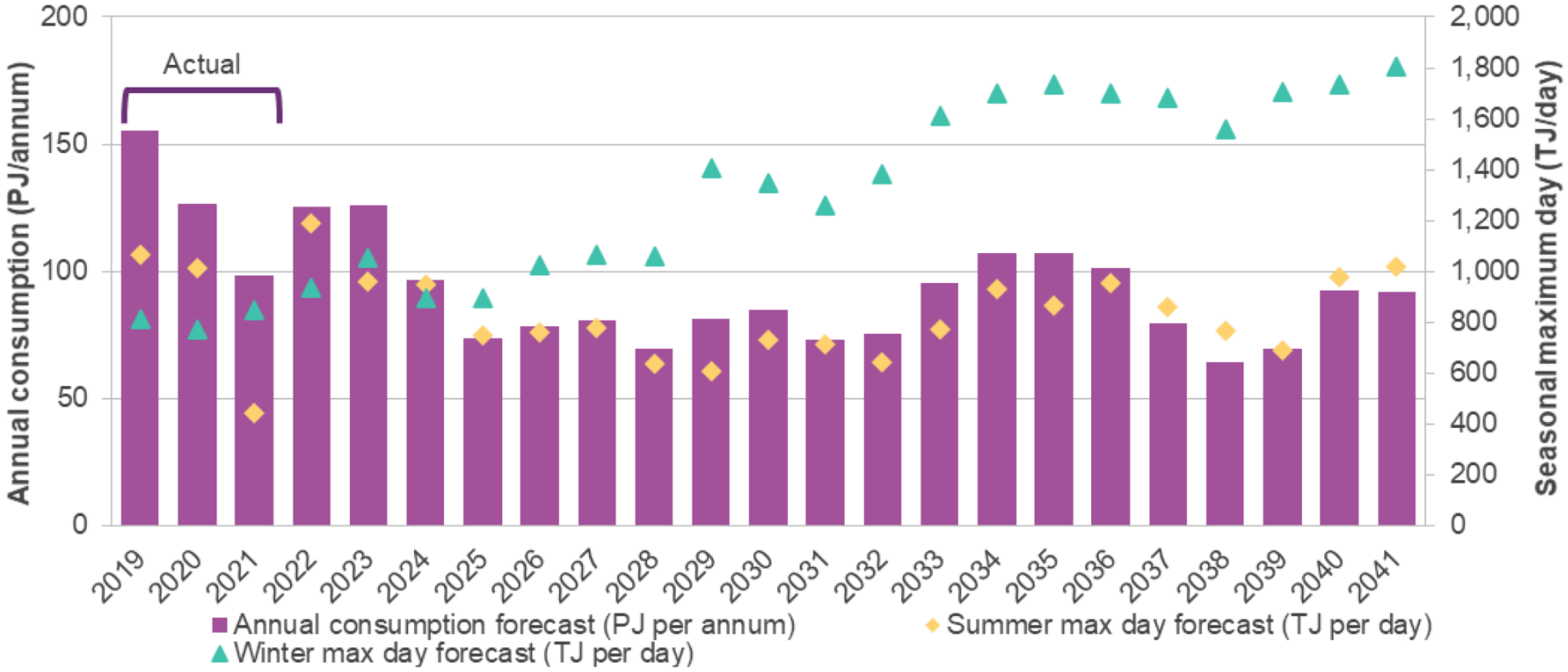
Slower rate of transition

Faster transformation towards net zero emissions

The future role of natural gas as Australia transitions towards net zero emissions is a major uncertainty, exemplified by the speed of electrification and the potential impact of hydrogen

Gas generation seasonal forecasts

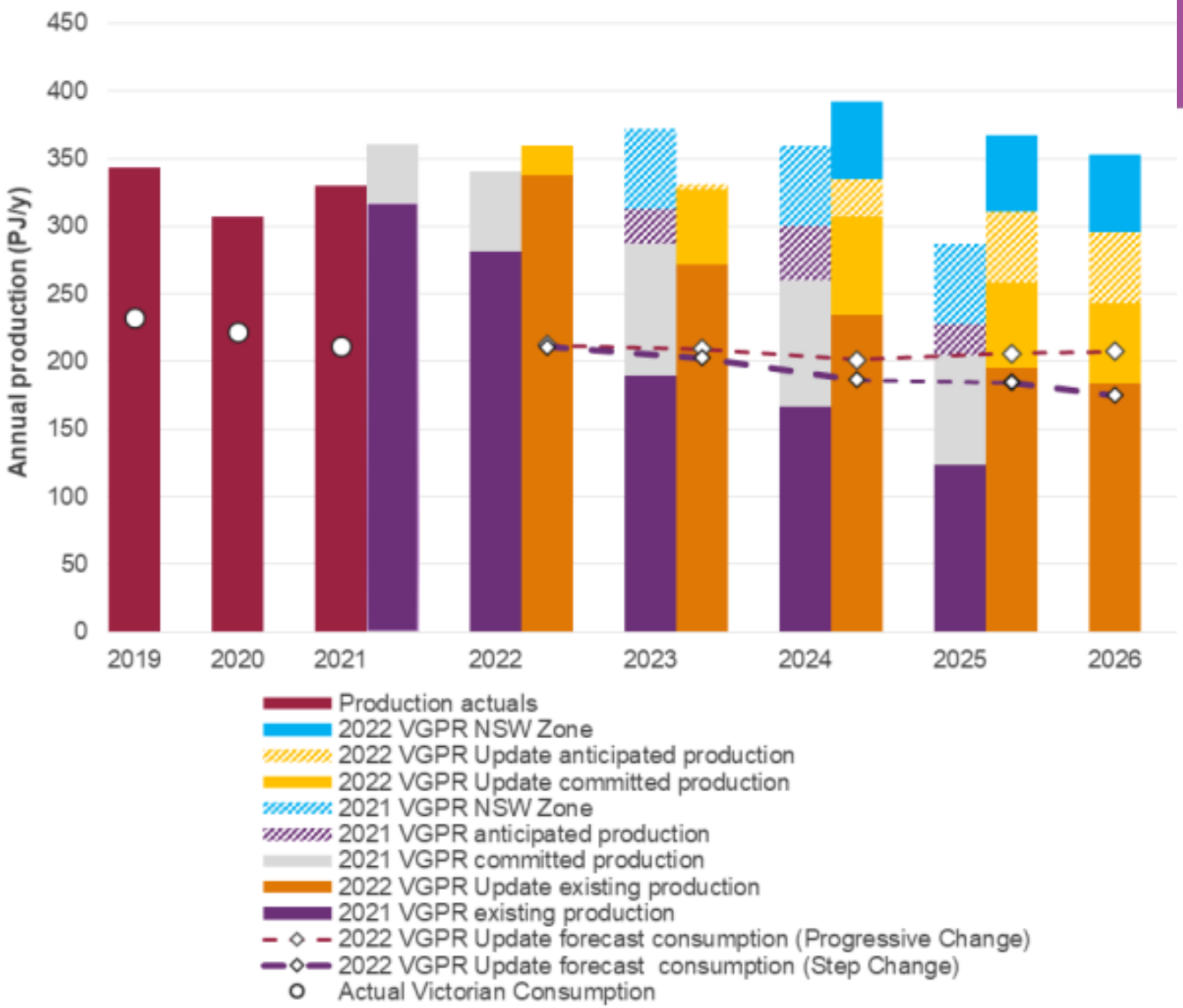
Figure 2 Actual and forecast gas generation annual consumption (PJ/annum) and seasonal maximum daily demand (TJ/d), *Step Change* scenario, 2019-41



Note: The forecast maximum daily demand shown for summer and winter represents the median across different modelled weather patterns.

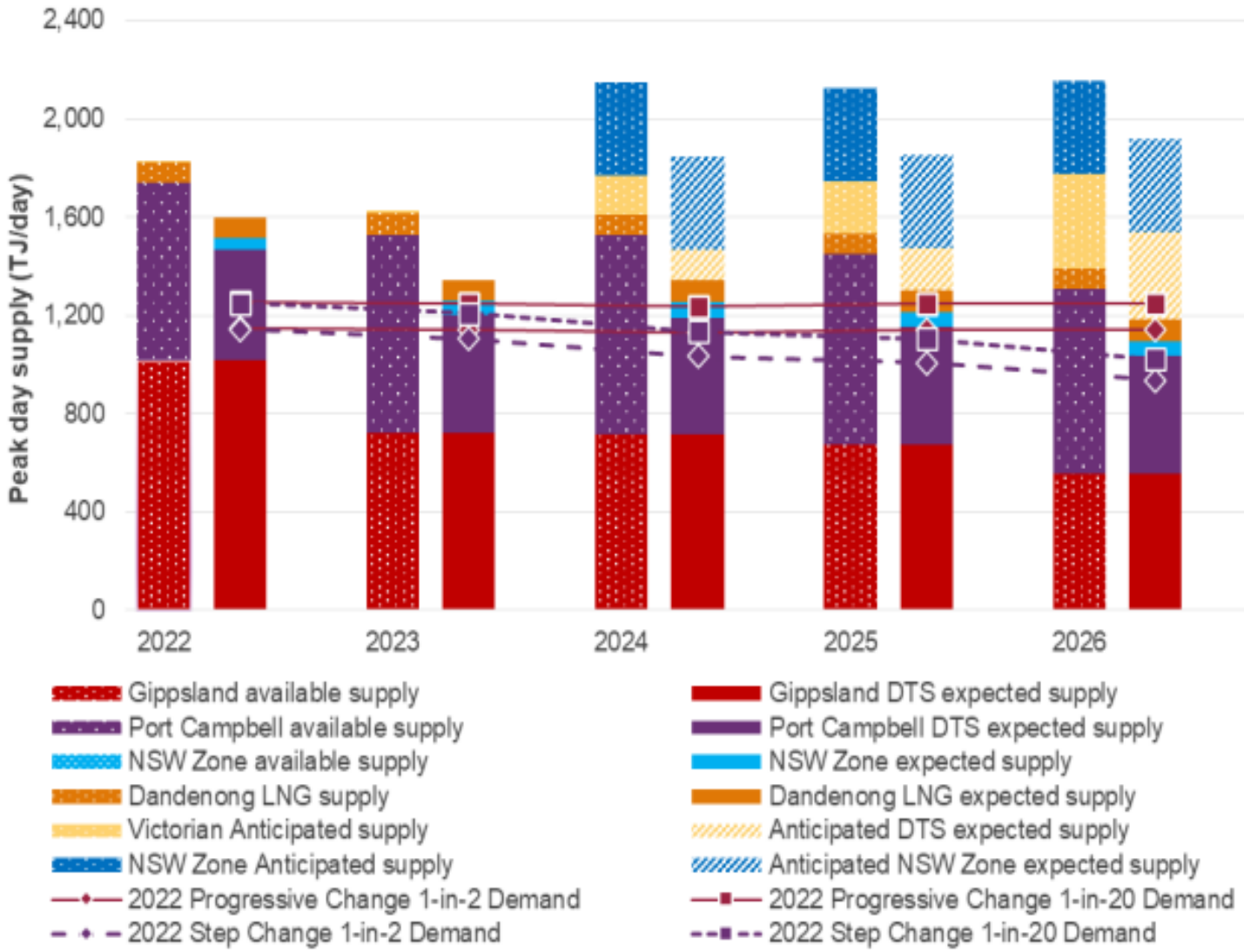
Victorian gas production forecasts

- Victorian production forecasts are higher than in the 2021 VGPR / GSOO
  - Gippsland production reducing from 312 PJ in 2022 to 200 PJ in 2026
  - Retirement of Longford Gas Plant 1 inlet section December 2021 (increased outage risk)
  - Large reduction in Longford production from winter 2023
  - Port Campbell increasing from 33 PJ in 2021 to 48 PJ in 2022, increases again to 69 PJ in 2023, falling to 42 PJ in 2026

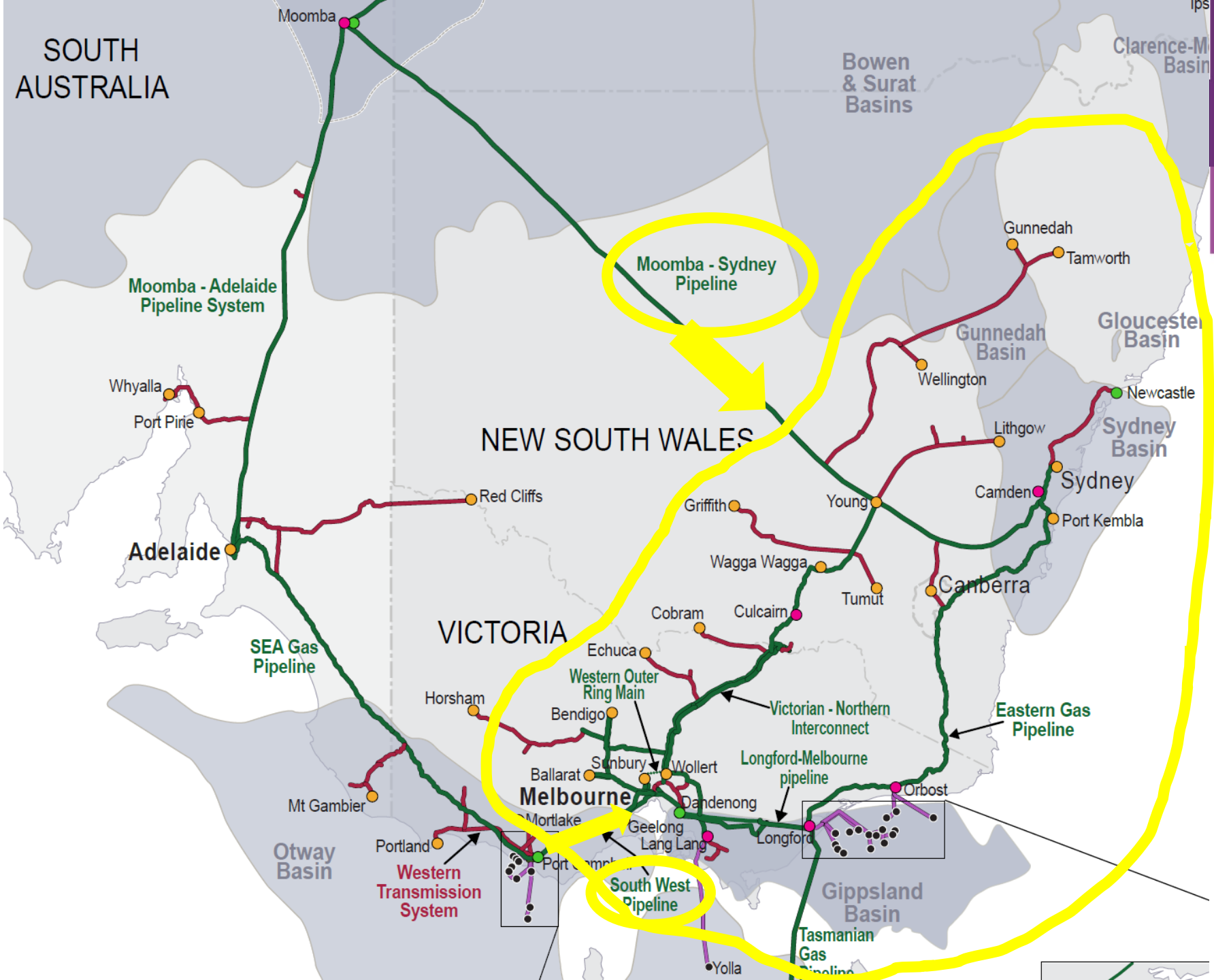


Victorian supply capacity forecasts

- Gippsland supply reduces from 1,018 TJ/d in 2022 to 558 TJ/d in 2026
- Port Campbell supply (includes Iona UGS) increase from 719 TJ/d in 2022 to 803 TJ/d in 2023, then decrease to 725 TJ/d in 2026
- Tight supply-demand balance in 2023 – **unlikely to be sufficient capacity to support gas generation on a peak day**
- No anticipated supply options prior to winter 2023
- Balance tight in 2024-25, and development of anticipated supply needed to avert peak day shortfalls in 2026 under *Progressive Change*



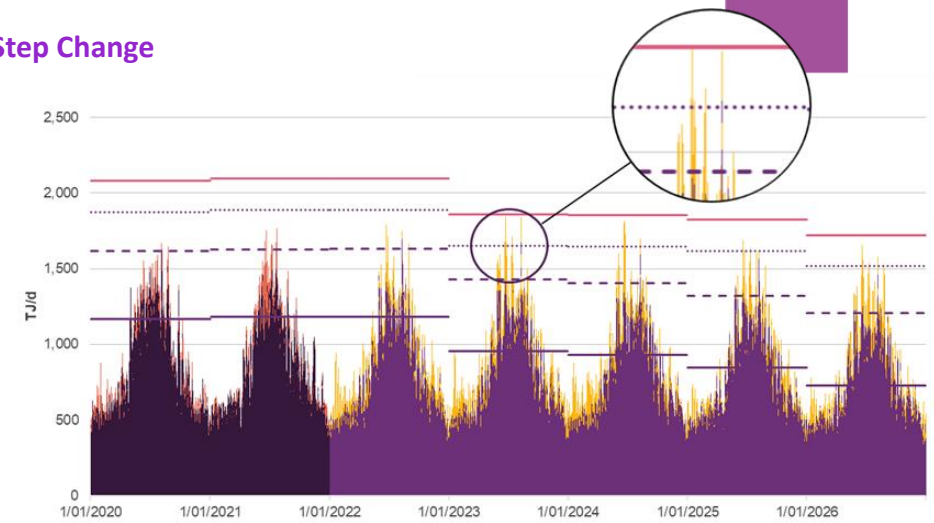
South-east constraint region



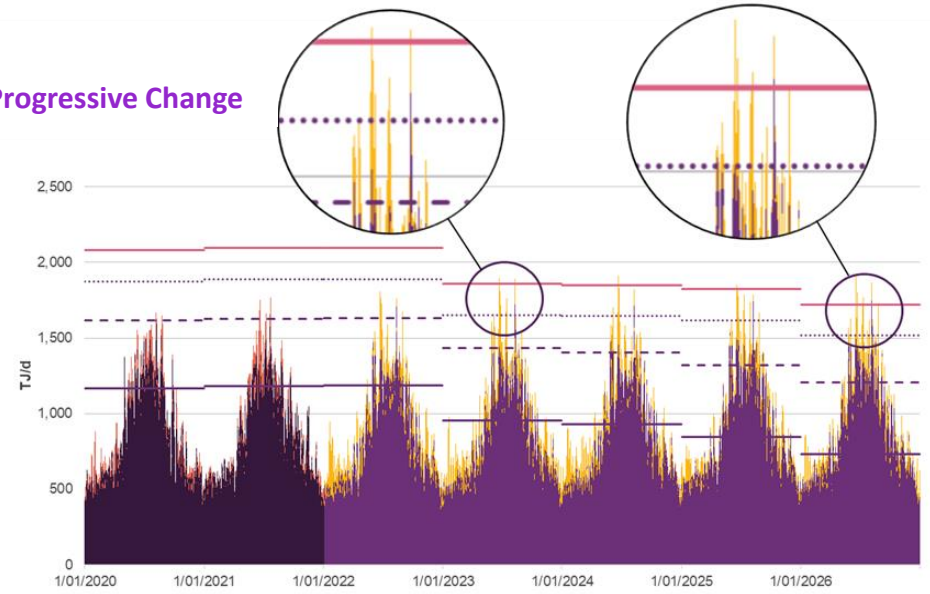
Daily gas supply adequacy in South-eastern region

- Very tight supply/demand balance in 2023 in *Step Change*, while risk of shortfalls in *Progressive Change*.
  - South-eastern gas production declining from 2023
  - Gas generation adds significant peaks, in particular in 2023 (post-Liddell) and 2026 (post-Eraring)
  - Increasing reliance on shallow (LNG) storages
- For 2023, solutions to manage shortfall risks:
  - Delivering committed infrastructure developments on schedule
  - Curtailing gas generation during times of peak gas demand
  - Voluntary demand side participation in the NEM to reduce gas generation
  - Requests through media for voluntary reductions in gas use on peak demand days

Step Change



Progressive Change

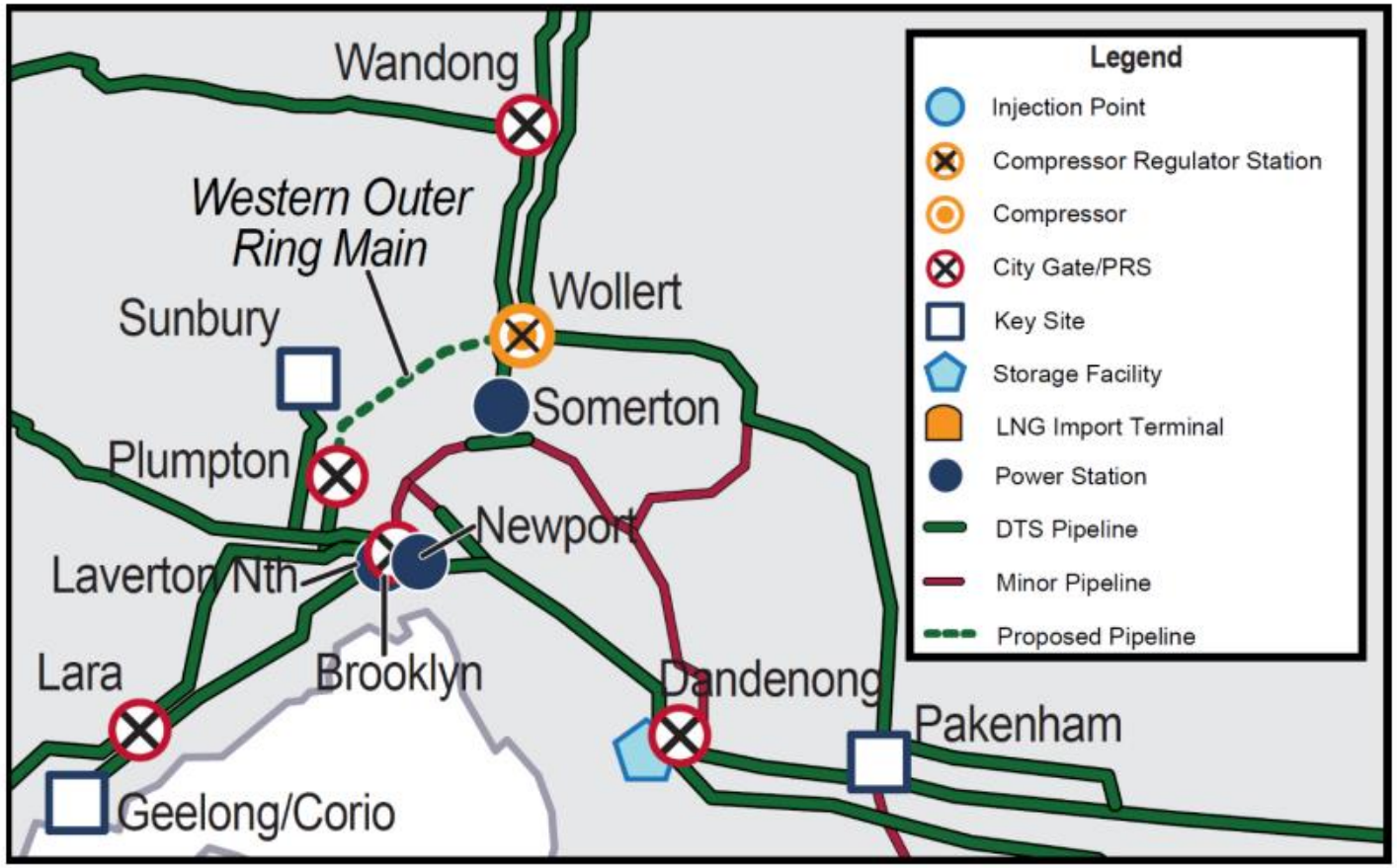


Actual south-eastern demand (gas generation)
Forecast south-eastern demand (gas generation)
Max. south-eastern production
Max. south-eastern production, MSP and constrained deep storage
Actual south-eastern demand (MMLI)
Forecast south-eastern demand (MMLI)
Max. south-eastern production and MSP pipeline capacity
Max. south-eastern production, MSP, constrained deep, and shallow storage

Additional Supply Projects

Western Outer Ring Main (WORM)

- 51 km of new pipeline Plumpton to Wollert
  - Connects SWP to VNI
  - Connects SWP to LMP
- New compressor unit at Wollert
- New PRS allowing flow from WORM into eastern Outer Ring Main

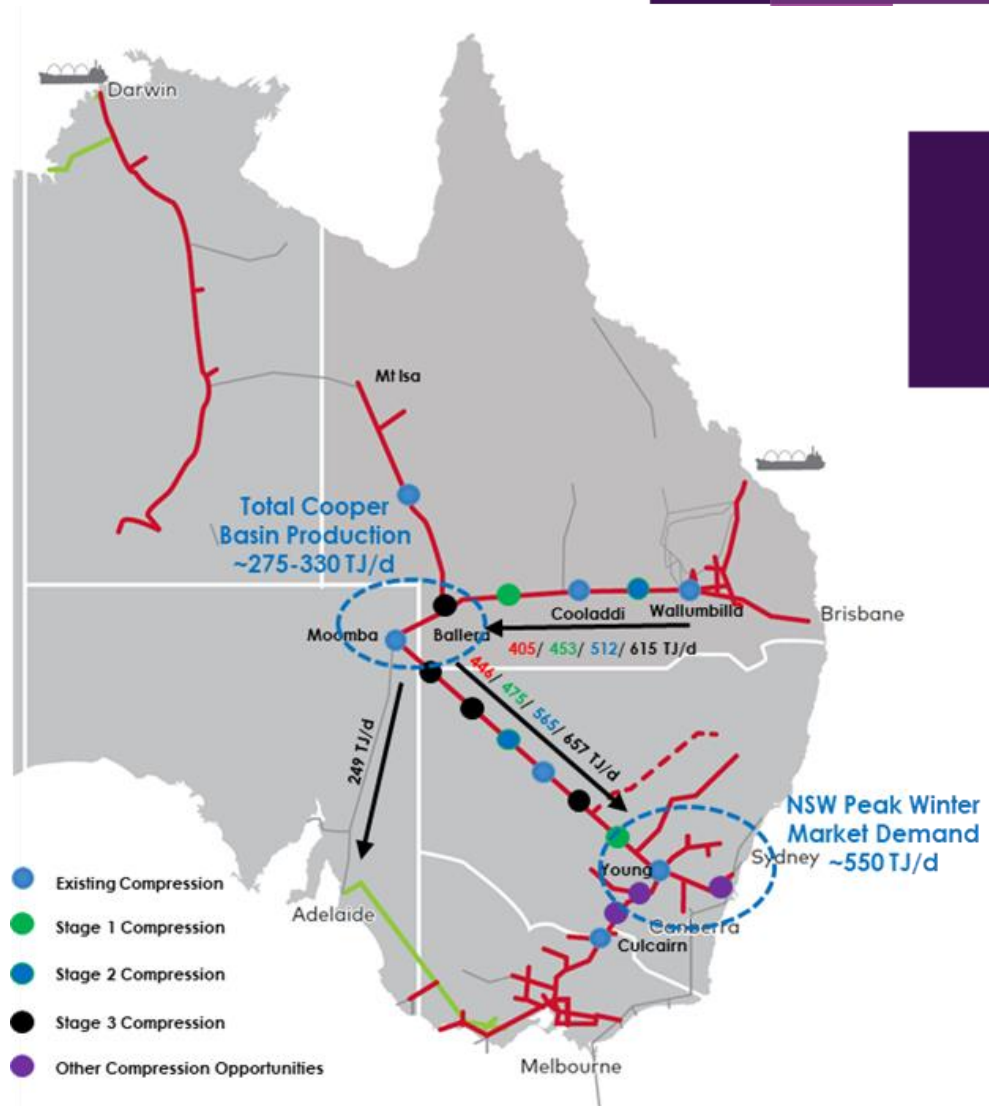


South West Pipeline expansion

- In April 2022 APA Group committed to expanding the capacity the South West Pipeline (SWP) through the addition of a duplicate compressor at Winchelsea prior to winter 2023.
  - Capacity increased by a further 41 TJ/d to 517 TJ/d
  - Estimated cost of $60 million
- Alternative option was to construct two new greenfield compressor stations at Pirron Yallock and Stonehaven (the land at Stonehaven is owned by APA).
  - Capacity increase of ~90 TJ/d, cost expected to be at least $100 million
  - New compressors would not be available until at least 2024 (Stonehaven) and 2025 (Pirron Yallock)
  - Significant schedule risk including planning approvals, establishment of power supply and communications, and cutting into the SWP at Pirron Yallock.

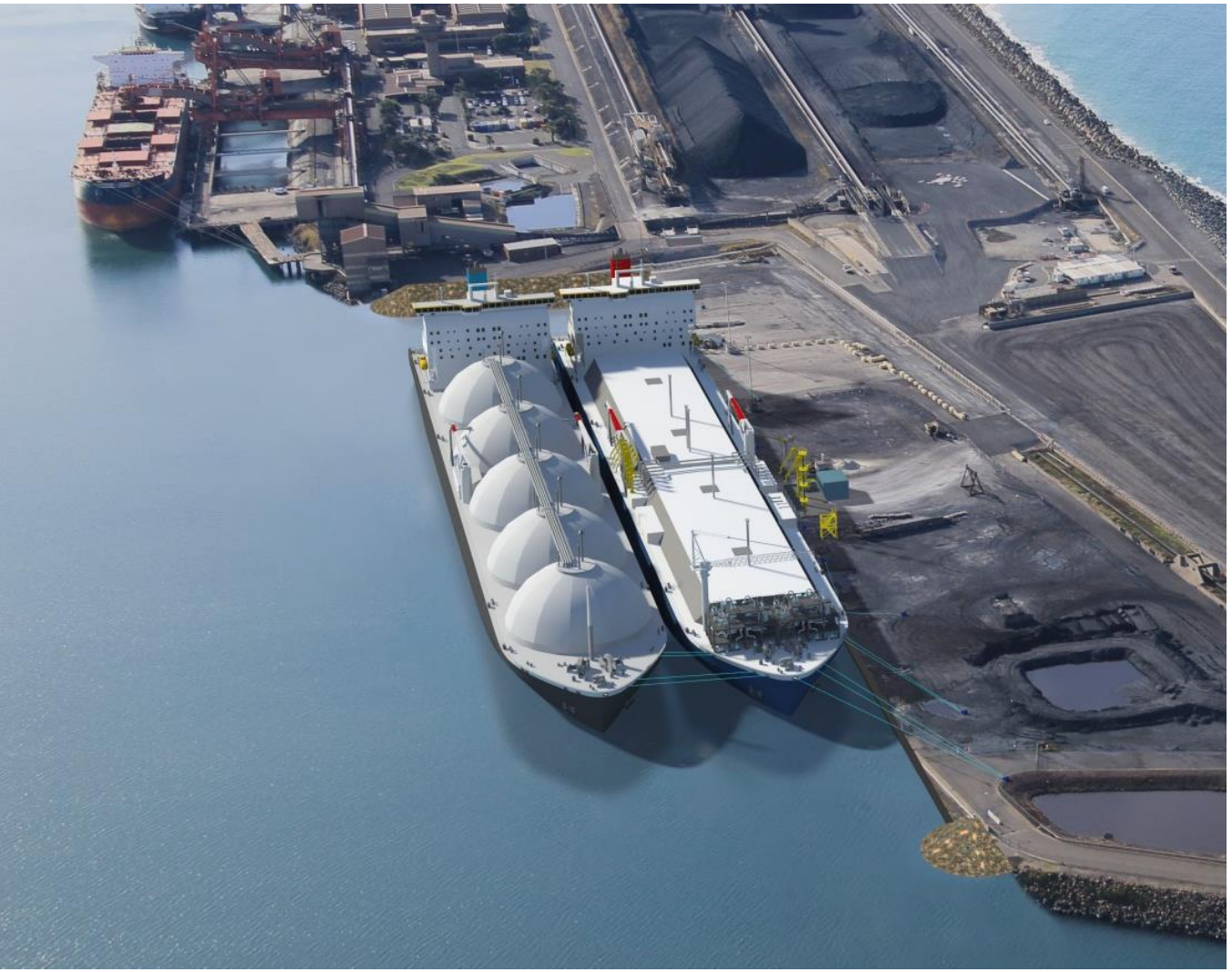
APA East Coast Grid expansion

- Gas flows from Queensland to the southern states is limited by the capacity of the APA East Coast Grid, which includes the South West Queensland Pipeline (SWQP) and Moomba to Sydney Pipeline (MSP).
- On 5 May 2021 APA announced a 25% expansion of the MSP and SWQP at a cost of approx. $270 million, with Stage 1 completed prior to winter 2023:
  - SWQP capacity: 404 TJ/d + 49 TJ/d => 453 TJ/d
  - MSP capacity: 446 TJ/d + 30 TJ/d => **475 TJ/d**
- On 25 May 2022, APA announced that it would commence the Stage 2 expansion, with completion prior to winter 2024:
  - SWQP capacity: 453 TJ/d + 59 TJ/d => 512 TJ/d
  - MSP capacity: 475 TJ/d + 90 TJ/d => **565 TJ/d**



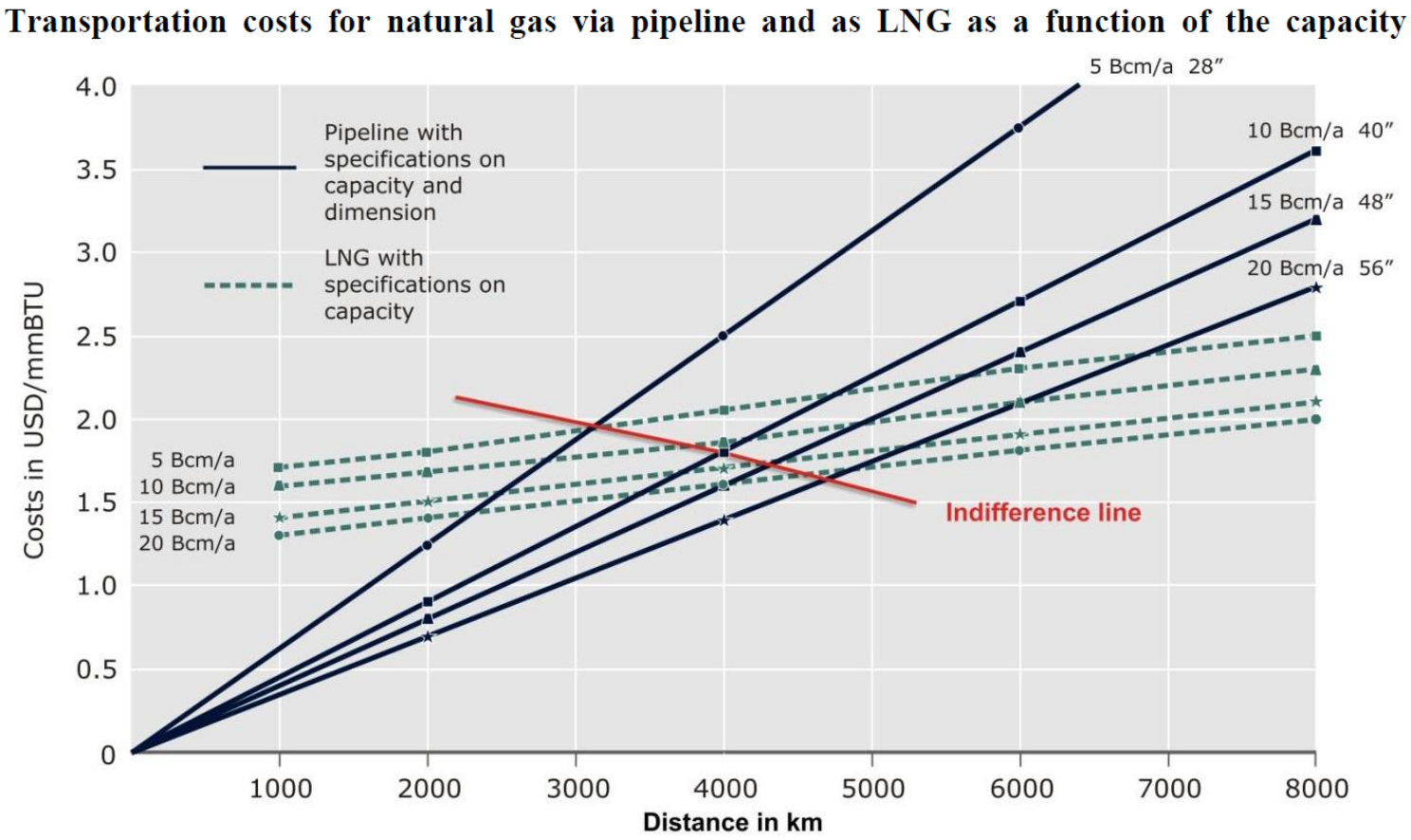
Supplied by APA Group

Port Kembla LNG Import Terminal



- Capacity of ~500 TJ/d – firm
  - 700 TJ/d – non-firm
- Modifications on Jemena Eastern Gas Pipeline (EGP) to enable southbound flow, including VicHub expansion (in additional to northbound flow to Sydney).
- Proposed commissioning date of prior to winter 2024
- Project at risk due to global demand for Floating Storage Regassification Units (FSRUs) due to war in Ukraine.
- Other proposed projects.

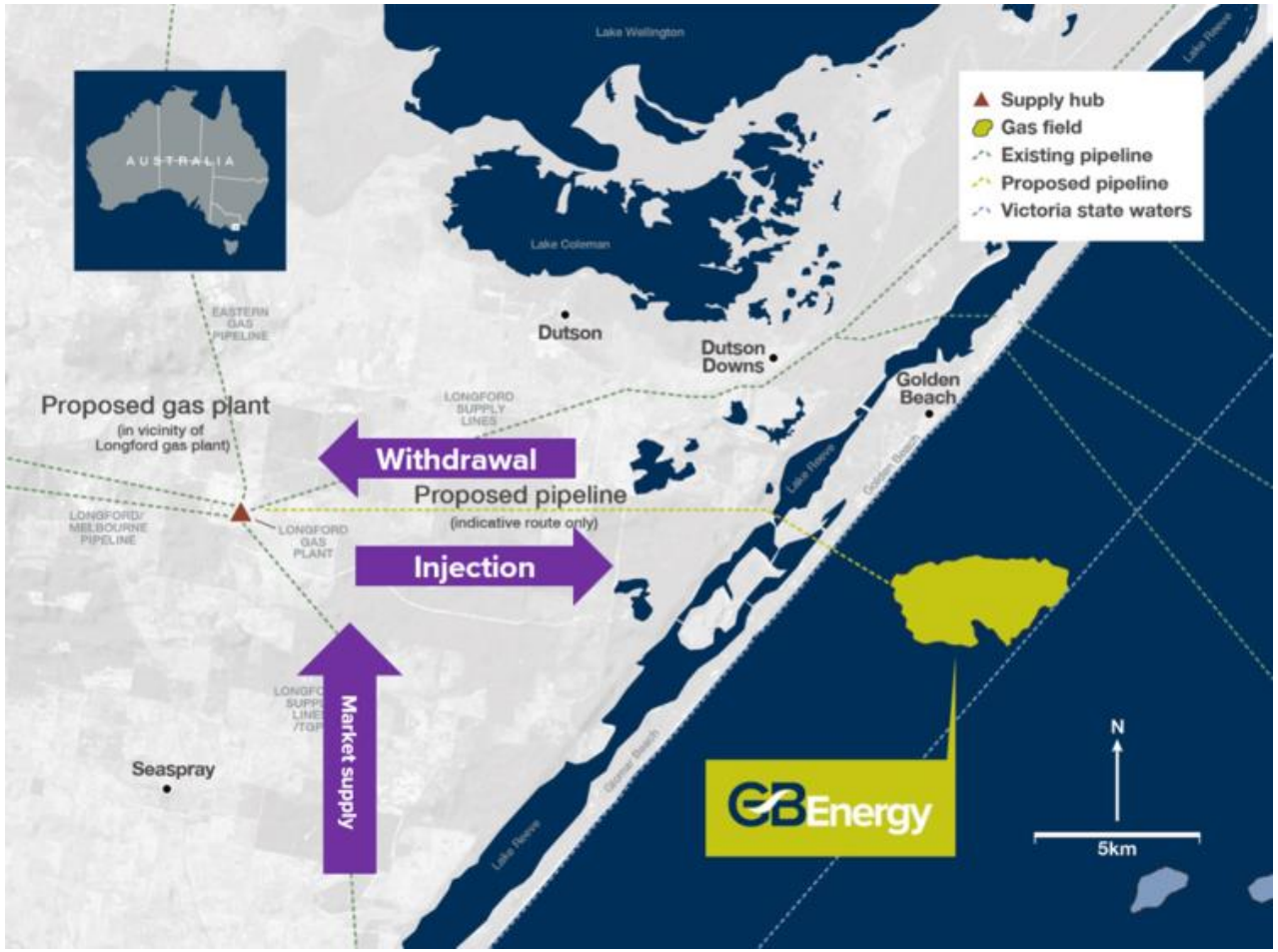
LNG Imports vs Pipelines



Source: Transport of Natural Gas, Jürgen Messner and Georg Babies, POLINARES working paper n. 24, March 2012
Note 1 Bcm of Ntaural gas = 37.4 PJ

- LNG imports makes sense where pipeline distances are long and pipeline utilisation would be low e.g. due to seasonality.
- North West Shelf to Melbourne is ~4,000 km with a pipeline cost ~$7 billion. Would need a throughput of 10 Bcm/yr (i.e. 374 PJ ~80% of east coast demand) for a pipeline to be cheaper than LNG imports.
- LNG imports can be viewed as virtual gas pipelines with floating storage that can provide significant MDQ. However, the storage volume and shipping movements needs to be carefully managed.
- Importing LNG inevitably also means paying commodity prices linked to international prices rather than traditional A$, CPI linked gas prices.

Golden Beach Gas Plant and Underground Gas Storage (UGS)



- Additional storage in the southern states reduces the amount of interstate pipelines or LNG import infrastructure required.
- Proposed Golden Beach production and storage facility backed by Origin Energy.
  - New capacity of ~200-250 TJ/d
  - CAPEX approximately $450 million
  - Proposed production from winter 2024
  - Conversion to storage in 2026

End of Part 1

- Questions?

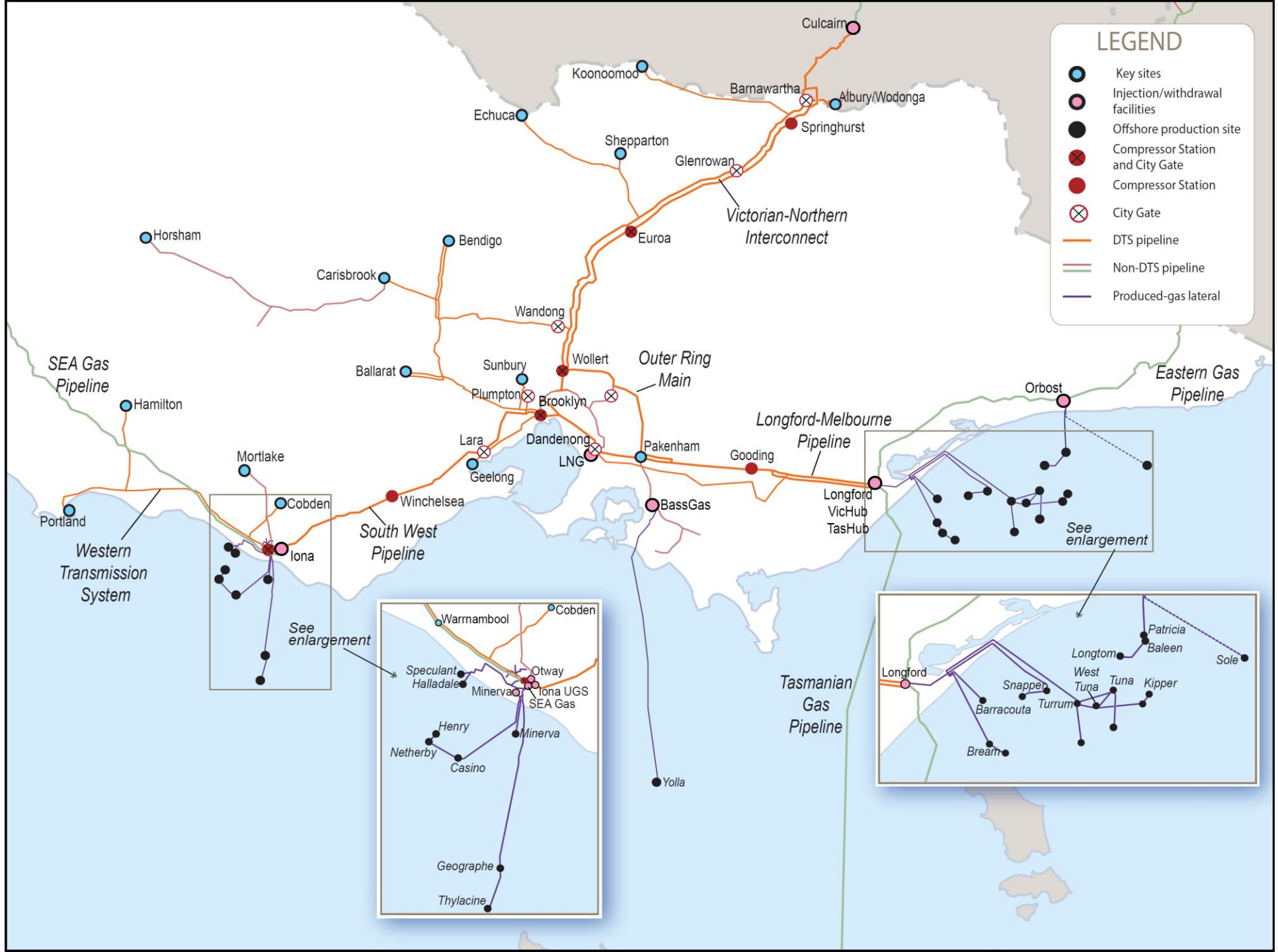
Part 2

- Victorian Operations Overview
- Demand Forecasting and Operating Challenges
- Market Intervention Case Study
- Emergency Management

Victorian Operations Overview

AEMO Gas Roles & Responsibilities

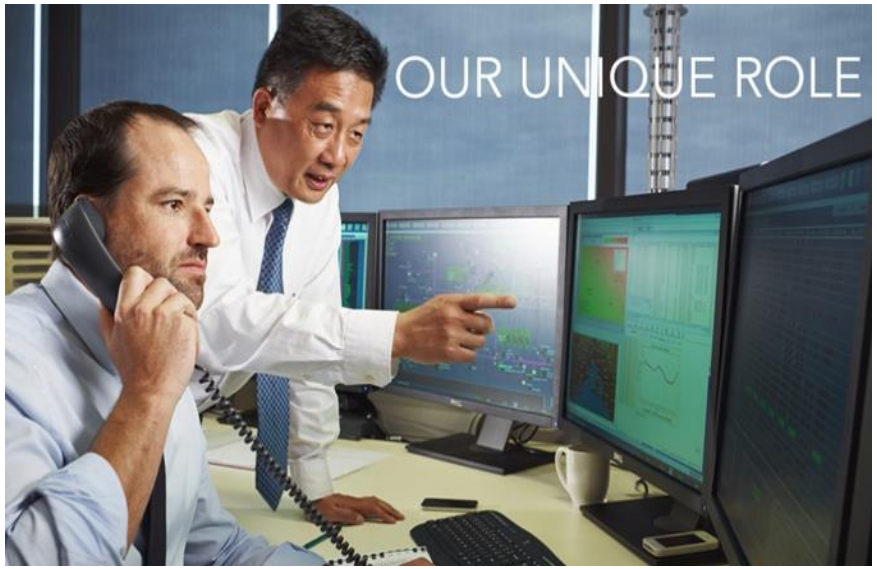
- Victorian gas operations
  - Scheduling (DWGM)
  - Transmission (DTS System Security)
  - Gas Quality Management including specifications and off-specification gas guidelines
  - Emergency Management including curtailment and gas rationing
  - Planning Information (Victorian Gas Planning Review)
  - Transmission Connections and Metering including Heating Value allocation
- Outage and maintenance coordination for southeast Australia
  - Producers (Longford, Moomba, Otway, Minerva, Lang Lang)
  - Storage facilities (Iona UGS, Dandenong and Newcastle LNG)
  - Pipelines (DTS, EGP, SEA Gas, MAPS, MSP including Culcairn, TGP)
- Gas Bulletin Board (Gas Transparency Measures)
- STTM, Gas Supply Hub, Pipeline Capacity Auctions and Trading
- Gas Supply Guarantee (assessing gas supply for Gas Powered Generation)
- National Gas Emergency Response Advisory Committee (NGERAC) support


LEGEND
Key sites
Injection/withdrawal facilities
Offshore production site
Compressor Station and City Gate
Compressor Station
City Gate
DTS pipeline
Non-DTS pipeline
Produced-gas lateral
Culcairn
Koonoomoo
Barnawartha
Albury/Wodonga
Springhurst
Echuca
Shepparton
Glenrowan
Victorian-Northern Interconnect
Euroa
Horsham
Bendigo
Carisbrook
Wandong
Wollert
Outer Ring Main
Sunbury
Ballarat
Plumpton
Brooklyn
Dandenong LNG
Lara
Geelong
Pakenham
Gooding
Longford-Melbourne Pipeline
Orbost
Eastern Gas Pipeline
Longford VicHub TasHub
SEA Gas Pipeline
Hamilton
Mortlake
Portland
Western Transmission System
Cobden
Iona
Winchelsea
South West Pipeline
BassGas
See enlargement
Warrnambool
Speculant
Halladale
Otway
Minerva
Iona UGS
SEA Gas
Henry
Netherby
Casino
Geographe
Thylacine
Yolla
Tasmanian Gas Pipeline
Patricia
Baleen
Sole
Longtom
Longford
West Tuna
Tuna
Kipper
Snapper
Barracouta
Turrum
Bream

Service Envelope Agreement

AEMO
Independent operator of the DTS

APA Group
Owner of DTS infrastructure



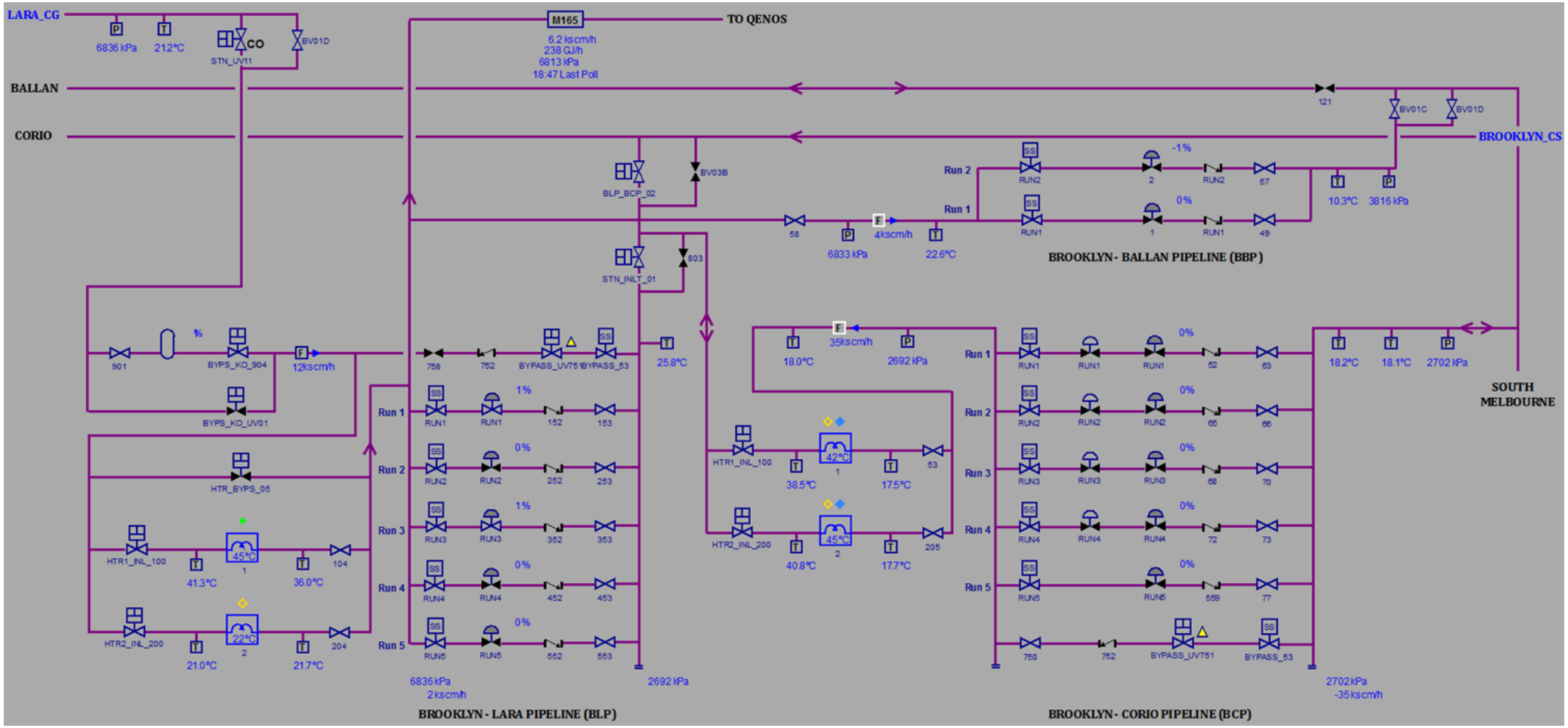
- The Service Envelope Agreement (SEA) is a contract between AEMO and APA that specifies the responsibilities each have in respect to operation maintenance and asset performance.

Major Site Layout

Brooklyn Compressor Station and City Gate, Melbourne western suburbs

AEMO Gas SCADA System

SCADA (Supervisory Control and Data Acquisition) is a control system operating with coded signals over communication channels (e.g. phone lines and IP data links) so as to provide control of remote equipment (e.g. pipeline compressors and valves).



Gas Compressors

- Gas pressures decline along length of pipelines
- Compression of gas and boosts pressure, particularly during demand peaks, moving gas closer to demand centre
- Typically gas turbine engines with centrifugal compression
- Increases capacity of the pipeline system as an alternative to pipeline duplication

Regulating Stations

- Reduces pressure and controls flow from high pressure pipelines into lower pressure pipelines
- Heaters usually used to control downstream temperatures
- Protects downstream assets that cannot withstand high operating pressures and low temperatures
- Used strategically to manage linepack allocation in the system

Dandenong LNG Storage Facility

12,000 tonnes (600 TJ) of Liquefied Natural Gas at minus 160°C

LNG is used:

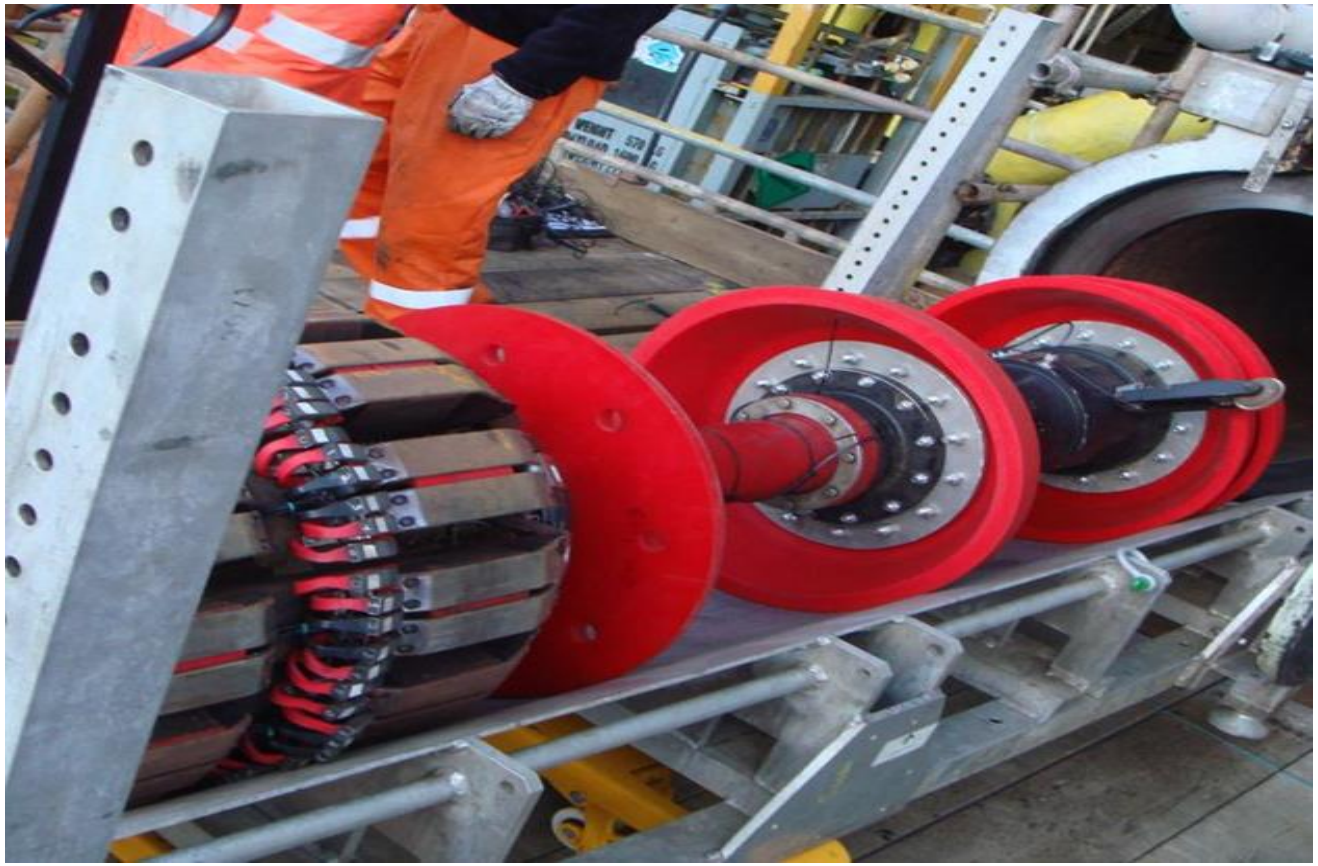
- for market response to supply demand (peak shaving)
- to manage transmission constraints, supply or transmission outages
- emergency response for use during curtailment to manage system pressures

Injection Rate:

- 5.5 TJ/hr firm
- 9.9 TJ/hr non-firm

Maintenance and Projects

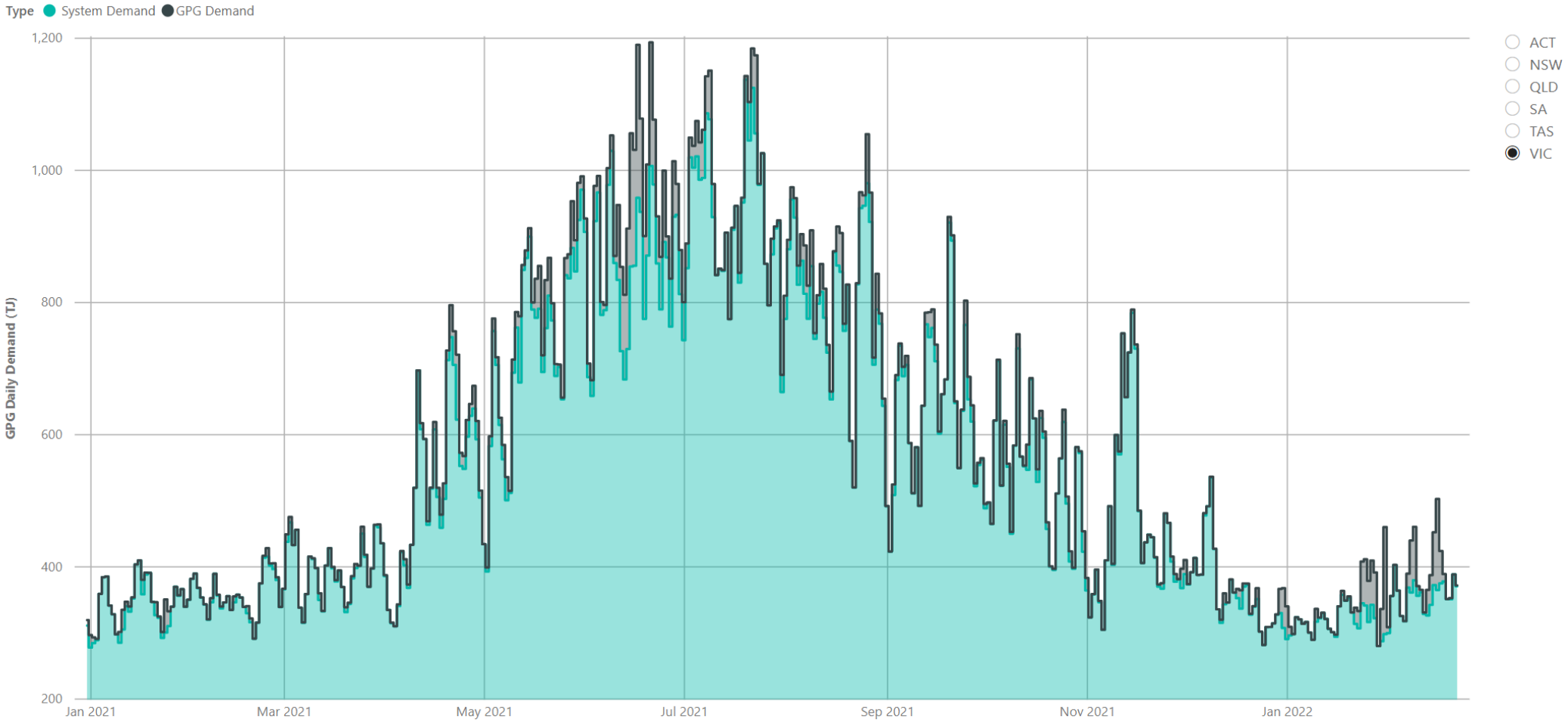
- Gas Production and Storage Facility outages
- Individual compressor and entire station outages
- New connections – “Hot Tapping”
- Stoppling
- Pipeline Inline Inspections (“Pigging”)
- Pipeline repairs – reduced pressure operation



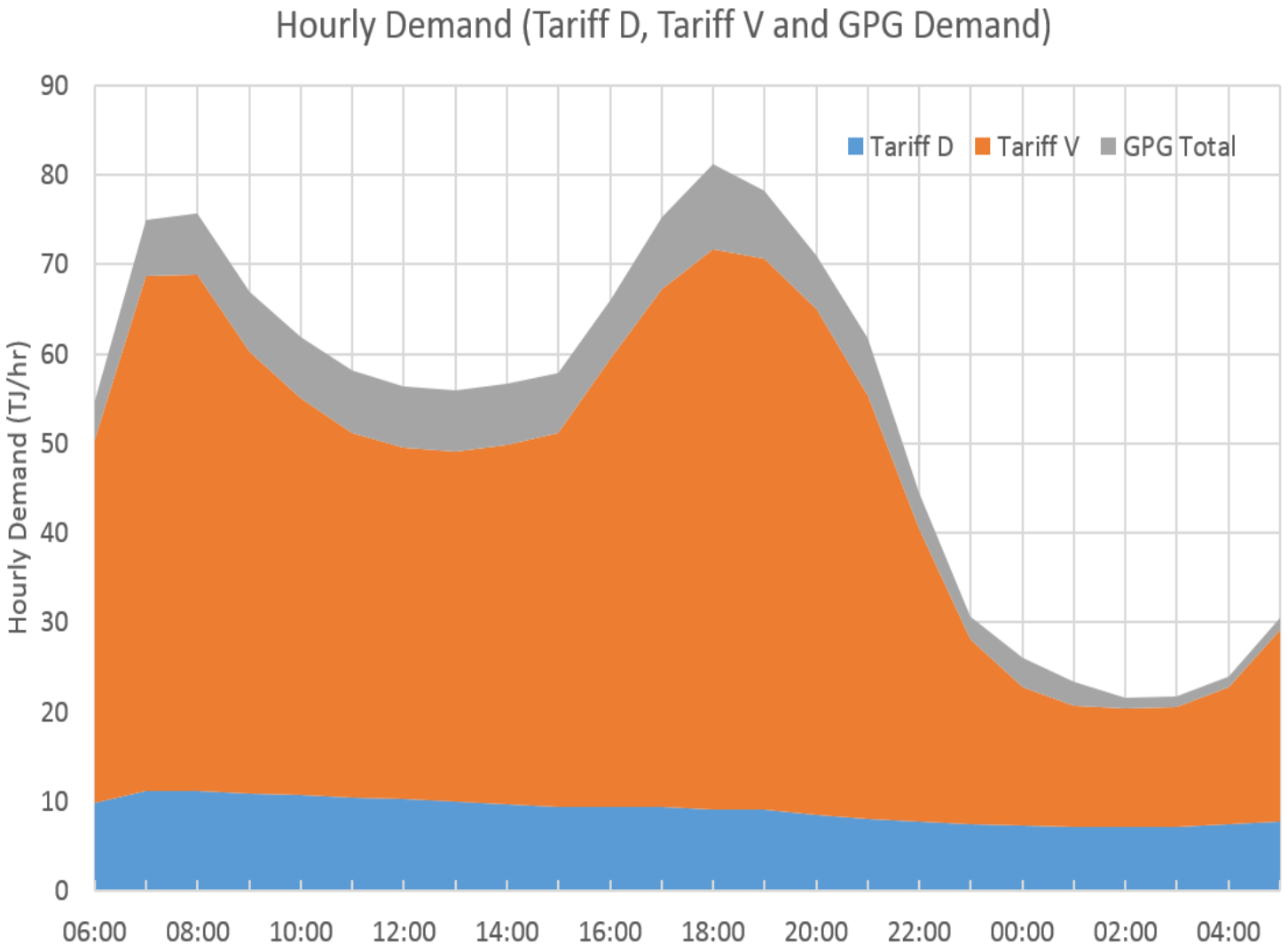
Victorian Demand Forecasting and Operating Challenges

Seasonal Demand Variation

- Victorian demand ranges from less than 250 TJ/d to at least 1,200 TJ/d
- Highest residential gas demand in Australia

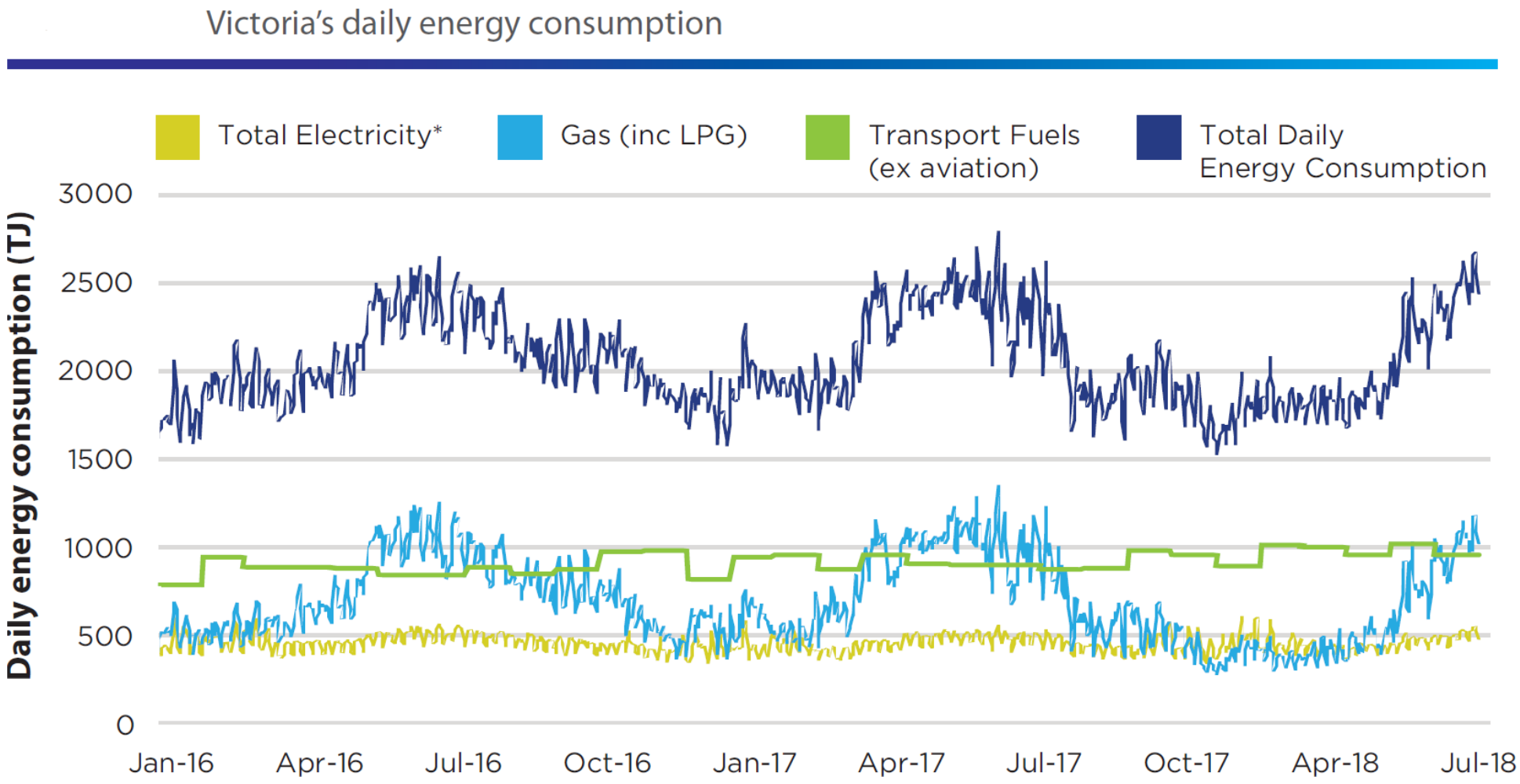


Hourly Demand Variations



- Hourly gas demands vary throughout the day, particularly during winter.
- Morning and evening peaks driven by residential demand – heating, cooking and hot water.
- Demand during the day between the peaks is impacted by weather – sunshine reduces hourly demand, while cold and rainy conditions increases demand (can lead to a threat to system security).

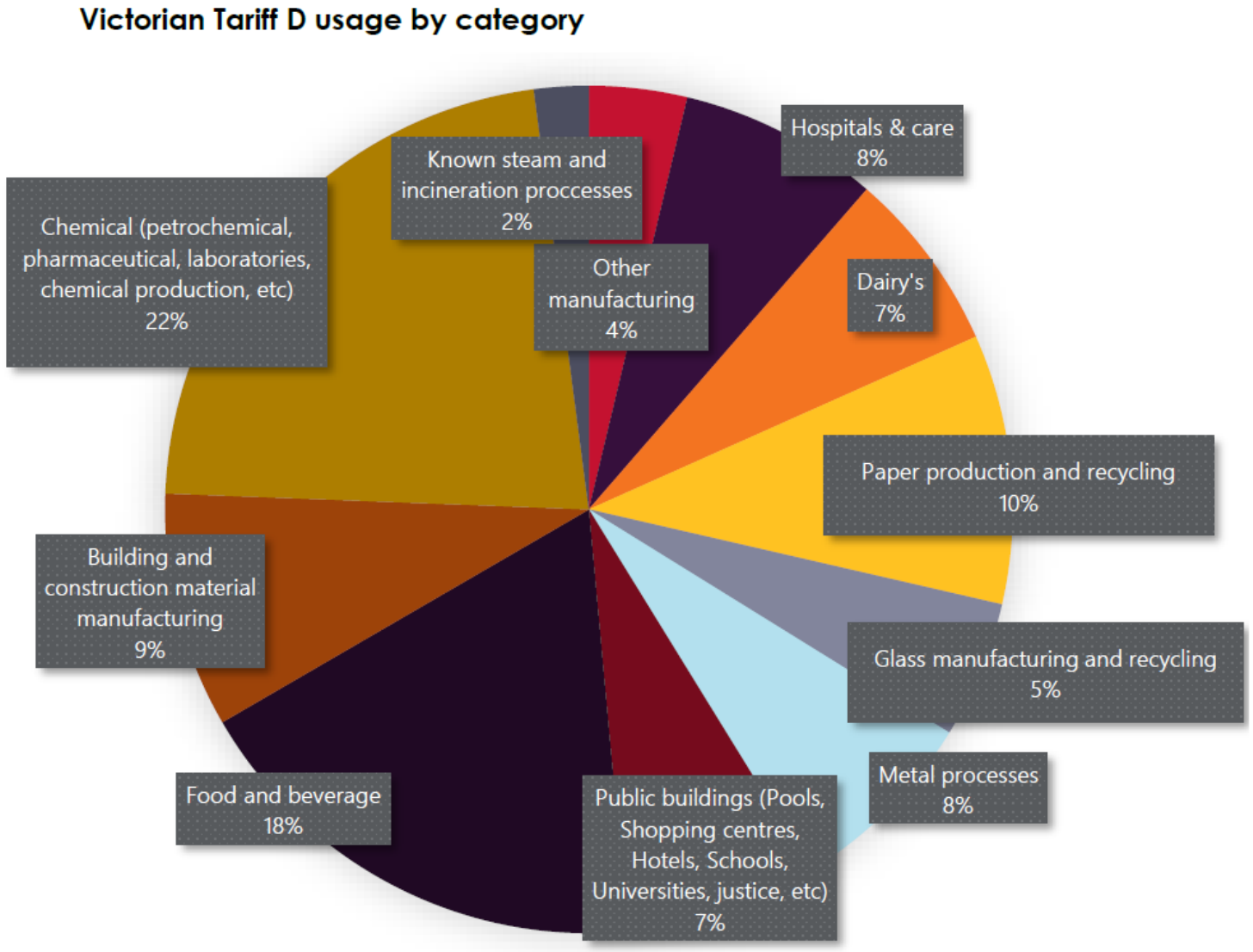
Energy Consumption Comparison



Note: *Total electricity includes electricity from gas and renewables, total gas includes gas used for power generation. Total consumption removes this double count.

Source: AEMO data, Deloitte Access Economic analysis (2019), Energy Networks Analysis (2020)

Commercial and Industrial gas use

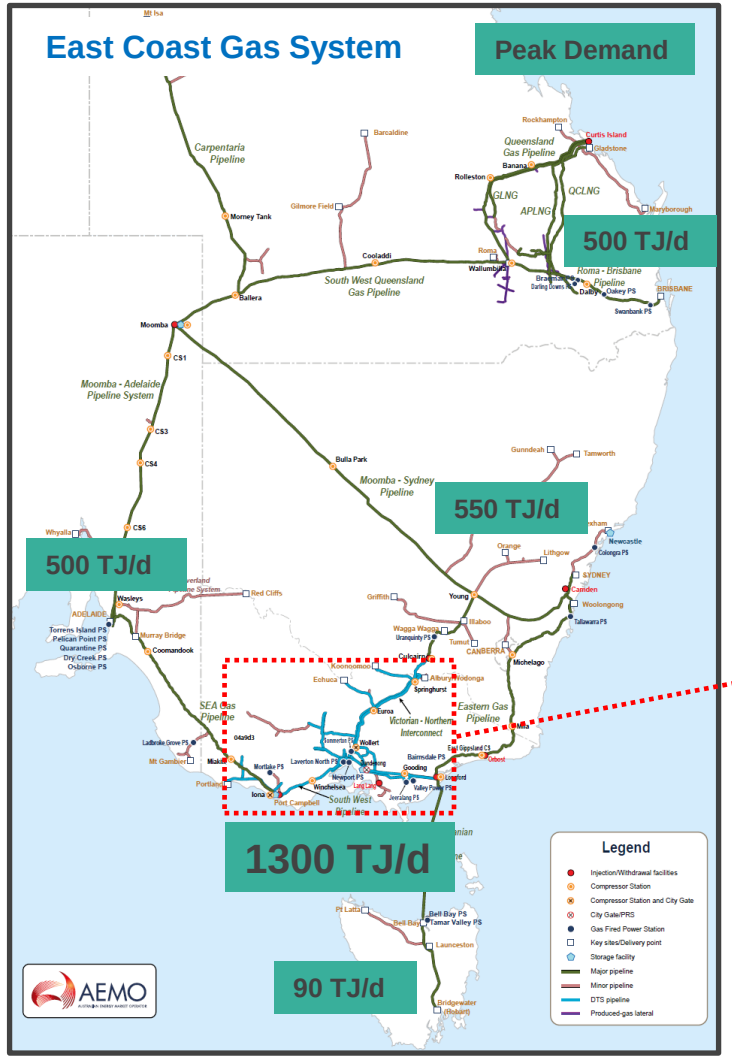


- Tariff D customers use more than 10 TJ/year of gas.
- Customers range from large industrial facilities and food processing through to small factories, hospitals, shopping centres, and universities.
- Forecasts predict the electrification of gas demand, but many processes cannot be easily electrified.

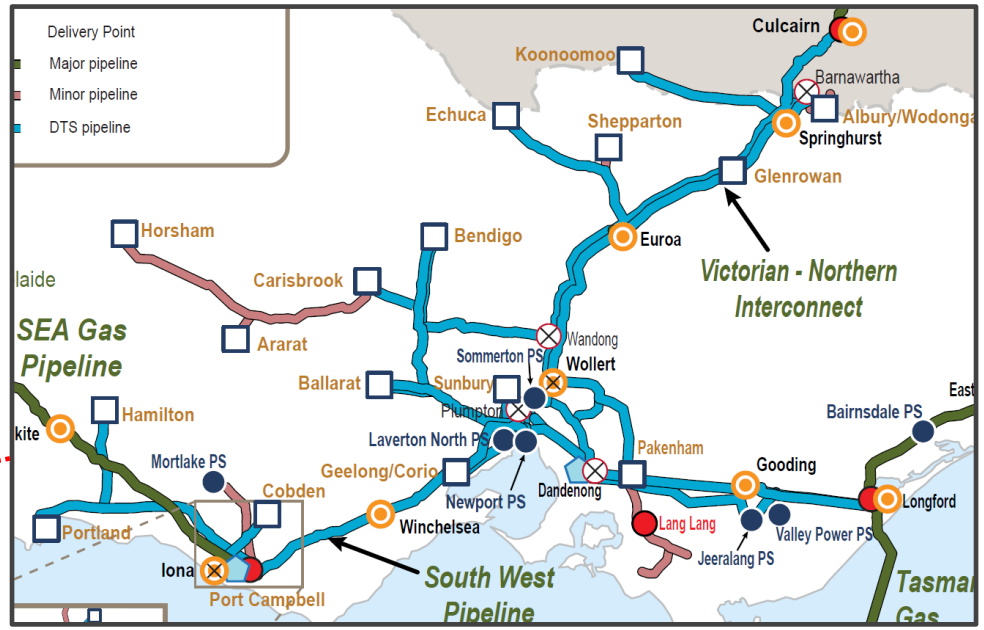
How the Victorian DTS is different

- The Victorian DTS is complex and different
  - Three main transmission pipelines – two are bi-directional – with interactions between these.
  - Pipeline pressure and linepack variations are significant (less than 500 TJ linepack)
- The main supply sources – Longford and the Port Campbell facilities are approx. 200 km from to Melbourne
- Sydney and Adelaide are each supplied by two pipelines that are approx. 800 km long – more linepack than the DTS
- Victoria has the coldest winter of the mainland states and the highest residential gas demand
  - Demand varies substantially with temperature
  - Weather forecast inaccuracies create demand uncertainty
  - Gas Powered Generation impact on linepack

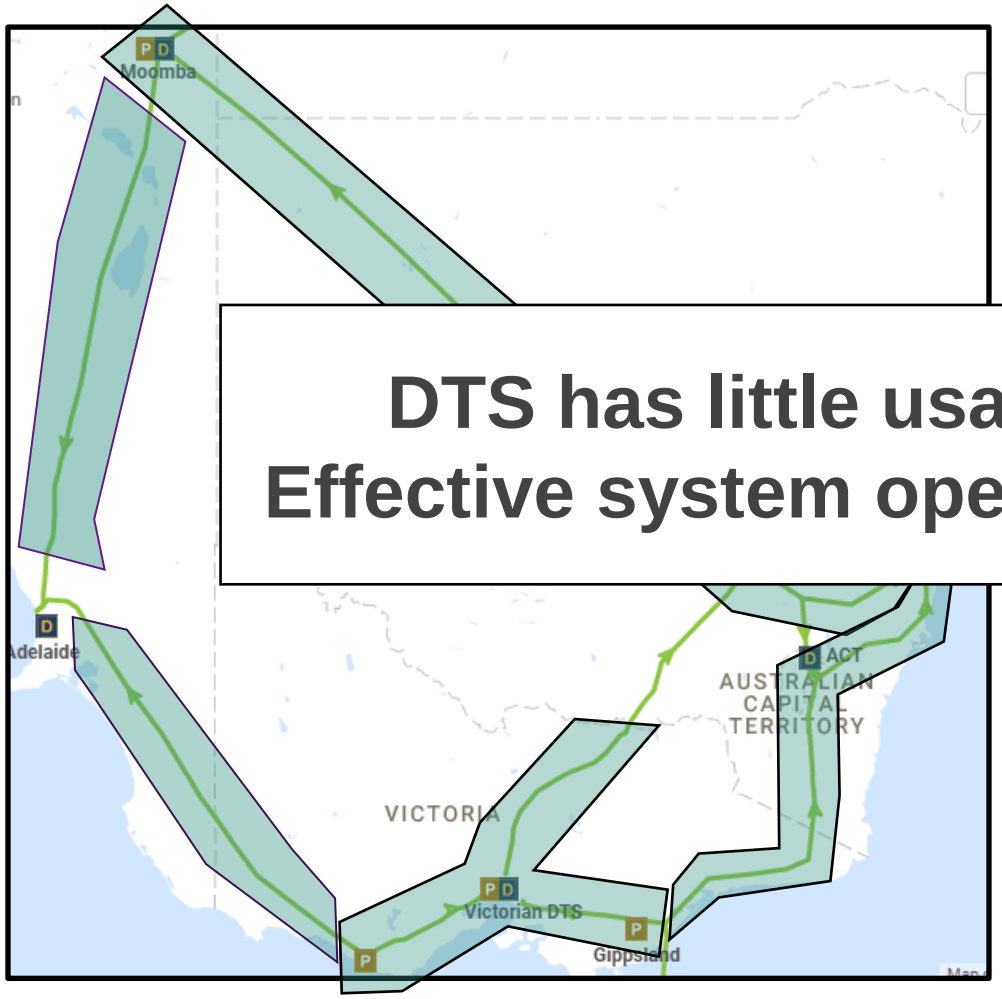
East Coast Gas System Overview



Victorian Declared Transmission System (DTS)



DTS Linepack vs. other Pipelines



NSW and SA demand both supplied by **two** major pipelines.

2–4 days of usable linepack!

DTS has little usable linepack.
Effective system operation is critical.

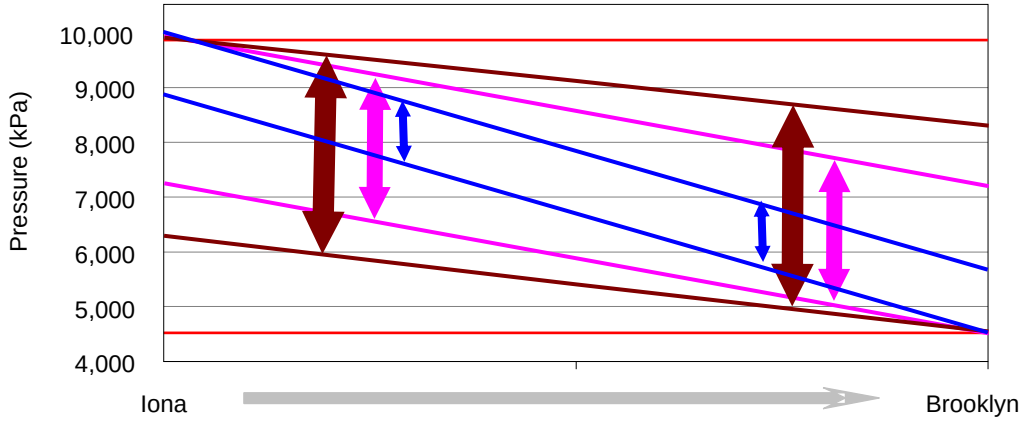
VIC demand supplied by **one** small interconnected network.

Very large demand!

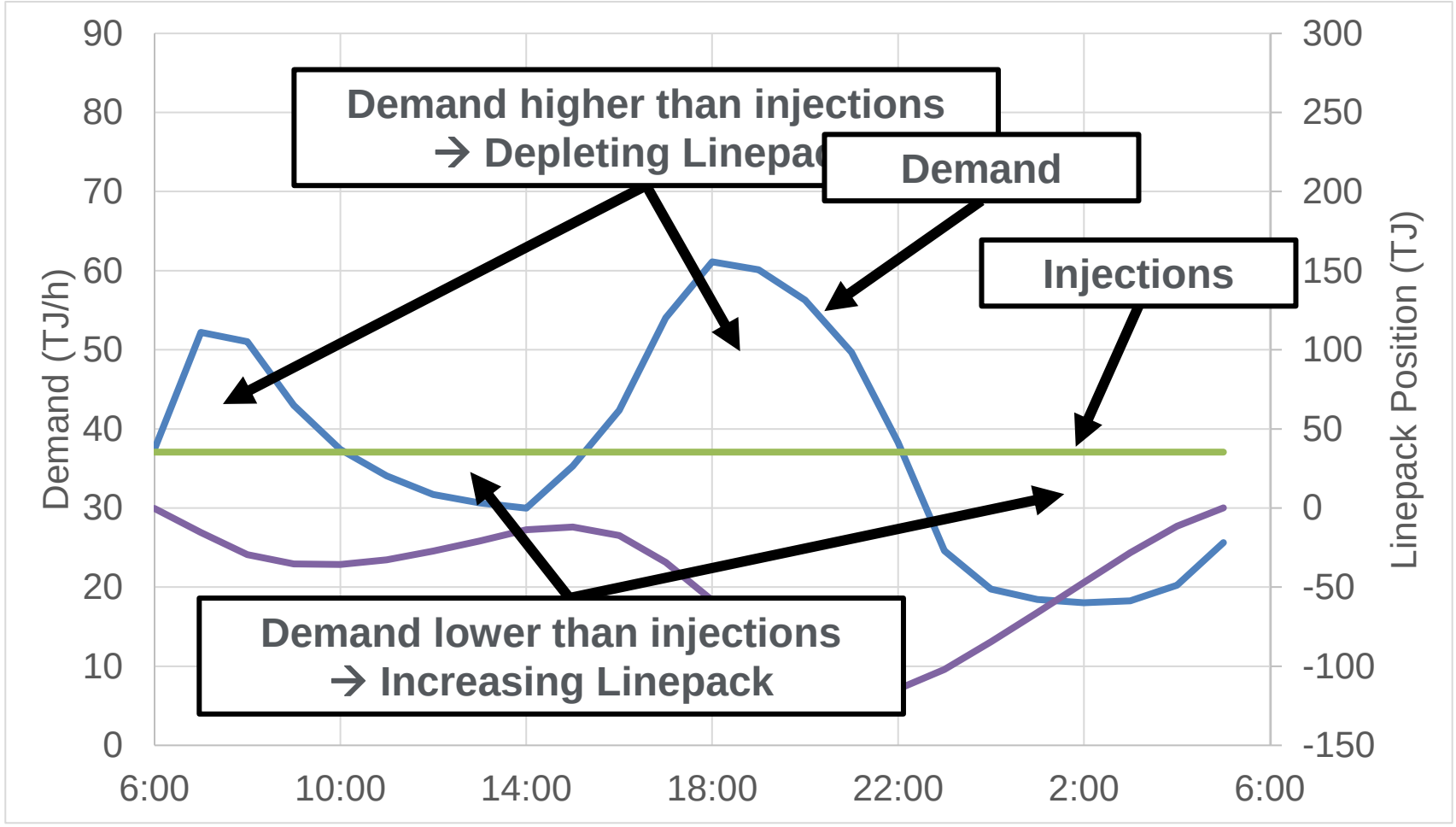
Only **2–4 hours** of usable linepack!

Demand vs. Linepack

- Using the South West Pipeline (SWP) as an example:
  - The usable linepack in the SWP reduces when gas injections at the Iona supply end of the pipeline approach the maximum design flow capacity
- The usable linepack is a function of flow rate
  - Injection rate ↑
  - Usable linepack ↓



Demand Profile



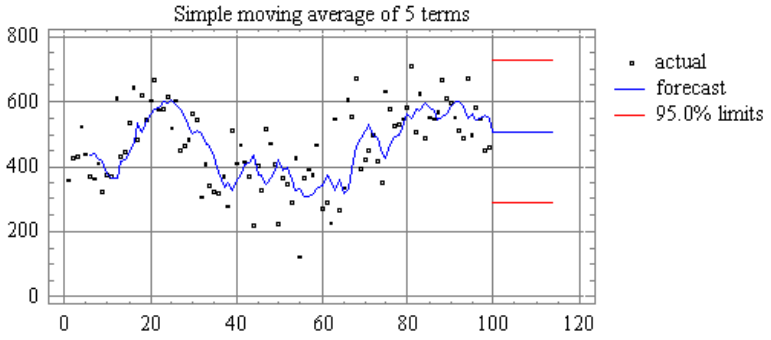
Gas Demand Influences

Temperature

Wind

Sunshine hours

Range 250 to 1300 TJ per day



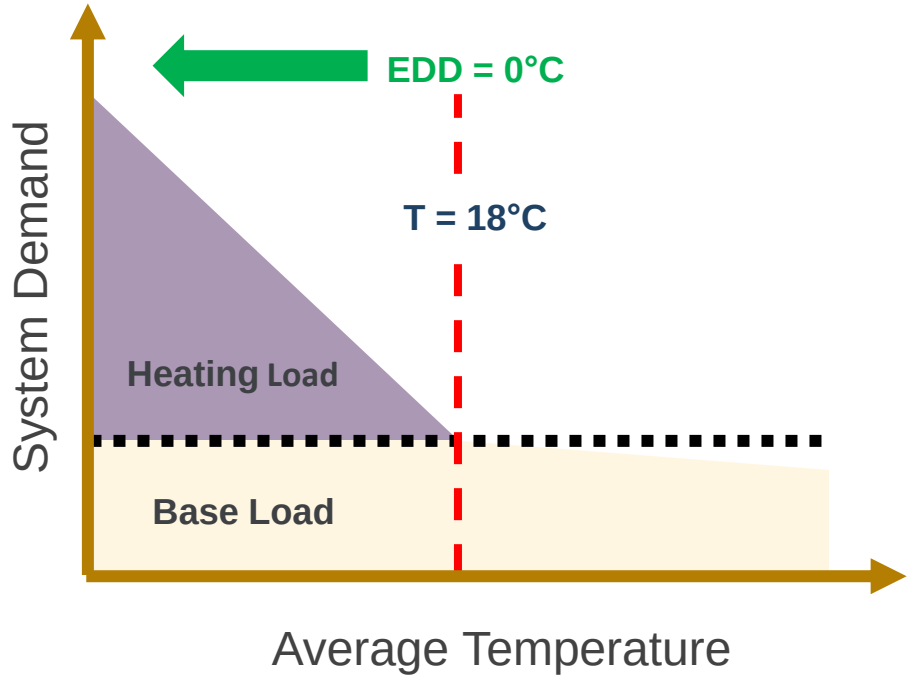
Running Average Model

Similar Day Database

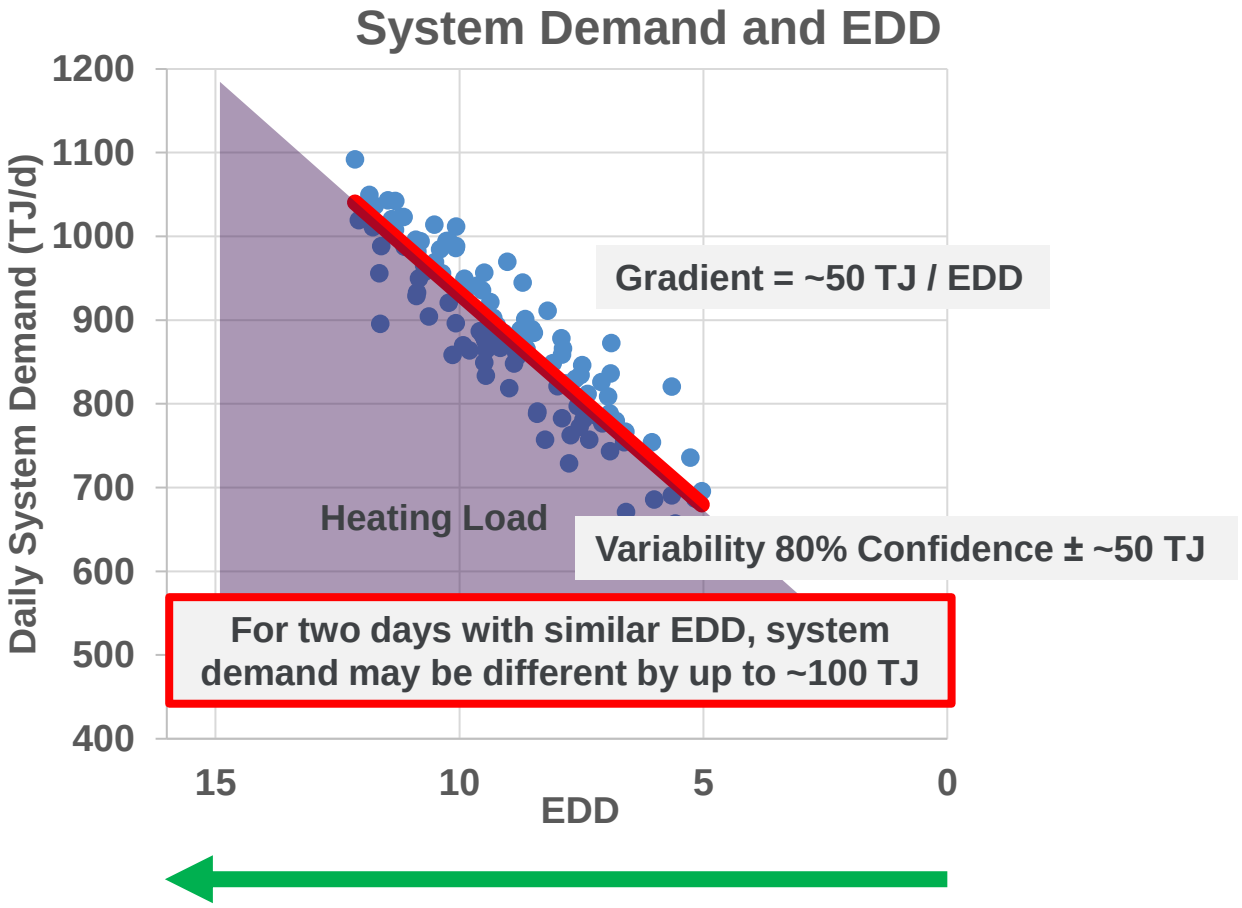
Demand Forecasting

Effective Degree Day (EDD) – Average Temperature, Wind Speed, Sunshine Hours

Inverse magnitude to Average Temperature

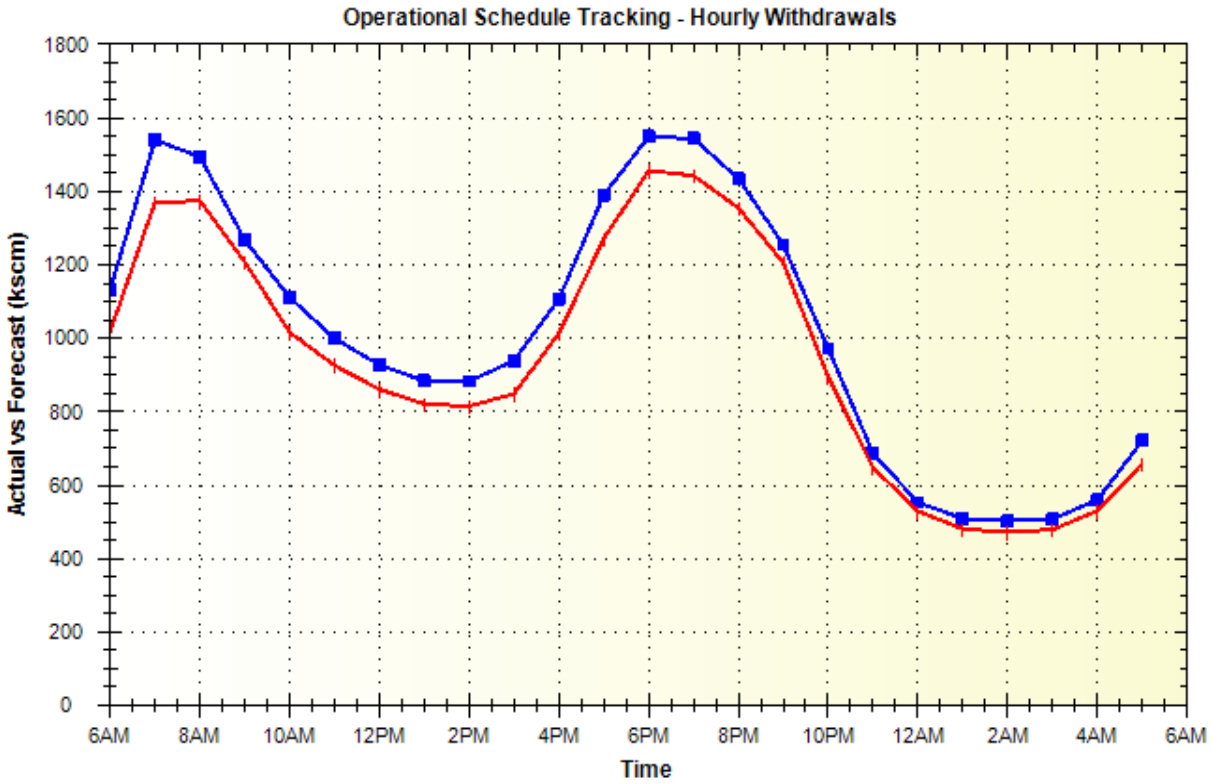


Demand Forecasting



Market Intervention Case Study

System Components and Inputs



Model inputs automatically:

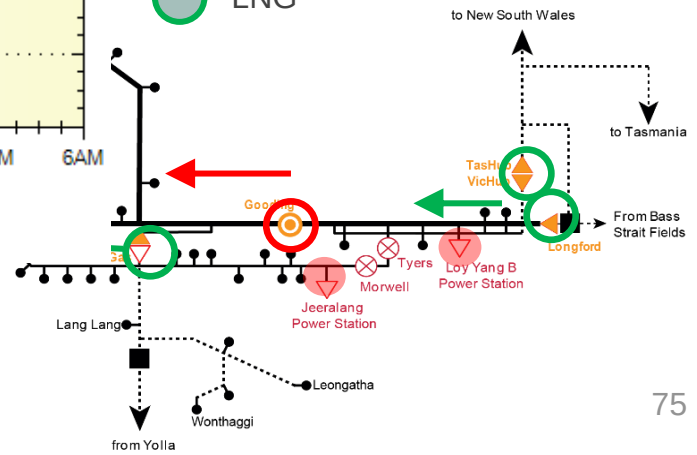
- System Pressures (SCADA)

Market outcomes:

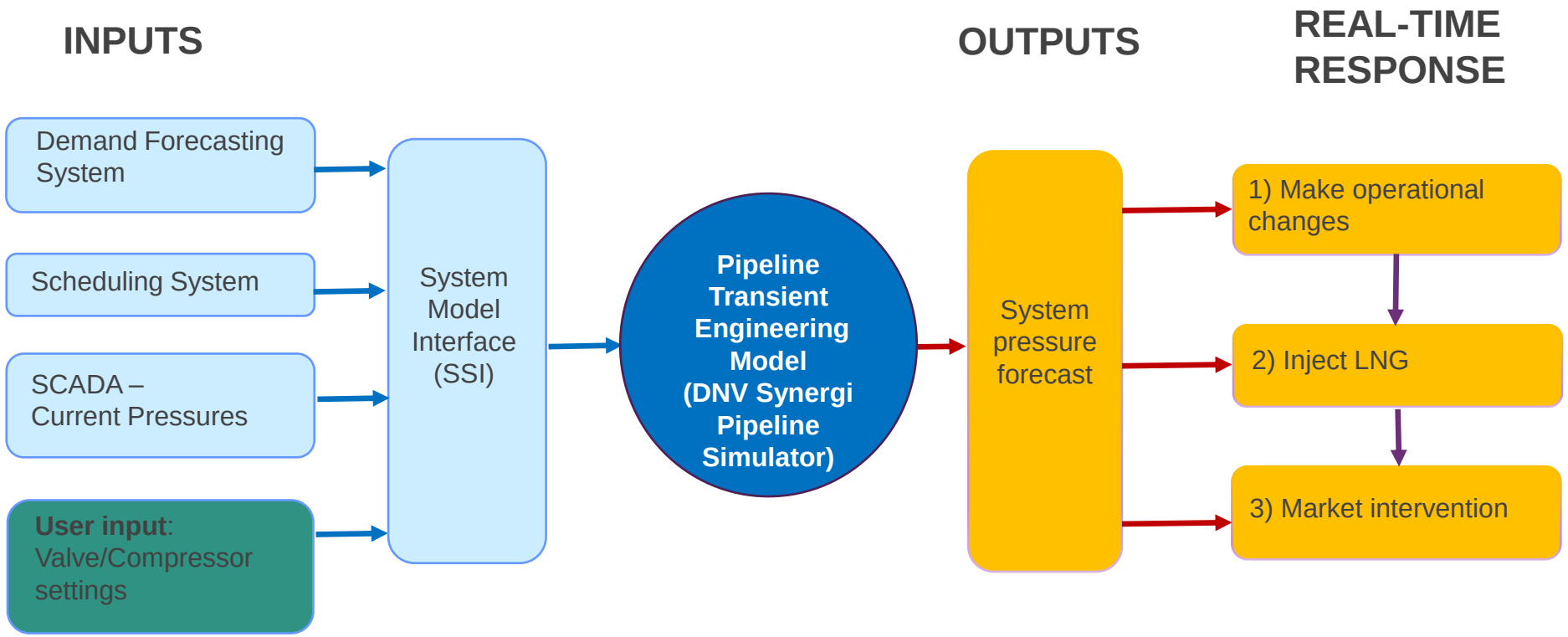
- Demand Forecast
- Injection/Export Quantities
- Gas Powered Generation Forecast

User input:

- Regulator Settings
- Compressor Settings
- LNG



Real-time Pipeline Modelling



Case Study: Longford Gas Plant Trip – 30 November 2017

Event overview:

- Beginning-of-Day (BoD) linepack was on target at ~420 TJ for the 6:00am schedule
- The forecast temperatures on the day were high with a maximum of 34.8°C in Melbourne
- The system demand forecast remained steady throughout the day at approximately 300 TJ
- GPG demand 191 TJ due to high temperatures and coal fired generation outages
- A Lack of Reserve Level 2 (LOR2) condition was forecasted for the Victorian region of the NEM
- AEMO NEM RTO had activated and dispatched the Reliability and Emergency Reserve Trader (RERT) for Victoria to increase electricity generation reserves
- GPG demand increased by 14 TJ to 205 TJ
- Longford Gas Plant experienced an unplanned outage, significantly reducing scheduled gas supply

AEMO's objectives during this event were to:

- Operate in accordance with the NGR and the Wholesale Market Procedures
- Ensure sufficient gas supply for GPG

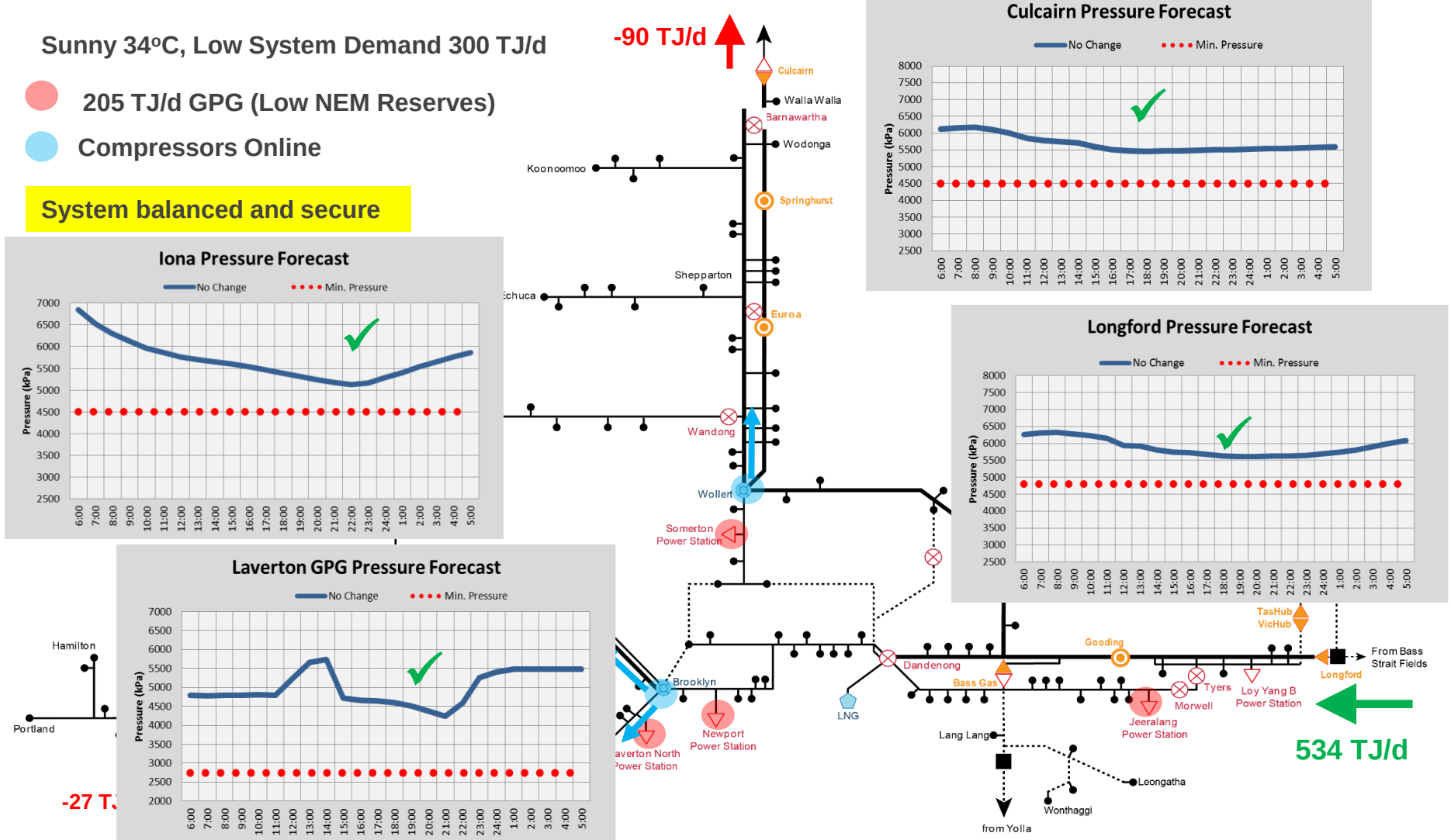
System at 2pm Schedule

Sunny 34ºC, Low System Demand 300 TJ/d

205 TJd GPG (Low NEM Reserves)

Compressors Online

System balanced and secure

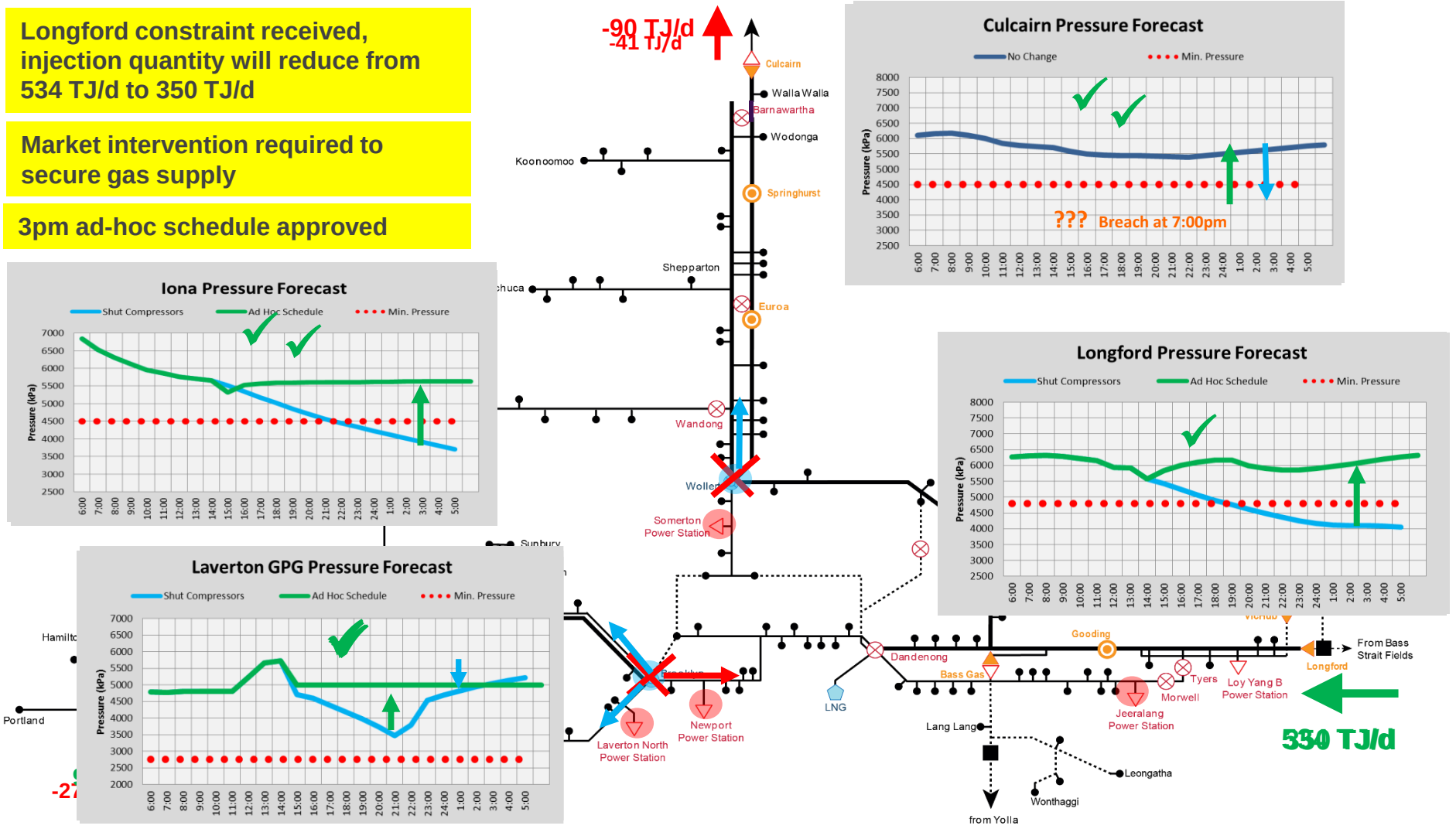


System 3pm ad-hoc schedule

Longford constraint received, injection quantity will reduce from 534 TJ/d to 350 TJ/d

Market intervention required to secure gas supply

3pm ad-hoc schedule approved



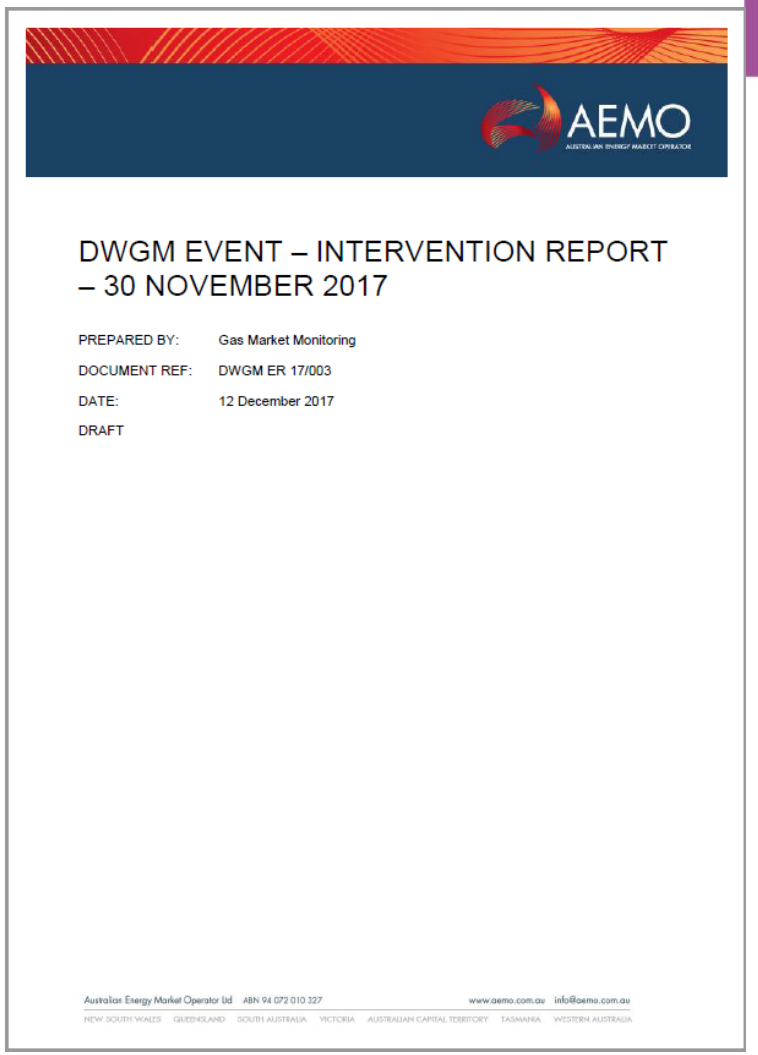
Summary

Real time modelling is crucial for decision making to:

- Reduce risk to gas supply in the Victorian transmission system
- Minimise cost to the wholesale gas market

Event outcome:

- Gas supply for gas generation was maintained
- Ancillary payments and uplift charges resulting from the ad-hoc schedule were $265,929
- Lower than $3,103,145 on 1 October 2016 when Longford offline for 6 hours (from 5.30 to 11.45am AEDT)


DWGM EVENT – INTERVENTION REPORT – 30 NOVEMBER 2017

PREPARED BY: Gas Market Monitoring

DOCUMENT REF: DWGM ER 17/003

DATE: 12 December 2017

DRAFT

Australian Energy Market Operator Ltd ABN 94 072 010 327 www.aemo.com.au info@aemo.com.au

NEW SOUTH WALES QUEENSLAND SOUTH AUSTRALIA VICTORIA AUSTRALIAN CAPITAL TERRITORY TASMANIA WESTERN AUSTRALIA

Emergency Management

AEMO's Responsibilities and Powers

National Gas Law

National Gas Rules

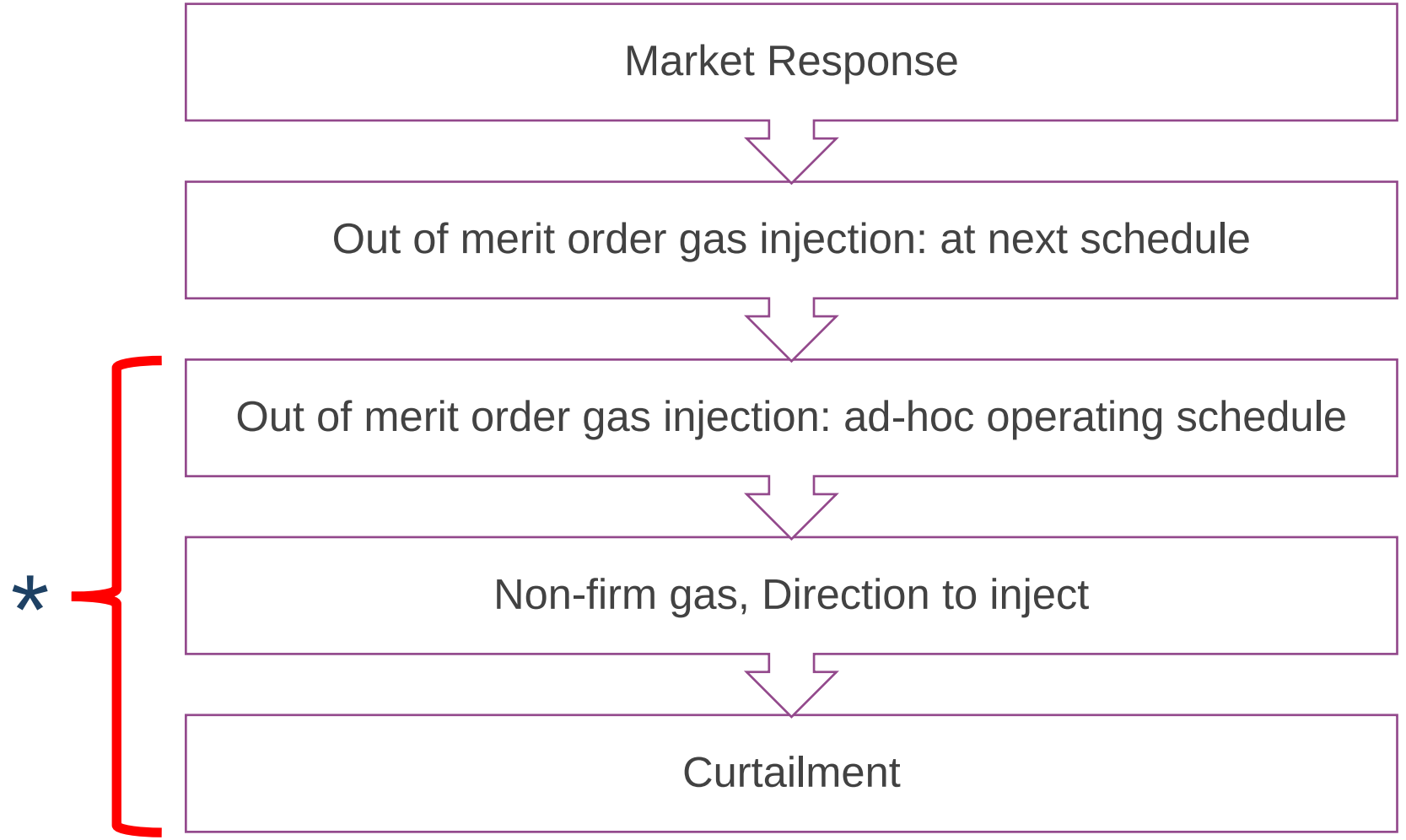
Rule 339	Declarations and directions in an emergency
Rule 341	Notice of threat to system security
Rule 342	Market response to threat to system security
Rule 343	Intervention due to system security threat

Market Response

Market Intervention

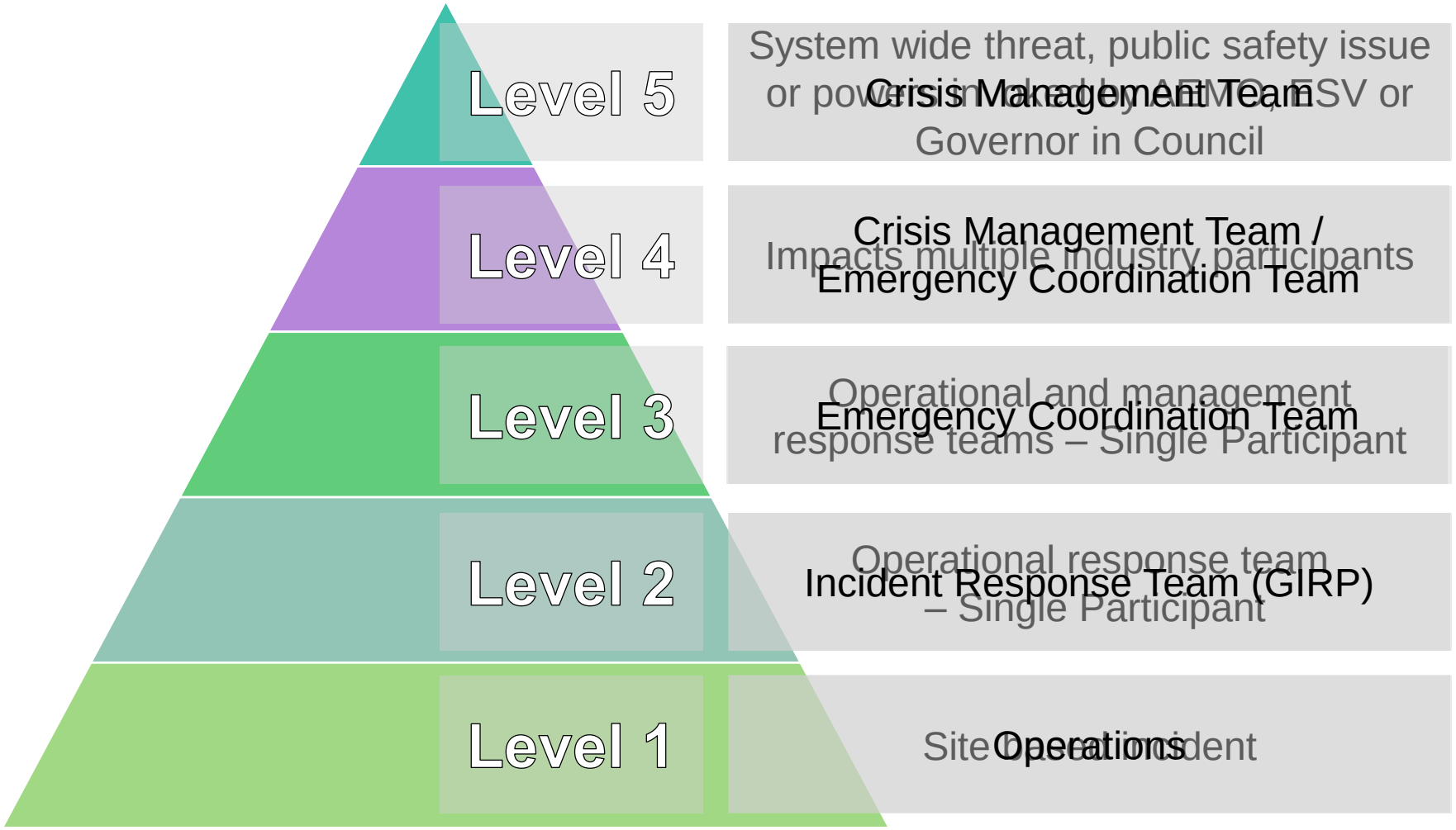
Curtailment

System Security Management



* Market interventions

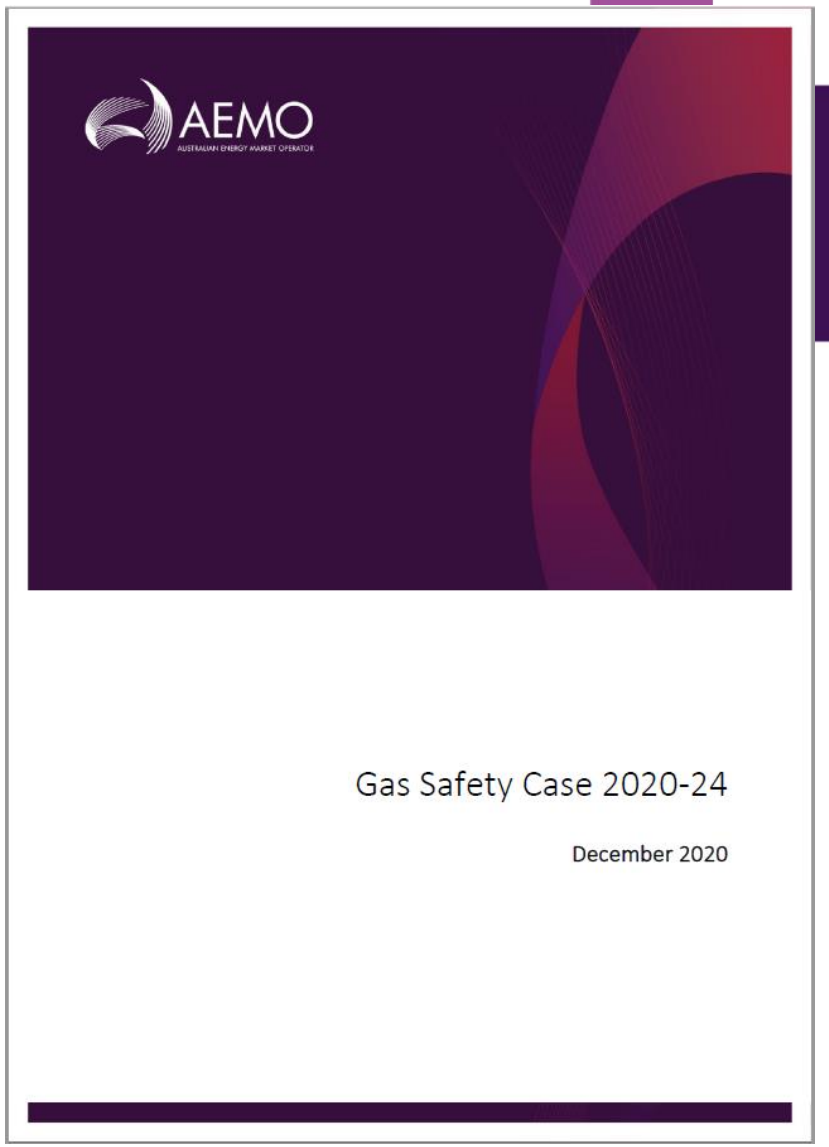
Gas Emergency Levels



Note: A Notice of a Threat to System Security may be issued at any level

Gas Safety Case

- AEMO prepares and submits a Safety Case to Energy Safe Victoria (ESV) every five years
- Safety Case required under:
  - Section 37 (1) of the Gas Safety Act 1997 (Vic) (Gas Safety Act)
  - Gas Safety (Safety Case) Regulations 2018
- Emergency Management responsibilities under Section 53, National Gas (Victoria) Act 2008
  - AEMO Emergency Procedures Gas
  - AEMO Wholesale Market Gas Load Curtailment and Gas Rationing and Recovery Guidelines
  - AEMO Wholesale Market System Security Procedures



End of Part 2

- Questions?

For more information visit

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