EnergyQuest

Victorian peak demand analysis

An independent report prepared by EnergyQuest

August 2023

Table of contents

List of tables and figures

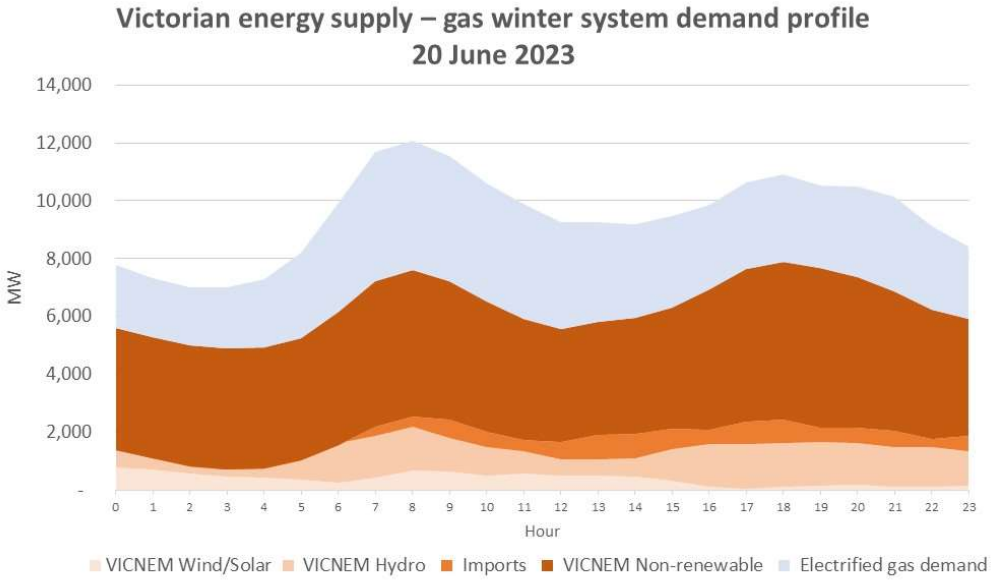
Figures

Tables

Executive Summary

- Victoria has a diverse energy system. Natural gas accounts for 23% of energy consumed in Victoria, oil for a further 37%, 34% of energy comes from coal, and 6% from renewables[1].
- Victorian energy demand peaks in winter when gas and electricity are both used for heating.
- The Victorian Government has released a *Gas Substitution Roadmap* that proposes to replace gas use with renewables and electricity in order to reduce greenhouse gas emissions.
- This report examines the increased generation capacity needed to electrify Victorian gas supply, the potential costs of electrification, and alternative options that may achieve emissions reduction at a lower cost.
- Figure 1 shows the contribution of natural gas to Victorian energy supply on 20 June 2023 which was a cold winter day. To ensure an accurate comparison this chart converts the energy supplied by pipeline gas to equivalent electricity accounting for the increased efficiency of electrical appliances relative to gas appliances. The energy supplied by 'electrified' natural gas is adjusted to the winter system demand profile.

Figure 1 Victorian energy supply – gas winter system demand profile 20 June 2023



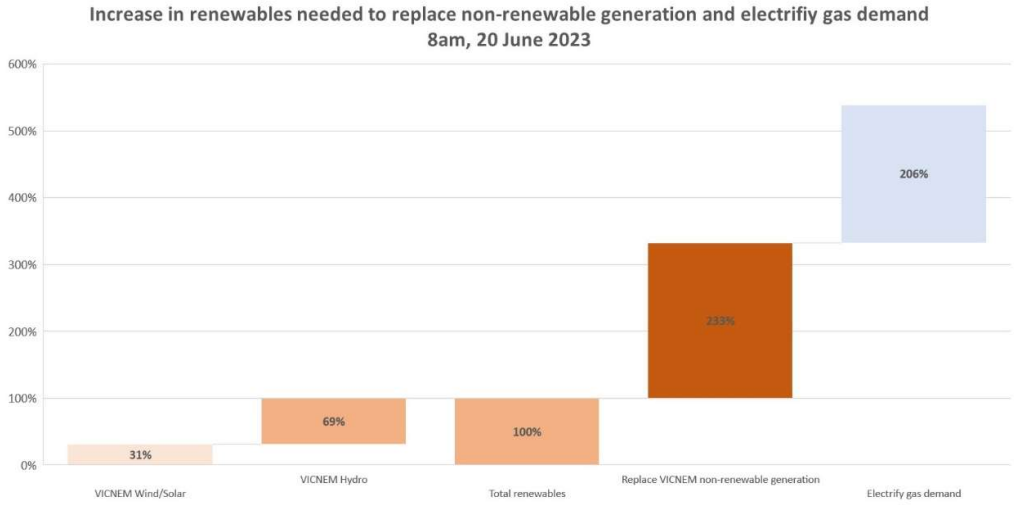
Source: OpenNEM, EnergyQuest analysis

- The data shown in Figure 1 indicates that if pipeline gas had been electrified it would have accounted for 36% of Victorian electricity supply on 20 June 2023 compared to 4% from wind and solar (excluding rooftop solar), 12% from hydro, and 49% from non-renewable power generation.

[1] Department of Climate Change, Energy, the Environment and Water, 'Australian energy mix by state and territory 2020-21, https://www.energy.gov.au/data/australian-energy-mix-state-and-territory-2020-21

- Peak hourly demand for gas on a weekday in winter occurs at around 8 am. Accounting for the peak demand profile, if pipeline gas with electricity would require 62% more electricity generation than was observed at 8 am on 20 June 2023.
- Replacing existing non-renewable generation with renewable power (wind, solar, and hydro) would require 233% more output from renewable sources than was observed during peak hour demand on 20 June 2023, and electrifying gas supply with renewables would require an additional 206% renewable output (Figure 2).

Figure 2 Increase in renewable generation needed to replace non-renewable generation and electrify gas demand - 8 am, 20 June 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

- This report includes a second case study for 15 August 2023, another cold day in winter, which produces similar results to the analysis for 20 June 2023.
- Given how much energy is currently provided by natural gas, avoiding energy shortfalls and price volatility in the medium term will require ongoing natural gas supply for household, commercial, and industrial use. The Australian Energy Market Operator (AEMO) forecasts east coast domestic natural gas consumption will be significant to at least 2042 in all emissions reduction scenarios.
- In the 2023 Electricity Statement of Opportunities AEMO advises that within the National Electricity Market (NEM) Victoria is most at risk of demand for electricity exceeding supply resulting in loss of supply in the absence of out of market intervention. Victoria may see electricity shortages as soon as the coming summer of 2023. AEMO also states that 'the projected electrification of traditional gas loads, particularly heating loads in Victoria, increases forecast consumption and maximum demands in winter'.
- A shift from gas to electricity in the short to medium term would therefore add to electricity demand and supply risk when there may already be shortfalls.
- In the longer term, an alternative and potentially lower cost option to electrification of natural gas is to substitute natural gas with renewable gases such as green hydrogen and biomethane.

- According to the Australian Energy Regulator the key risks of electrifying gas demand are the reduced use of gas networks earlier than necessary and increased upwards pressure on gas and electricity prices.

Introduction

For this report EnergyQuest has carried out modelling of peak electricity and gas demand in Victoria, and analysis of recent trends in the NEM including the energy shortages seen in winter 2022.

EnergyQuest has also undertaken a literature review to identify energy transition costs with respect to transmission, storage, and renewable gas.

Assumptions

Electricity and gas use

This report includes analysis of electricity and gas use during periods of peak demand.

There are over 2 million natural gas customers in Victoria including[2]:

- 2,050,000 residential
- 64,600 commercial
- >600 industrial

Household and commercial users account for 59% of the natural gas consumed in Victoria, industrial production uses 29%, and GPG 8%[3].

Households account for some 80% of the household and commercial sector and within households 60% of gas is used for space heating and 36% for water heating[4]. Demand for space heating rises substantially during cold weather making winter the peak season for Victorian gas use.

Record Victorian gas demand was on one of the coldest days on 9 August 2019, with demand reaching 1,308 TJ. For 2023, AEMO estimates 1-in-20 peak day system demand to be 1,217 TJ/d.

This report examines energy usage during 20 June 2023 and 15 August 2023 which were both cold days in winter. On 20 June Victorian gas demand reached 1,089 TJ and on 15 August demand reached 899 TJ. These levels are well below demand on the record day but as our analysis below shows there would still need to be a substantial increase in electricity generation to replace the energy provided by pipeline gas.

Timing of gas use

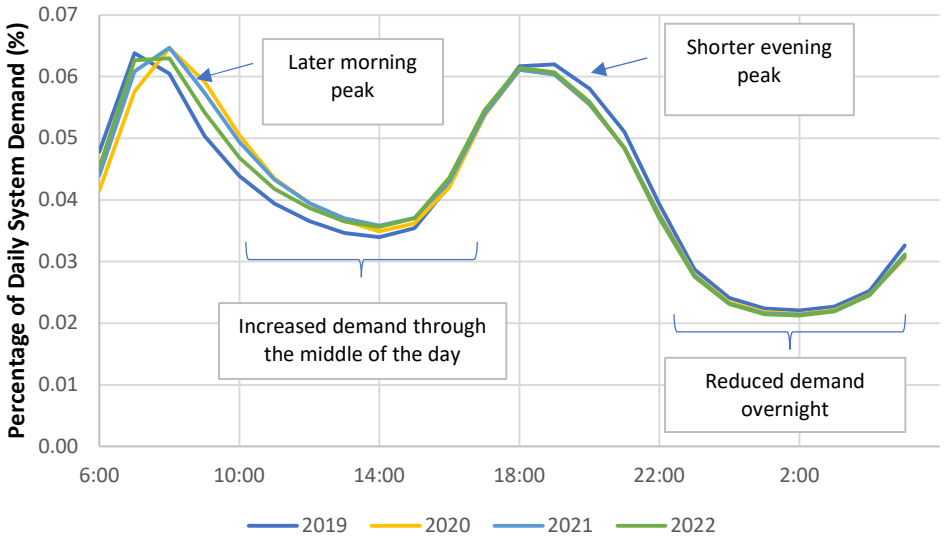
As noted above, households account for the largest demand for gas in Victoria and the primary uses of gas by households are space heating and water heating.

---

[2] Victorian Government, 'Victoria's Gas Substitution Roadmap Consultation Paper, 26 June 2021, https://engage.vic.gov.au/help-us-build-victorias-gas-substitution-roadmap
[3] AEMO, National Electricity and Gas Forecasting, 2023, http://forecasting.aemo.com.au/Gas/AnnualConsumption/Total
[4] Infrastructure Victoria, 'Towards 2050: Gas infrastructure in a net-zero emissions economy', December 2021, https://www.infrastructurevictoria.com.au/wp-content/uploads/2022/07/Towards-2050-Gas-infrastructure-in-a-net-zero-emissions-economy_Webinar_Final-report.pdf

Gas demand in Victoria peaks in the morning and evenings when space and water heaters are most in use. To estimate gas demand through the day we have used AEMO's estimate of the average Victorian weekday winter system demand profile for 2022 (Figure 3)[5].

Figure 3 Average percentage of weekday winter system demand profile in 2019, 2020, 2021 and 2022



Source: AEMO

Relative efficiency of gas and electrical appliances

Electrical appliances are more efficient than gas appliances. For example, a typical electric heat pump uses significantly less energy per unit of heat output than a gas space heater.

This report compares the energy provided by pipeline gas with the energy provided by electricity and estimates how much extra electricity would be needed to replace gas with electricity. In making this comparison it is important to recognise that gas and electrical appliances have different energy efficiencies. We have assumed that heat pump appliances used to replace gas appliances would use 71% less energy on average than the existing gas appliance fleet. We have excluded pipeline gas used for gas fired electricity generation from this calculation.

The relative efficiency of electrical appliances versus gas varies according a range of factors including the use, type, model, and in use efficiency of the appliance in question. Reverse cycle air conditioning is a particularly efficient use of energy compared to gas space heaters. Ducted gas heating is common in Victoria but the age, maintenance, and efficiency of individual appliances varies significantly.

Analysis by Frontier Economics suggests the mid-point coefficient of efficiency for gas space heating is 0.73 which compares to 2.5 for reverse cycle air conditioning, indicating this use of electricity is 3.4 times more efficient than the gas alternative[6]. Alternative data from the ACT Government for gas hot water systems produces similar results with a finding

[5] AEMO, 'Victorian Gas Planning Report', 16 March 2023, https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/vgpr/2023/2023-victorian-gas-planning-report.pdf?la=en
[6] Frontier Economics, 'The benefits of gas infrastructure to decarbonise Australia', 17 September 2020, https://www.energynetworks.com.au/resources/reports/2020-reports-and-publications/the-benefits-of-gas-infrastructure-to-decarbonise-australia-frontier-economics/

that gas hot water consumes 16.5 kWh equivalent compared to 4.7 kWh for a hot water heat pump, indicating heat pumps consume 3.5 times less energy than gas for hot water heating[7].

We rely on the above estimates and assume for this report that if all gas demand (excluding gas used in gas fired power generation) was electrified using all heat pump appliances then the electricity required would be equivalent to 29% of the energy content of the gas. This approach will tend to underestimate the electricity required to replace gas as even under a full electrification scenario not all gas appliances would be converted to heat pumps.

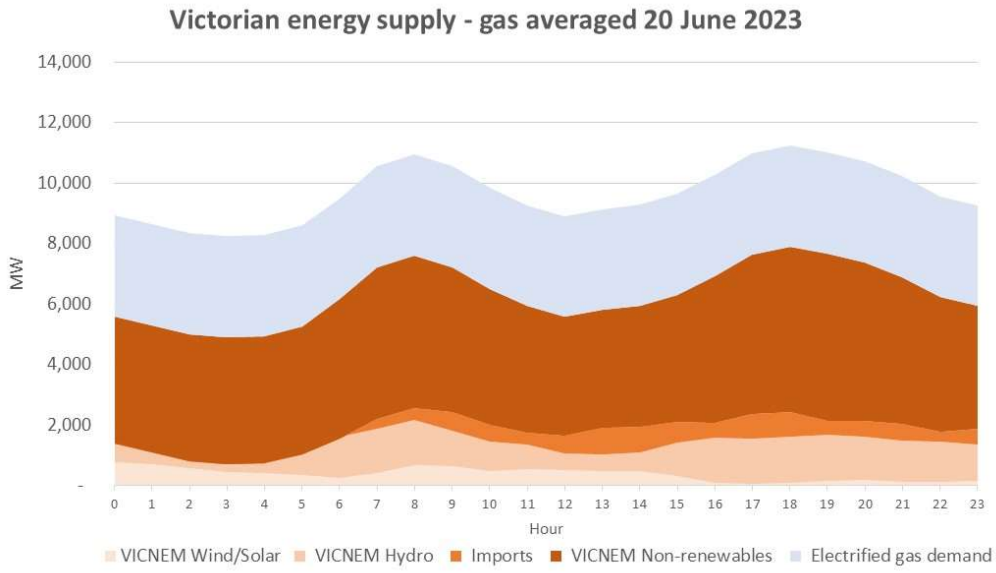
Case Study 1: 20 June 2023

Model results

On 20 June 2023, the weather was cold and gas supplied via pipeline to residential, commercial, and industrial users accounted for a significant proportion of energy in Victoria.

Victorian energy supply from NEM and the pipeline gas network is shown in Figure 4 with gas supply assumed to be electrified and spread evenly over the day. This analysis is focussed on the Victorian NEM (VICNEM) and therefore excludes solar rooftop energy.

Figure 4 Victorian energy supply (gas averaged) – 20 June 2023



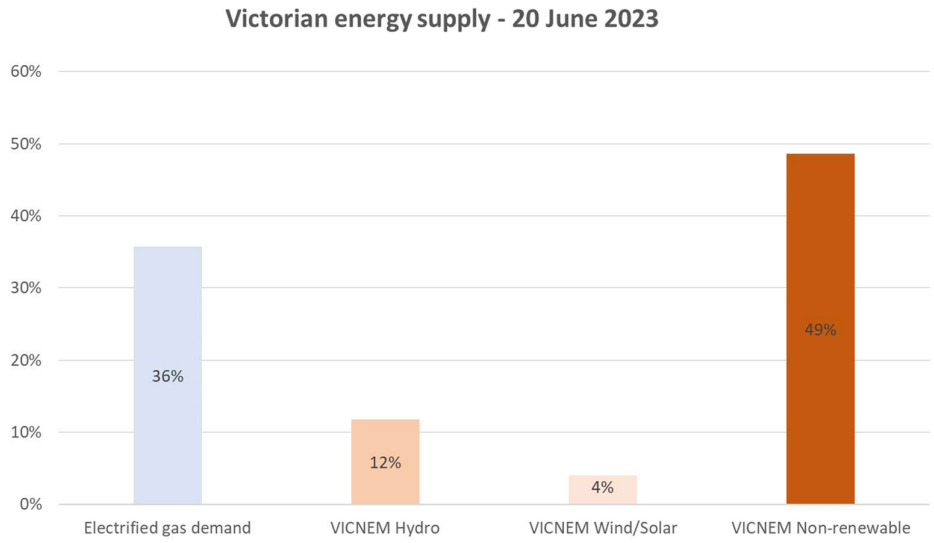
Source: OpenNEM, EnergyQuest analysis

The relative contribution of pipeline gas, renewable electricity, and non-renewable electricity on 20 June 2023 is shown in In this comparison the energy provided by pipeline gas has been discounted by 71% to estimate how much electricity would be required to replace pipeline gas. On that basis, if pipeline gas had been electrified it would have accounted for 36% of VICNEM supply on 20 June 2023 compared to 4% from wind and solar, 12% from hydro, and 49% from non-renewable power generation.

[7] ACT Government, 'Everyday Climate Choices', https://www.climatechoices.act.gov.au/policy-programs/sustainable-household-scheme/buyers-guides/singing-in-the-shower-a-guide-to-hot-water-heat-pumps

Figure 5. In this comparison the energy provided by pipeline gas has been discounted by 71% to estimate how much electricity would be required to replace pipeline gas. On that basis, if pipeline gas had been electrified it would have accounted for 36% of VICNEM supply on 20 June 2023 compared to 4% from wind and solar, 12% from hydro, and 49% from non-renewable power generation.

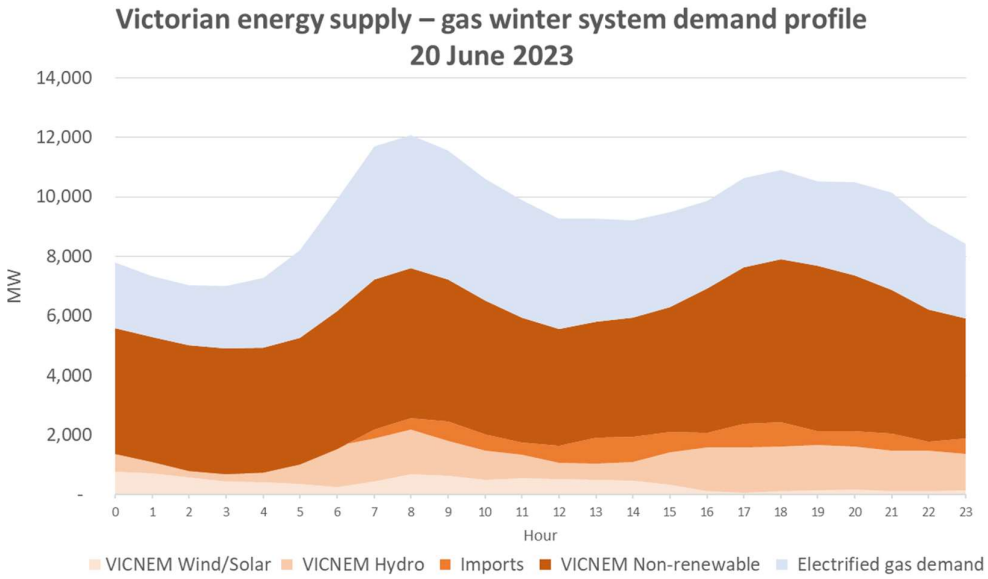
Figure 5 Victorian energy supply – 20 June 2023



Source: OpenNEM, EnergyQuest analysis

Figure 6 shows energy supply through the day with electrified gas demand adjusted to reflect the average Victorian weekday winter system demand profile for 2022 with peaks in demand occurring during the morning and evening.

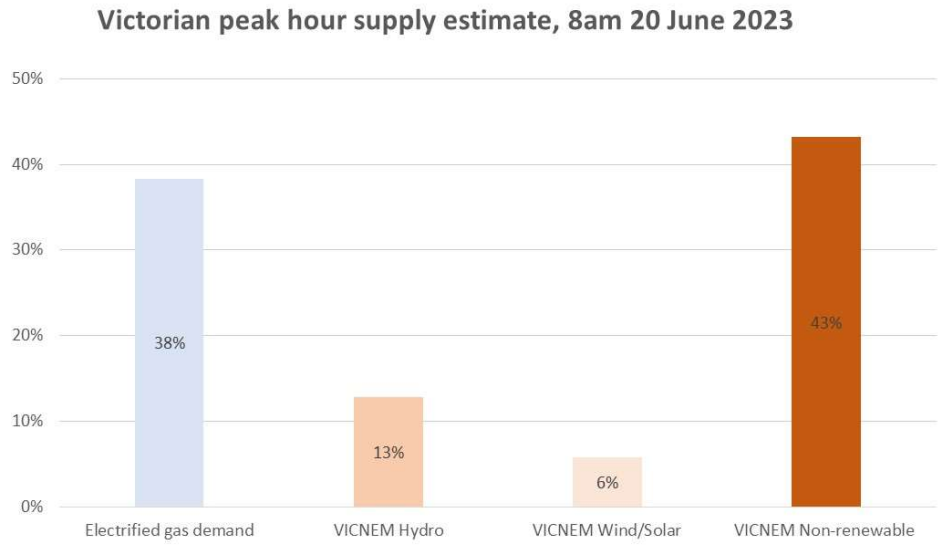
Figure 6 Victorian energy supply – gas winter system demand profile 20 June 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Figure 7 is based on the same data set as Figure 6 and shows estimated energy supply for 8 am which is the peak hour for gas demand in winter. If pipeline gas had been electrified it would have accounted for 38% of VICNEM supply at 8 am on 20 June 2023 compared to 13% from wind and solar, 13% from hydro, and 43% from non-renewable power generation.

Figure 7 Victorian peak hour supply estimate, 8 am 20 June 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

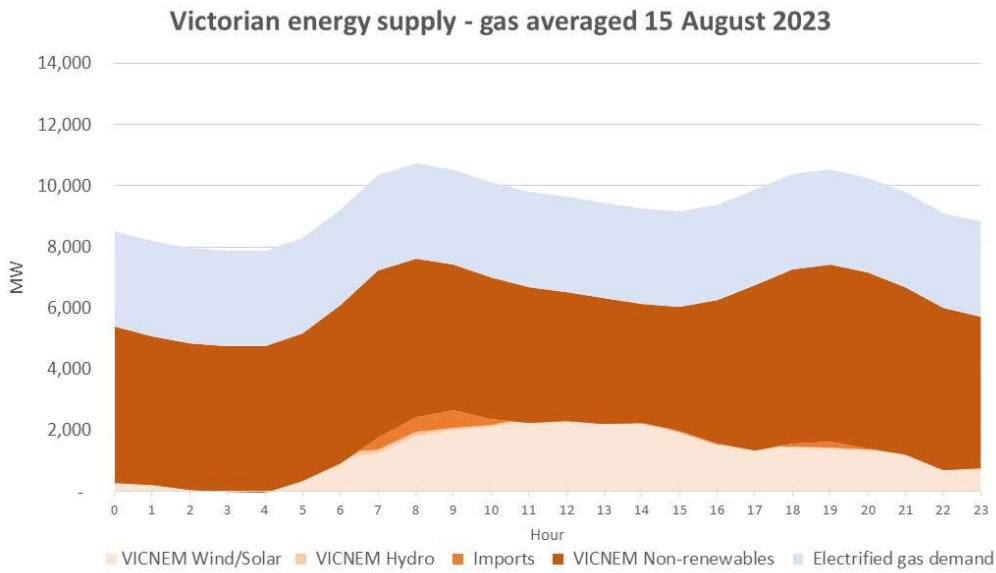
Case Study 2: 15 August 2023

Model results

On 15 August 2023, the weather was cold and gas supplied via pipeline to residential, commercial, and industrial users accounted for a significant proportion of energy in Victoria.

Victorian energy supply from the NEM and the pipeline gas network is shown in Figure 8 with gas supply assumed to be spread evenly over the day. We have excluded solar rooftop energy from this analysis.

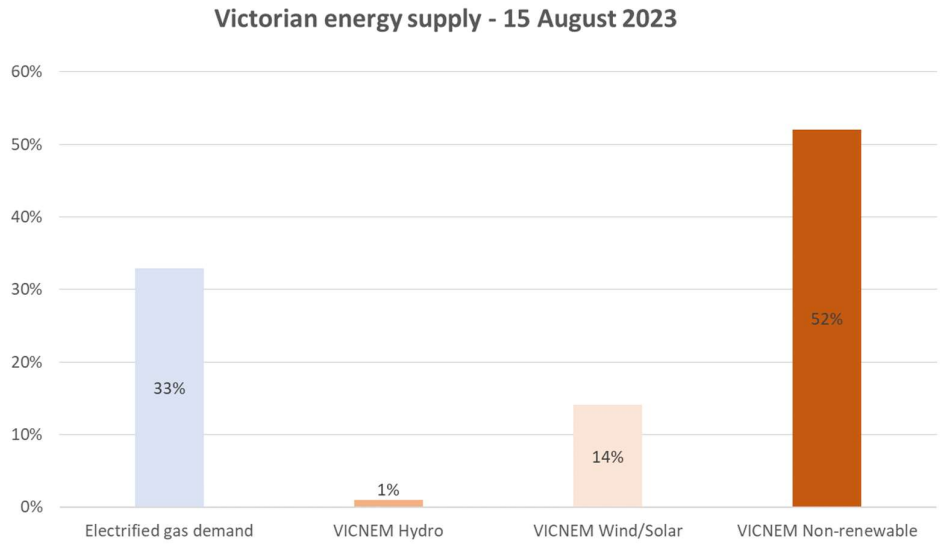
Figure 8 Victorian energy supply (gas averaged) – 15 August 2023



Source: OpenNEM, EnergyQuest analysis

The relative contribution of pipeline gas, renewable electricity, and non-renewable electricity on 15 August 2023 is shown in Figure 10. In this comparison the energy provided by pipeline gas has been discounted by 71% to estimate how much electricity would be required to replace pipeline gas. On that basis, if pipeline gas had been electrified it would have accounted for 33% of VICNEM supply on 15 August 2023 compared to 14% from wind and solar, 1% from hydro, and 52% from non-renewable power generation.

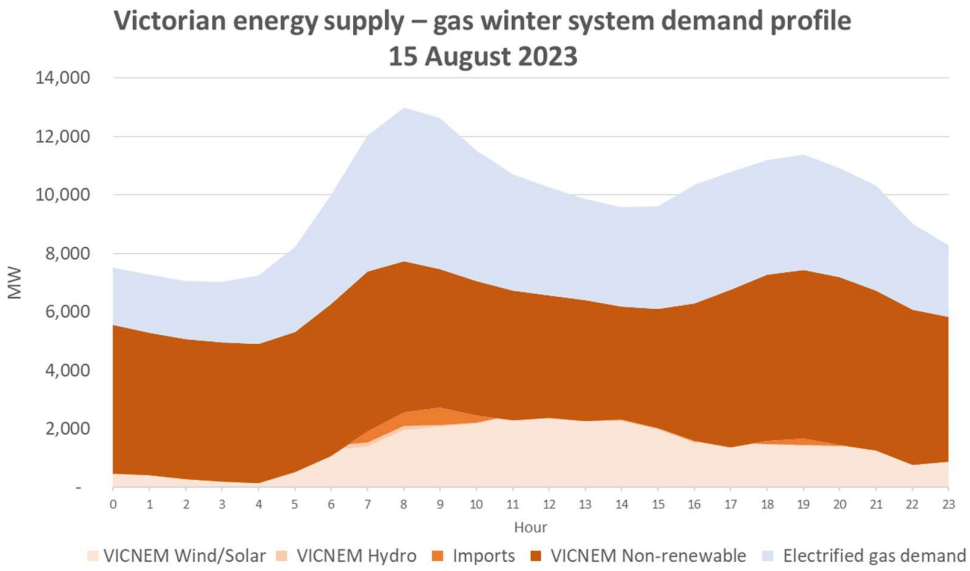
Figure 9 Victorian energy supply – 15 August 2023



Source: OpenNEM, EnergyQuest analysis

Figure 10 shows energy supply through the day with daily gas use adjusted to reflect the average Victorian weekday winter system demand profile for 2022 with peaks in demand occurring during the morning and evening.

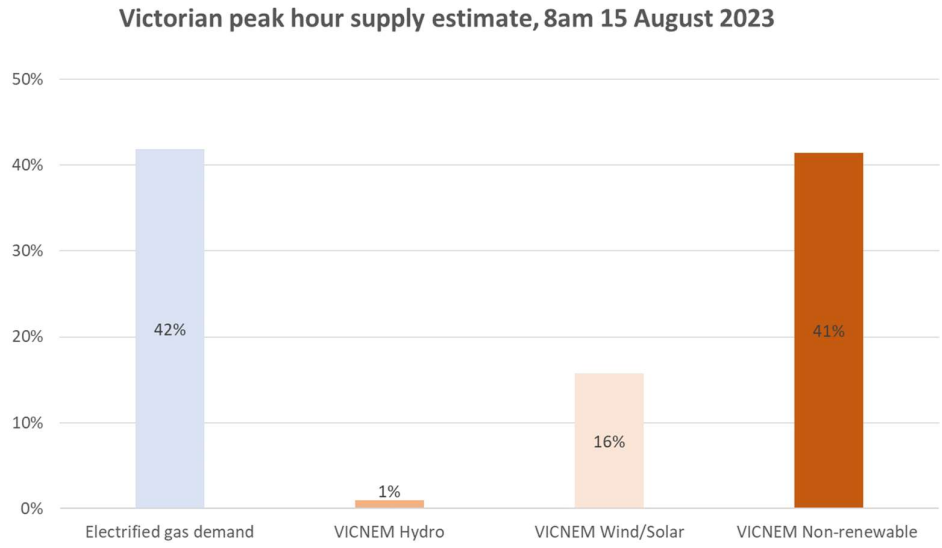
Figure 10 Victorian energy supply – gas winter system demand profile 15 August 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Figure 11 is based on the same data set as Figure 10 and shows estimated energy supply at 8 am which is the peak hour for gas demand in winter. If pipeline gas had been electrified it would have accounted for 42% of VICNEM supply at 8 am on 15 August 2023 compared to 16% from wind and solar, 1% from hydro, and 41% from non-renewable power generation.

Figure 11 Victorian peak hour supply estimate, 8 am 15 August 2023



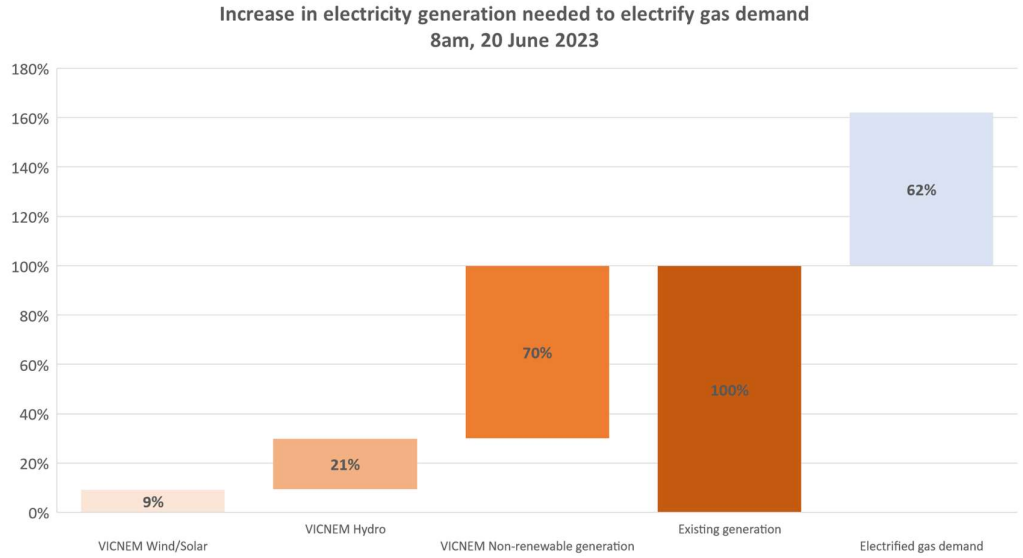
Source: AEMO, OpenNEM, EnergyQuest analysis

Discussion

The modelling results above indicate that full electrification of pipeline gas in Victoria would require a substantial increase in electricity generation to avoid supply shortages.

Figure 12 compares output from renewable electricity and the existing energy mix (renewables plus non-renewables) during peak hour demand on 20 June 2023. As shown in the chart, replacing the energy provided by pipeline gas would require 62% more electricity than was observed at this time.

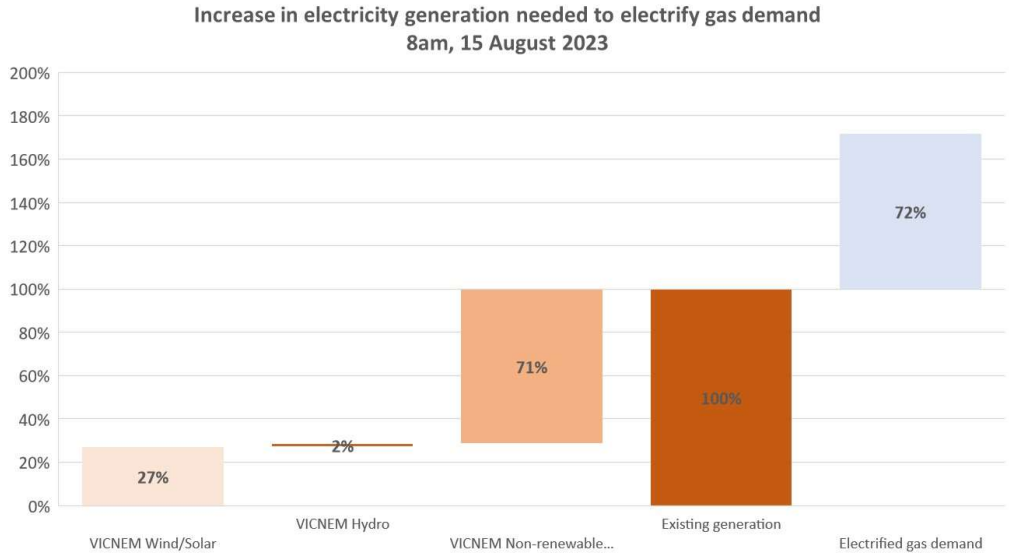
Figure 12 Increase in electricity needed to electrify gas demand – 8 am, 20 June 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Figure 13 compares output from renewable electricity and the existing energy mix (renewables plus non-renewables) during peak hour demand on 15 August 2023. As shown in the chart, replacing the energy provided by pipeline gas would require 72% more electricity than was observed at this time.

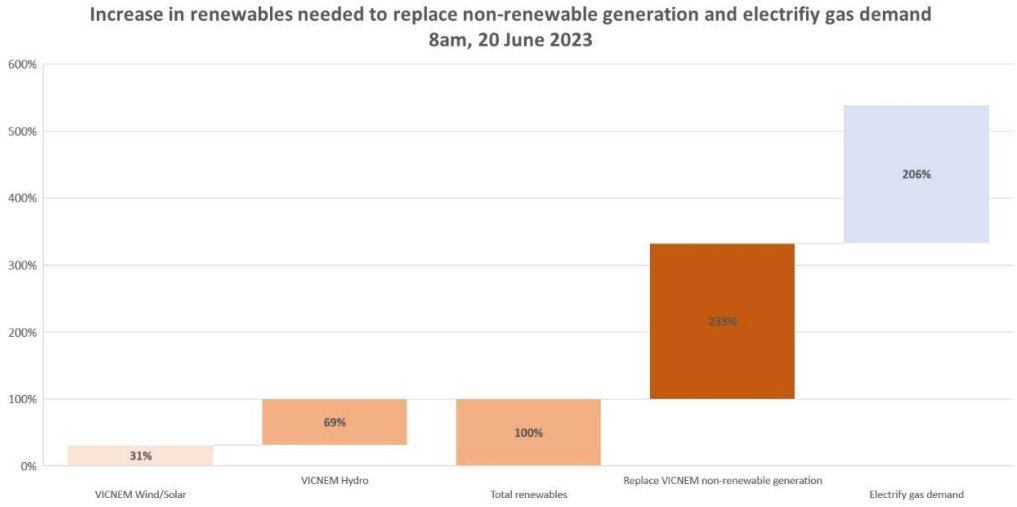
Figure 13 Increase in electricity needed to electrify gas demand – 8 am, 15 August 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Replacing non-renewable generation and pipeline gas with wind, solar, and hydro would require 439% more output from those sources combined than was observed during peak hour demand on 15 August 2023 - 233% more to replace existing non-renewable generation and 206% more to replace pipeline gas (Figure 14).

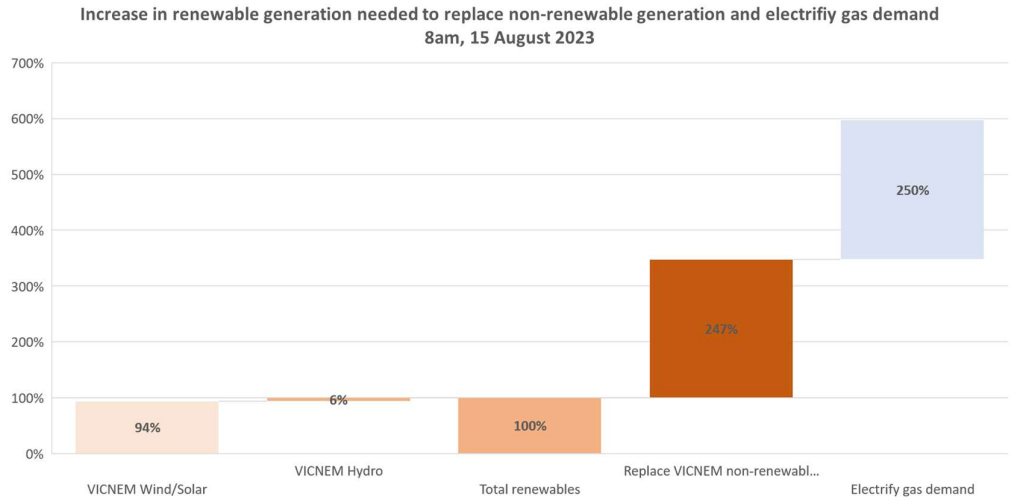
Figure 14 Increase in renewable generation needed to replace non-renewable generation and electrify gas demand - 8 am, 20 June 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Replacing non-renewable generation and pipeline gas with wind, solar, and hydro would require 497% more output from those sources combined than was observed during peak hour demand on 15 August 2023 - 247% more to replace existing non-renewable generation and 250% more to replace pipeline gas (Figure 15).

Figure 15 Increase in renewable generation needed to replace non-renewable generation and electrify gas demand - 8 am, 15 August 2023



Source: AEMO, OpenNEM, EnergyQuest analysis

Increasing the capacity of the electricity network to achieve increases of this scale would come at substantial cost. Overnight renewable electricity supply would need to come from energy storage, wind, or hydro power.

As we discuss in the following sections, Victoria's natural gas pipeline network is a significant existing method of energy transmission and storage. Substituting natural gas with renewable gases would avoid the substantial cost of replacing pipelines with electrical infrastructure and may therefore offer a lower cost decarbonisation pathway to electrification.

Energy transition

Key points

- Victoria's energy system and the NEM more broadly are undergoing a major energy transition.
- Electricity generation shortfalls in winter 2022 led to extreme price movements and the underlying causes of these shortfalls remains.
- Gas supplied via pipeline to the household, commercial, and industrial sectors is a major energy source, providing almost as much energy as electricity during peak day demand.
- AEMO forecasts significant demand for domestic natural gas to 2042 under all emissions reduction scenarios.
- AEMO's Orchestrated Step Change (1.8°C) scenario and the Victorian Government's Gas Substitution Roadmap both forecast a move away from natural gas as an energy source but note the potential for renewable gases to substitute for natural gas.
- The cost of replacing existing gas transmission and storage capacity with electricity would be substantial and has the potential to increase electricity and gas prices.

- In the longer term, renewable gas has the potential to substitute for natural gas and decrease the cost of new electrical transmission and storage infrastructure.

Discussion

The Australian energy system has been transitioning to lower emissions generation for over a decade.

For many years regulatory bodies and the energy industry have issued warnings on the potential for energy shortages in Victoria and the east coast energy market more broadly. As far back as 2015, AEMO was advising that Victoria could breach the Reliability Standard in 2024-25 under a medium demand scenario, and earlier for other states connected to Victorian electricity supply in the NEM[8].

The warnings from regulators are becoming more strident. In their latest report on the east coast gas market the ACCC notes that AEMO's latest projections indicate that if extreme winter weather conditions in southern jurisdictions coincides with high demand for GPG then peak day supply shortfalls could occur[9].

Most recently, AEMO's 2023 Electricity Statement of Opportunities says that urgent investment in energy supply is needed or the reliability of the NEM will be at risk[10]. According to AEMO, Victoria is most at risk of demand for electricity exceeding supply resulting in loss of supply in the absence of out of market intervention. Victoria may see electricity shortages as soon as the coming summer of 2023. AEMO also states that 'the projected electrification of traditional gas loads, particularly heating loads in Victoria, increases forecast consumption and maximum demands in winter'.

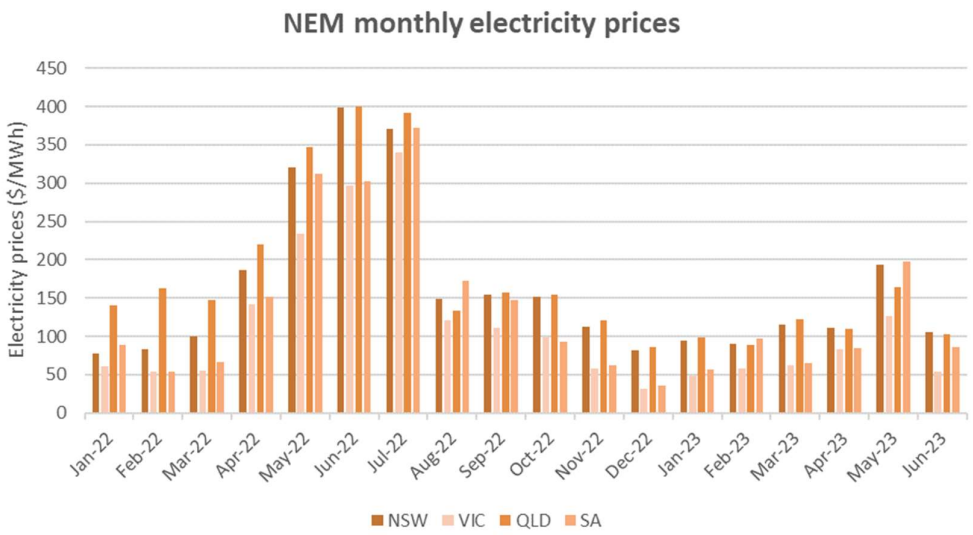
Winter 2022

These issues came to a head in the winter of 2022 when a confluence of factors combined to create an unprecedented price and supply shock to the east coast energy system.

In the first half of 2022, electricity prices in the southern state more than tripled, and prices in Queensland (off a higher base, with 20% of baseload capacity unavailable due to outages at the end of January 2022) more than doubled for May compared to the first quarter average as shown in Figure 16.

[8] AEMO, '2022 Electricity Statement of Opportunities', August 2015, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo/2015-nem-electricity-statement-of-opportunities
[9] ACCC, 'Gas inquiry June 2023 interim report', 30 June 2023, https://www.accc.gov.au/about-us/publications/serial-publications/gas-inquiry-2017-30-reports/gas-inquiry-june-2023-interim-report
[10] AEMO, '2023 Electricity Statement of Opportunities', 31 August 2023, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo

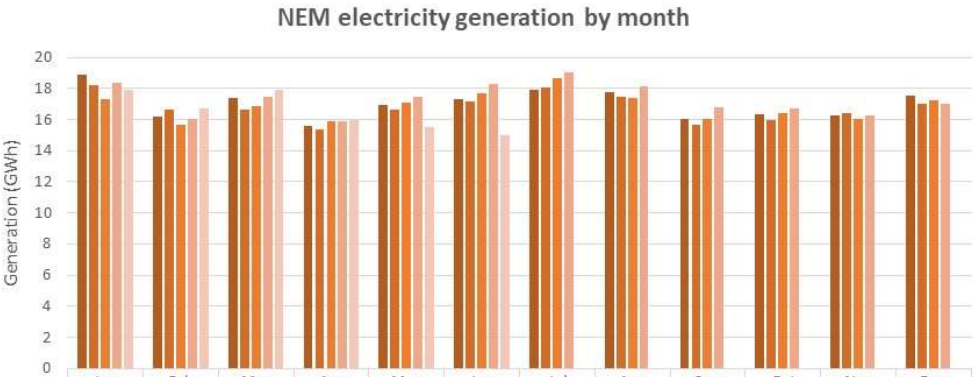
Figure 16 NEM monthly electricity prices



Note: Simple average calculation
Source: AEMO, EnergyQuest analysis

Price increases were not obviously driven by excessive demand for generation, which in 2022 for each month was less than 5% more than the 3-month average for 2019–2021 (Figure 17).

Figure 17 NEM electricity generation by month (GWh/month)

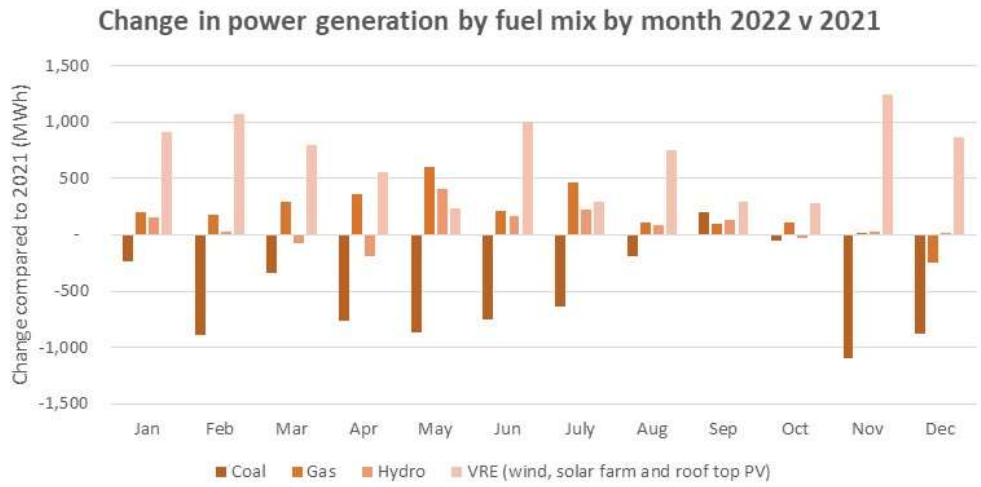


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	19	16	17	16	17	17	18	18	16	16	16	18
2020	18	17	17	15	17	17	18	17	16	16	16	17
2021	17	16	17	16	17	18	19	17	16	16	16	17
2022	18	16	17	16	17	18	19	18	17	17	16	17
2023	18	17	18	16	15	15						

Note: includes rooftop solar
Source: AEMO, EnergyQuest analysis

What caused the electricity price increase for April to August 2022 was that compared to the prior year CPG was down in every month, offset by substantial gains in gas, hydro and variable renewable energy (VRE, which includes wind, solar farms and roof top PV) (Figure 18).

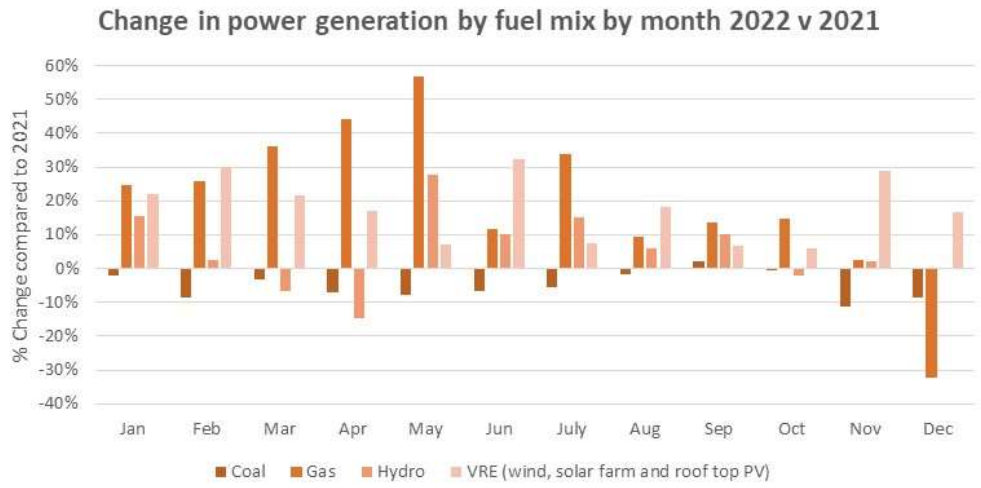
Figure 18 Change in power generation by fuel mix and month: 2022 less 2021



Note: Gas includes oil
Source: AEMO, EnergyQuest analysis

This caused large increases in the non-coal fuels to offset the lower CPG. GPG increased up to 58% in May 2022 compared to May 2021 (Figure 19) – and this priority to maintain electricity generation supply was a major contributor to the gas price increases in April (up 52% on March) and May (up 75% on April) 2022, even with declining LNG feedstock demand. AEMO imposed market price controls in the form of a $40/GJ gas market cap in June.

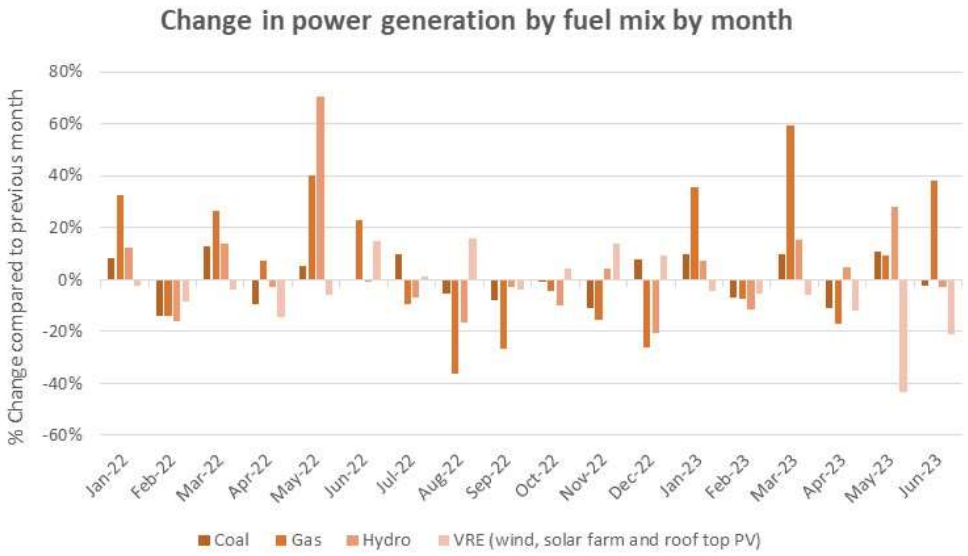
Figure 19 Change in power generation by fuel mix by month: 2022 vs 2021



Note: Gas includes oil
Source: AEMO, EnergyQuest analysis

Not only was this an increase against the same period in 2021, but the month to month increases were substantial, with GPG increasing by 39% in May when compared to April, while VRE's fell 6% with unfavourable weather, and hydro was called upon with a 71% increase (Figure 20).

Figure 20 Change in power generation by fuel mix by month compared to previous month



Source: AEMO, EnergyQuest analysis

In May 2022, GPG had increased 474 GWh compared to April 2022, and 567 GWh compared to May 2021. With an assumed heat rate for open cycle gas generators of 9.9 TJ/GWh, to generate the additional 567 GWH required approximately 5.6 PJ of additional gas in a domestic market of approximately 60 PJ[11] for May 2022.

Relevance for Victoria

As shown in Figure 16 above, during the winter of 2022 Victorian electricity prices increased by more than six times over. The immediate causes of the price spikes in winter 2022 were transitory and have since been resolved, but the underlying problem has not.

Managing the exit of CPG in a coordinated manner is challenging. Adding further demand for electricity through the electrification of Victorian household, commercial, and industrial gas demand would add significantly to the firmed renewable capacity needed.

Transitional scenarios

AEMO established five scenarios in its *Integrated System Plan*[12] for possible change in the NEM to 2040 in consultation with stakeholders. The scenario considered most likely by stakeholders is the *Step Change* scenario.

Step Change has multiple elements but most significant for the purpose of this report are:

- Most consumers rely on electricity for heating and transport as consumers switch from gas to electricity
- Manufacturing and industrial processes strongly increase electrification
- The global manufacture of internal-combustion vehicles all but ceases

[11] The domestic market includes east coast gas demand for GPG, Industrial, Commercial and Residential customers, but not export LNG feedstock. For May 2022, actual gas demand for GPG was 14.9 PJ, up from 11.3 PJ in April 2022, and 9.9 PJ in May 2021.
[12] AEMO, '2022 Integrated System Plan', 30 June 2022, https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

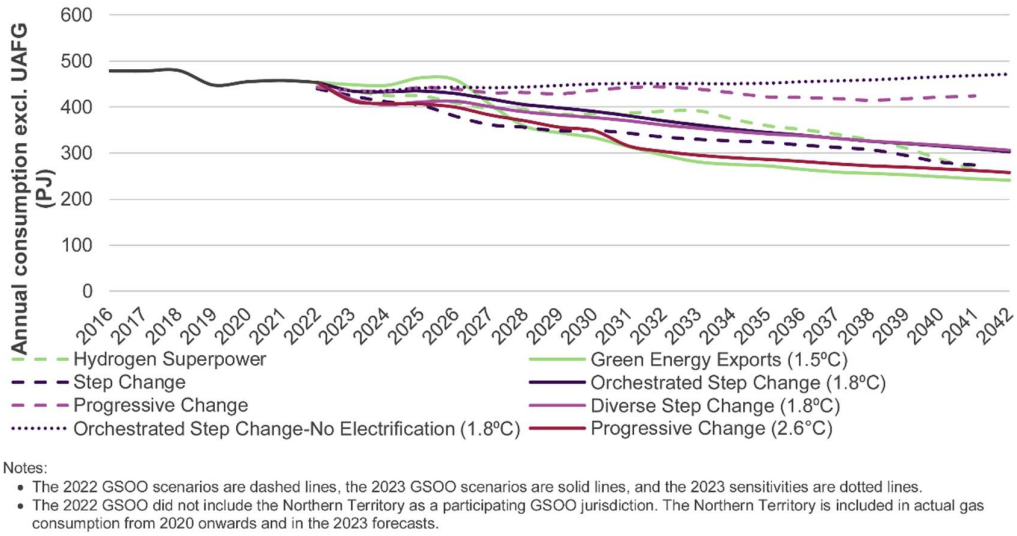
- Domestic hydrogen production supports transport and pipeline gas

The Step Change scenario therefore envisages a move away from conventional natural gas over time but ongoing use of gaseous fuels to produce heat and electricity remains.

AEMO forecasts gas demand over the next 20 years with results published in the *Gas Statement of Opportunities* (GSOO). The GSOO focusses on the 'Orchestrated Step Change (1.8°C) scenario which is most similar to the Step Change scenario in the *Integrated System Plan*.

The GSOO forecasts are updated annually and the 2023 results for domestic natural gas consumption (excluding gas generation) are shown in Figure 21 below. As indicated in this chart, natural gas consumption declines in most scenarios but remains significant to 2042.

Figure 21 AEMO forecast domestic natural gas consumption, excluding gas generation, all scenarios and compared to 2022 GSOO forecasts (PJ), 2016-42[13]



Notes:
- The 2022 GSOO scenarios are dashed lines, the 2023 GSOO scenarios are solid lines, and the 2023 sensitivities are dotted lines.
- The 2022 GSOO did not include the Northern Territory as a participating GSOO jurisdiction. The Northern Territory is included in actual gas consumption from 2020 onwards and in the 2023 forecasts.

Source: AEMO

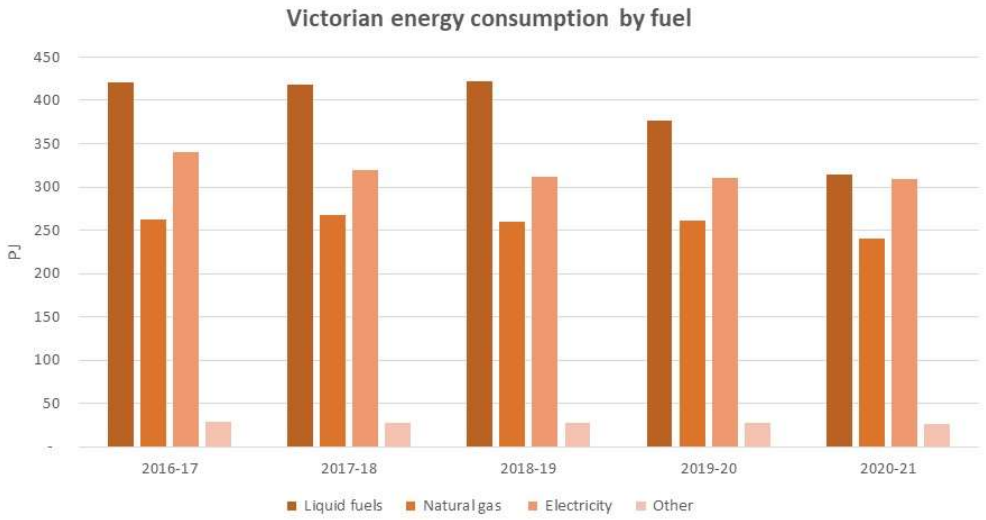
The Victorian Government indicates in the *Gas Substitution Roadmap* that alternative sources of gas will be essential and envisages renewable gases and hydrogen being taken up at increasing scale. The existing pipeline network offers a mechanism for storage and delivery of gas under this scenario.

Energy provided by natural gas

Natural gas is currently a major source of energy in Victorian and accounted for 27% of energy consumed in Victoria in 2020-21[14]. Liquid fuels (primarily gasoline and diesel) and electricity each contributed some 35%. Victorian energy consumption by fuel is shown in Figure 22 below.

[13] AEMO, '2023 Gas Statement of Opportunities', 28 April 2023, https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/gsoo/2023/2023-gas-statement-of-opportunities.pdf?la=en
[14] Department of Climate Change, Energy, the Environment, and Water, 'Australian Energy Statistics', 2 September 2022, https://www.energy.gov.au/government-priorities/energy-data/australian-energy-statistics

Figure 22 Victorian energy consumption by fuel



Source: Australian Energy Statistics, EnergyQuest analysis

Electricity in Victoria is at present predominantly sourced from CPG. Electricity generation as a whole is the source of 50.1% of Victoria's total emissions with CPG accounting for 47.4% of total emissions[15]. GPG accounts for 1.7% of total emissions. Today, electrifying gas demand using the existing Victorian power fleet would therefore be shifting energy demand to a more greenhouse intensive energy source.

Replacing pipeline gas with electricity while also ensuring peak demand is met would require firmed electrical generation capacity to increase sufficiently to meet the additional peak demand that is currently served by natural gas. Based on seasonal estimates for 2023 the Victorian electricity system would need firm capacity sufficient to meet an additional 91% demand during winter and 55% during summer (Table 1).

Table 1 Maximum Victorian demand 2023 – electricity and gas

		Winter	Summer
Electricity maximum demand	MW	8,976	8,135
Gas max peak day demand 1-in-20	MW	8,182	4,444
Electricity demand increase - gas electrification	**MW**	**91%**	**55%**

Source: AEMO, AER, EnergyQuest analysis

Victoria gets its electricity from and is part of the NEM. Wholesale prices in the NEM are fundamentally driven by supply and demand as they are in any market. A shift away from gas to electrification in the short to medium term would add to electricity demand during a period when there may be shortfalls even without a significant shift to electrification[16].

[15] Victorian Government, 'Victorian Greenhouse Gas Emissions Report', 2020, https://www.climatechange.vic.gov.au/greenhouse-gas-emissions

[16] Infrastructure Victoria, 'Towards 2050: Gas infrastructure in a net-zero emissions economy interim report', June 2021, https://www.infrastructurevictoria.com.au/wp-content/uploads/2021/07/Gas-Infrastructure-Advice-Interim-Report-FINAL-4.pdf

Energy transmission and storage

Victoria's natural gas pipeline network is an established and significant energy transmission and storage system. The network comprises 1,900 km of high-pressure pipelines, 32,000 km of low pressure distribution pipelines, and an asset base of some $6 billion[17].

At present the network is based on natural gas produced from petroleum formations which is energy dense and can be stored within the pipeline network and in geological formations. Continued use of this network for the transmission and storage of renewable gases offers the potential to reduce emissions at a lower cost than electrification of all gas uses.

The capital cost to replace the existing gas transmission and distribution infrastructure would be significant. The regulated asset base of existing electrical infrastructure is over three times the value of the gas network but delivers some two thirds the energy and has one third the capacity (Table 2).

Table 2 Victorian energy infrastructure 2021

Transmission and distribution infrastructure	Regulated Asset base ($m)	Actual Annual Revenues ($m)	Actual Energy Delivered (GWh)	Max Demand Capacity (MW)
Electricity	18,905	2,800	42,259	7,786
Gas	5,775	810	64,387	23,507

Source: AER, AEMO, APA

Reducing utilisation of the pipeline network can also carry an additional cost in the form of increased costs for remaining users. An example of this effect is the decision by the Australian Energy Regulator (AER) to allow for accelerated depreciation of Evoenergy's gas assets in the ACT in response to falling gas demand which in turn was driven by the ACT Government's climate change strategy[18]. The decision increased costs for remaining gas users as the recovery of network costs was brought forward.

The AER notes the key risks of electrifying gas demand are the reduced use of gas networks earlier than necessary and increased upwards pressure on gas and electricity prices[19].

Appliance conversion

The cost of replacing existing gas appliances with electrical equivalents can be substantial. The Victorian Government estimates the cost of converting an existing home with solar power to electrical appliances to be $14,500 including the solar hot water rebate[20].

---

[17] Ibid

[18] Australian Energy Regulator, 'AER allows revenue to support gas consumers in transition to renewables', 30 April 2021, https://www.aer.gov.au/news-release/aer-allows-revenue-to-support-gas-consumers-in-transition-to-renewables

[19] AER, 'AER submission – Victoria's Gas Substitution Roadmap', 2 August 2021, https://www.aer.gov.au/system/files/AER%20submission%20to%20Victoria%27s%20Gas%20Substitution%20Roadmap%20Consultation%20Paper.pdf

[20] Department of Energy and Climate Action, 'Embracing electricity to cut your bills at home', 2022, https://www.energy.vic.gov.au/__data/assets/pdf_file/0039/579882/Victorias-Gas-Substitution-Roadmap-Embracing-electricity-to-cut-your-bills-at-home.pdf

Excluding the upfront capital cost, switching from gas appliances to electrical can reduce the cost of energy bills for households. The Victorian Government estimates replacing a gas water heater with a heat pump can save between $100 to $200 per year and replacing a gas space heater with reverse cycle air conditioning can save $500 to $600 per year[21].

The upfront cost of electrification can therefore be significant relative to annual savings. The Victorian Government is offering rebates that cover part of the upfront cost.

Renewable gas as an alternative to electrification of natural gas

Key points

- Green hydrogen and renewable natural gas are zero emission energy sources that can substitute for natural gas use. Natural gas with CCS is also a potential zero or low carbon source of energy over the longer term.
- Biogas, biomethane, and renewable hydrogen use may grow significantly in coming decades.
- Analysis by the Victorian Government indicates the most promising options for decarbonising gas supply involve a mix of electrification, biogas, hydrogen, and CCS.

Discussion

Renewable gases are carbon neutral gaseous energy sources and includes renewable hydrogen, biogas, and biomethane.

Renewable hydrogen is produced by using renewable electricity to power electrolysers to produce hydrogen from water.

Biogas is a mix of methane, CO_2, and other gases and is produced by the decomposition of organic matter. Biogas can be produced using biodigesters or by capturing gas from landfill or wastewater treatment plants.

Biomethane is also referred to as renewable natural gas and is essentially identical to the conventional natural gas produced from petroleum formations. Biomethane can be produced by refining and upgrading biogas or by gasification of biomass followed by methanation. Globally, 90% of biomethane comes from upgrading biogas[22].

Renewable gas as an alternative to electrification

The IEA has examined the global potential for renewable gas under their Sustainable Development Scenario (SDS) and Stated Policy Scenario (STEPS). The SDS assumes various global sustainable development goals are achieved and forecasts a way for the global energy sector to be aligned with the Paris Agreement goals while also achieving goals relative to universal access to energy. The STEPS represents current energy and climate policies being achieved.

---

[21] Department of Energy and Climate Action, 'Gas Substitution Roadmap', 2022, https://www.energy.vic.gov.au/__data/assets/pdf_file/0025/586411/Victorias-Gas-Substitution-Roadmap.pdf

[22] International Energy Agency, 'Outlook for biogas and biomethane: Prospects for organic growth', March 2020, https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth

Biogas and biomethane are the fastest growing sources of energy under the SDS and the STEPS albeit from a low base. Market share for total bioenergy demand would grow to 12% by 2040 in the STEPS and to 20% in the SDS.

Renewable hydrogen also has significant potential. AEMO's Hydrogen Superpower scenario for the NEM examines strong global policy action to reduce emissions and technological improvements. Under the scenario, households with existing gas connections would switch to blended hydrogen and then to 100% hydrogen. The scenario if achieved would generate strong economic growth.

Analysis by Infrastructure Victoria[23] found there is no single path to achieving net zero emissions in the gas sector and recommended that production of biogas and biomethane be accelerated due to their potential to contribute to gas sector decarbonisation. Infrastructure Victoria further recommended that green hydrogen development should be fast tracked as it will potentially become cost-competitive.

As noted above, Victoria's pipeline network provides an existing energy transmission and storage mechanism and the capital cost of replacing the pipeline network with electrical infrastructure would be substantial. The cost of adding electrical infrastructure and replacing gas appliances could be significantly reduced, and emissions reduction goals achieved, if renewable gas substituted for natural gas instead of fully electrifying natural gas demand.

[23] Infrastructure Victoria, 'Towards 2050: Gas infrastructure in a net-zero emissions economy', December 2021, https://www.infrastructurevictoria.com.au/report/towards-2050-gas-infrastructure-in-a-net-zero-emissions-economy/

EnergyQuest standard terms and conditions

EnergyQuest Pty Ltd (**EQ**)

ACN 139 665 295 | ABN 89 139 665 295

Address: Unit 1002, 527 Coronation Drive, Toowong Qld 4066

Email: rwilkinson@energyquest.com.au

Website: www.energyquest.com.au

Version: 29 June 2023

About these terms

1. The Client acknowledges having had fair opportunity to read, understand and negotiate with EQ regarding these terms.

2. Subject to any special written offer by EQ or as otherwise agreed by EQ in writing, these terms form part of each contract for EQ to supply to the Client:

   2.1 a Multi-Client Report (or "**MCR"**) – being a publication of EQ not commissioned by a particular Client (such as EnergyQuarterly, Australian LNG Monthly report, East Coast Gas Outlook) supplied at the frequency they are produced (as specified for the particular MCR on the Website) upon payment by the Client of a subscription fee; or

   2.2 an Independent Consultancy Report (or "I**CR"**) – being a single, or series of, written reports or recommendations, or presentations (oral and/or visual), by EQ commissioned by a particular Client supplied in accordance the terms of engagement agreed between EQ and the Client (Consultancy Contract).

3. In these terms the term "**Report**" means MCR and ICR collectively or any one of them as the context requires.

4. The Client is deemed to have accepted these terms, if after receipt of a copy of these terms or after being able to access these terms on EQ's website, the Client places an order for, or commissions (as the case may be) a Report. The Client's failure to acknowledge these terms is not evidence these terms do not apply. These terms negate any terms the Client may issue.

5. EQ may at any time change these terms by notifying the Client or by issuing an alert on EQ's website. Any such change applies to any contract for a Report that is completed and supplied to the Client two (2) or more days after the change was so notified or the alert was issued.

Multi-Client Reports

6. Upon EQ receiving the relevant subscription payment from the Client in full clear funds, the MCR subscribed to will be delivered electronically to the Clients email address nominated in the subscription application, and at the frequency specified for the particular MCR on the Website.

7. The Client acknowledges that an MCR is necessarily of a general nature, does not constitute advice based on the particular circumstances of the Client and must not be relied on in making decisions in the Client's enterprise.

8. EQ reserves the right to suspend or terminate a subscription without giving reasons, subject to EQ refunding to the Client any prorated subscription fee paid to EQ in advance.

Independent Consultancy Reports

9. A Consultancy Contract only forms when EQ either agrees in writing (including by email exchange) to the engagement or commences work for that Client on the ICR.

10. A Consultancy Contract is comprised of these terms as read with and subject to the 'brief' (scope of work, timetable and other particulars) as last issued by the Client before the Consultancy Contract formed. The brief may not change thereafter except with EQ's consent. Consent may be conditional, such as a revision of the fee to be paid to EQ. If the brief changes, these terms also apply to the brief as changed. A Consultancy Contract may only be modified or cancelled as the parties agree in writing (includes by email exchange).

11. Any promotional materials EQ publishes only give a general idea of its services on offer and cannot be relied on for any other purpose.

12. If in the preparation of an ICR:

    12.1 EQ reasonably requires from the Client any direction, information or access to the Client's staff or records or premises, the Client must provide that input promptly and without charge;

    12.2 EQ acts on a direction given by the Client, that action is wholly at the Client's risk; or

    12.3 EQ uses information sourced from the Client or from a third party believed by EQ to be reputable, EQ may rely on that information without enquiry and the use of that information is wholly at the Client's risk.

13. For the purposes of paragraph 9, where the Client is the source of such information (Client Information), the Client warrants it has right to disclose the Client Information to EQ and that it does not infringe any third party's rights or applicable law.

14. EQ acknowledges that it remains liable for the due performance of the Consultancy Contract notwithstanding EQ may use subcontractors in the preparation of the ICR.

15. EQ must immediately notify the Client if EQ becomes aware of EQ having a conflict of interest, or a significant risk of a conflict, in performance of the Consultancy Contract. If EQ has a conflict of interest that cannot be managed to the Client's satisfaction, the Client may terminate the Consultancy Contract without penalty.

16. Unless otherwise specified in the EQ quotation or subsequently as agreed in writing (including by email exchange), EQ will issue a tax invoice for a ICR for payment by the Client in AUD within 30 days after completion of the ICR by electronic transfer in clear funds to a bank account nominated by EQ on the tax invoice. However, if the scope of work for the ICR is for a series of written reports, recommendations and/or presentations, EQ may issue interim tax invoices monthly with a final tax invoice to follow after completion of the ICR.

17. In addition to the fee referred to in paragraph 16, EQ may recover from the Client an amount equal to the GST for which EQ becomes liable by the Consultancy Contract being a taxable supply to the Client, conditional upon EQ issuing a tax invoice for that payment.

18. EQ may not claim against the Client for any cost or expense (other than GST) EQ incurs in a Consultancy Contract as an addition to its fee except to the extent provided for in the Consultancy Contract or approved in writing by the Client.

19. The Client must not deduct from EQ's invoice/s any set off, counterclaim or rebates asserted by the Client or other sum (such as taxes, charges etc).

20. If payment of EQ's invoice is late, then in addition to its other rights and remedies EQ may recover from the Client daily interest charged at the rate of 12% per annum on

the unpaid amount calculated from the date the payment was due. Interest not paid for 30 days adds to the debt (is capitalised), and thereafter attracts interest.

21. A party to a Consultancy Contract must not at any time make improper use or disclosure of any information about the affairs of the other party or any information the use or disclosure of which information is regulated by the Privacy Act 1988, or the Australian Privacy Principles obtained in negotiations for, or in performance of, the Consultancy Contract. The fact and terms of the Consultancy Contract are information to which the above applies to the benefit of all parties jointly. To obtain a copy of EQ's Privacy Policy, contact EQ.

25. Subject to paragraph 15 (conflict of interest) and paragraph 21 (confidentiality), a Consultancy does not prevent EQ from consulting to any third party, such as a competitor of the original Client.

26. EQ must use reasonable care in carrying out a Consultancy. Otherwise, EQ does not give any other warranty, condition or guarantee in connection with the conduct of the Consultancy unless required by law (for example, Australian Consumer Law).

27. As a continuing obligation (including after the Consultancy Contract terminates) the Client indemnifies and holds harmless EQ against any claim for any loss, damage, personal injury or death to the extent caused by the Client's improper distribution, sharing or use of a deliverable.

28. EQ accepts no liability to anyone other than the Client. The Client may not assign or declare a trust of a Consultancy Contract or the benefit of a service in the Consultancy Contract without EQ's prior written consent.

29. The Client agrees that EQ'S total liability in respect of any claim pertaining to the Consultancy Contract shall not exceed, in monetary terms, three times the quantum of EQ's fee (excluding GST) for its performance of the Consultancy Contract.

30. If in a Consultancy Contract, the Client is more than one (1) person, that contract binds each such person jointly and severally, and each of them is taken to have authority to bind the other/s in connection with the contract, including that a notice to / from any such person is notice to / from all of them. If the Client nominates a third party as the recipient of service in the Consultancy Contract or as the addressee of an invoice for the Consultancy Contract, the initial Client remains liable.

31. A party is not liable for a failure to perform a Consultancy Contract to the extent its performance is prevented by a circumstance not within that party's reasonable control and without its negligence.

32. Any provision of a Consultancy Contract that is unenforceable at law must be read down to the extent necessary to avoid that result, or if it cannot be read down it must be severed without affecting the validity and enforceability of the remainder of the contract.

33. A Consultancy Contract constitutes the parties as independent contractors and not as partners, joint venturers, principal and agent, or trustee and beneficiary for any purpose.

General terms

34. Where the Client elects to pay for a Report by providing the Client's credit card details, by providing that information, the Client irrevocably authorises and directs EQ to process the credit card payment through its merchant facility for the full amount of the relevant annual subscription or the fees payable pursuant to a Consultancy Agreement, as the case may be, (including GST), plus a surcharge of up to 1.5% to cover applicable bank, administration and processing fees.

35. EQ is not competent or licensed to provide financial services advice (such as whether to acquire, hold, vary or dispose of an investment), taxation advice, legal

advice, valuation advice, engineering or technical advice, and if the Client has need of that advice they should always seek it from an appropriately qualified professional.

36. The Client acknowledges that EQ almost exclusively conducts the work for the preparation of Reports through the use of subcontractors.

37. The Client acknowledges and agrees, regardless of whether EQ issues an oral or written Report, that:

    37.1 any historical information in the Report is not necessarily an indicator of future performance;

    37.2 any estimate, projection or forecast in the Report would be based on various assumptions (which might not be stated) and on subjective beliefs, opinions and estimates of EQ as of the date the supply of the Report;

    37.3 EQ is not obliged to update any forward-looking information as above if those beliefs, opinions or estimates should change or to reflect other future developments;

    37.4 the Report is confidential to EQ and the Client must not, without EQ's written approval:

        (a) allow any person (individuals, consultants, investors, joint venture partners, corporations or government body) outside the Client's enterprise to access the Report (or extract from it); or

        (b) cite or reference the Report in any material published externally by the Client;

    37.5 unless otherwise stated, the Report (including all text, images, tables, calculations, models, graphics and Intellectual Property) is the copyright of EQ and at all times remains the property of EQ; and

    37.6 the Client has a non-exclusive, non-assignable, irrevocable licence to use and reproduce the Report for, and only for, the Clients enterprise, conditional upon the Client having paid EQ in full for the Report.

38. The laws in Queensland govern these terms and a Consultancy Contract, and EQ has exclusive right to nominate the court in which any legal action is to be commenced and conducted. The parties submit irrevocably to the jurisdiction of those courts, and any courts that have jurisdiction to hear appeals from those courts.