

Flame out

The future of natural gas

Tony Wood and Guy Dundas



November 2020

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Overview

Natural gas has been a valuable energy source in Australia for more than 50 years. But it faces two challenges. Firstly, Australia must reduce emissions over time to meet our climate change targets. The gas sector is no exception. Secondly, the east coast will not go back to the good old days of low-priced gas, making gas an increasingly expensive energy source.

Faced with these challenges, the Federal Government's hopes for a gas-fired recovery from the COVID recession appear misplaced. Its plans include a range of sensible policies to improve today's gas market, but it has also raised expectations of large price reductions.

The reality is that eastern Australia faces inexorably more expensive gas, and the impact will be felt by manufacturers and power generators, and by small businesses and households. If the Government tries to swim against this tide through direct market interventions, it will probably require ongoing subsidies at great cost to taxpayers.

Even if the Government could significantly reduce gas prices, the benefits to manufacturing are overstated. Undoubtedly, high gas prices threaten some businesses. But gas use in manufacturing is highly concentrated in three sectors that contribute only about 0.1 per cent of gross domestic product, and employ only a little more than 10,000 people. And much of this gas-intensive industry is in Western Australia, which enjoys low gas prices already.

The best role for governments is to support the development and deployment of the low-emission alternatives that can replace natural gas in manufacturing, such as renewables-based hydrogen and renewables-based electricity. The Federal Government's low-emissions technology statement is a good start. Low-cost finance can particularly help smaller manufacturers overcome capital replacement barriers.

In power generation, the large-scale use of gas as a 'transition fuel' – supplying 'baseload power' with lower emissions than coal – does not stack up economically or environmentally. Gas has been declining as a share of Australia's power supply since about 2014, and the best estimates indicate this decline will continue over the coming decade. Gas will play an important backstop role in power generation when the sun isn't shining, and the wind isn't blowing – but this role does not require large volumes of gas.

At home, consumers value being able to choose between gas and electricity for tasks such as cooking and heating. But here too Australia must either replace natural gas with low-emissions substitutes such as biomethane or hydrogen, or switch to electricity and take advantage of the decarbonising grid.

The best long-term choice among biomethane, hydrogen, or electricity is not clear today and may vary between different parts of the country. Each has its challenges. Australia must fully analyse the options to work out the best path forward. In the meantime, it is already clear that households would save money and Australia would reduce emissions if new houses in NSW, Queensland, South Australia, and the ACT were all-electric. In these places, governments should impose a moratorium on new gas connections as a prudent, no-regrets option.

This report confronts the uncomfortable truth that natural gas is in decline in Australia. The consequences of that reality may be painful for some in the short term, but neither wishful thinking nor denial will serve us well. The only rational approach, for governments, the energy industry, and its customers, is to begin planning for a future without natural gas, or at least with a substantially reduced role for natural gas.

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1 Australia's gas puzzle

In the midst of a once-in-a-century pandemic Australia has, somewhat surprisingly, found itself talking about natural gas.

The Prime Minister, at the behest of the National COVID-19 Coordination Commission (NCCC),¹ has put gas at the heart of Australia's recovery from the COVID recession (Box 1). The Federal Government has indicated that if private investment in gas fields and pipelines is not sufficient, it might 'step in' to underwrite or co-invest in strategic 'nation-building' investments, at potentially significant cost to the taxpayer. It justifies these interventions on the basis that they will underpin manufacturing jobs and drive down electricity prices.

But the Government's plans for a gas-fired recovery face two key challenges. Firstly, Australia must reduce emissions over time to meet our climate change targets – and gas is not an exception. Secondly, eastern Australia has already burned most of its low-cost gas, and gas prices will not go back to the good old days.

Gas is a flexible and important fuel, and will be used in Australia's factories, power stations, shops, and homes for decades yet. But the increasing economic and environmental cost of gas means that this role must shrink rather than expand. This is not a simple task, and so it is crucial that we start now. This report confronts the uncomfortable reality that our use of gas must begin to change, and we must plan for that future now.

Box 1: The Federal Government and its advisers have put gas at the heart of the recovery from the COVID recession

'To help fire our economic recovery, the next plank in our JobMaker plan is to deliver more Australian gas where it is needed at an internationally competitive price... Gas is a critical enabler of Australia's economy' – Scott Morrison, Prime Minister, September 2020

'A gas-fired recovery will help Australia's economy bounce back better and stronger, while supporting our growing renewable capacity and delivering the reliable and affordable energy Australians deserve' – Angus Taylor, Energy Minister, September 2020

'The Government wants the private sector to step-up and make timely investments in the gas market. If the private sector fails to act, the Government will step in... to back these nation-building projects' – Prime Minister Morrison, Ministers Taylor and Pitt, joint media release, September 2020

'We have the opportunity to increase the supply of gas, bring the price down to competitive levels... and to put those manufacturing businesses in place' – Neville Power, Chair, NCCC, May 2020

'We now actually have a strategy to put at the heart of our recovery, how to build an energy transition that includes natural gas, that hitherto we have excluded' – Andrew Liveris, Special Adviser, NCCC, September 2020

1. In July the NCCC was renamed to the National COVID-19 Commission Advisory Board: Australian Government (2020a). For consistency with sources such as Long (2020) we continue to refer to it as the NCCC.

1.1 Gas production in Australia

Australia is a major global producer of natural gas.² In recent years Australia has vied with Qatar as the world's largest exporter of liquefied natural gas (LNG).³ In 2019 Australia was the world's seventh largest gas producer.⁴ But our time near the top of the gas tree may not last long – Australia ranks only 14th in the world for proven gas reserves, with just 1.2 per cent of the world total.⁵

Australia's natural gas industry has matured and grown over many decades. The first gas discovery was made near Roma, Queensland, in 1900 during drilling for water. But commercial development didn't come until the 1950s and 1960s, when natural gas was found during oil exploration in the Bass Strait off the coast of eastern Victoria, and the Cooper Basin in central Australia, and the Surat Basin reserves near Roma were more fully explored.⁶ By the mid-1970s natural gas was being piped to homes and industries in Sydney, Melbourne, Brisbane, and Adelaide from these early gas fields.⁷ In the 1980s large gas reserves were developed off the north-west coast of Western Australia. By 1984 this gas was supplying Perth, and by 1989 it was supplying Australia's first LNG shipments to Japan.⁸

2. In this report, unless otherwise specified, when we use the terms 'natural gas' or 'gas' we mean a fossil fuel gas stream made up primarily of methane (CH_4). But when first extracted, raw natural gas often includes a range of other saleable hydrocarbon gases, such as ethane, propane, and butane, which are often separated during processing and sold as distinct products.
3. BP (2020, p. 42). Natural gas is liquefied to LNG by cooling to minus 161 degrees Celsius. This is done to reduce its volume and so make it easier to ship.
4. Ibid (p. 35).
5. Ibid (p. 32).
6. IC (1995, pp. 197–199).
7. The Australian Pipeliner (2010); The Age (2020); The Australian Pipeliner (2016); and Donovan and O'Neil (2020).
8. North West Shelf Gas (2020). Perth had been supplied with gas from the nearby Perth Basin since 1971: IC (1995, p. 200).

These key early developments produce what the industry calls 'conventional gas'. Conventional gas is found under pressure in underground reservoirs, and can be produced by drilling through the impervious rock layer holding the gas in place, allowing it to flow upwards under its own pressure. In the past decade Australia has begun producing 'unconventional' gas in large quantities, particularly coal seam gas from Queensland. Unconventional gas involves drilling many smaller wells rather than a few large ones, to access methane trapped in coal seams or shale rock. Sometimes, but not always, unconventional gas production involves a controversial technique known as hydraulic fracturing, or 'fracking'.⁹

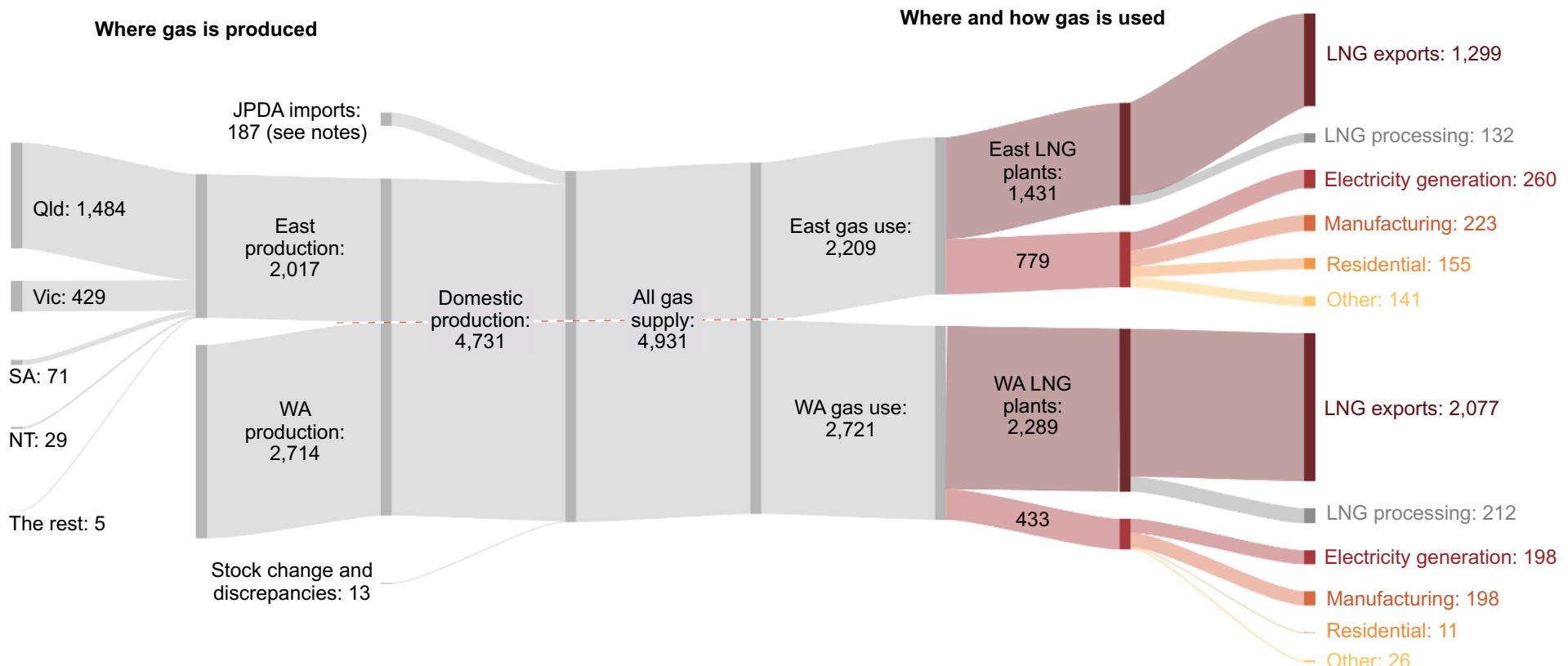
Western Australia produces most of Australia's gas (Figure 1.1), and has most of Australia's remaining gas reserves (primarily offshore conventional gas).¹⁰ By contrast, eastern Australia has a mix of smaller gas resources, such as conventional offshore gas in the Bass Strait, conventional and shale gas in the Cooper Basin, coal seam gas in Queensland (in production) and NSW (largely undeveloped), and both conventional and unconventional gas in the NT. For the purpose of this report, the NT is treated as part of eastern Australia, because a small pipeline connects the NT to the main east coast gas grid at Mt Isa.

Almost 70 per cent of all the gas produced in Australia is liquefied and exported as LNG, and another 7 per cent is used to fuel the export liquefaction facilities. WA is the largest supplier of LNG (Figure 1.1), followed by Queensland and the Northern Territory.

9. CSIRO (2020). Fracking involves pumping a mix of water, sand, and chemicals into wells at high pressure. This material helps to fracture rocks or coal seams, allowing gas to flow. Conventional gas does not require fracking.
10. Most of these reserves are further offshore, in waters regulated by the Federal Government rather than WA. For simplicity we refer to this as WA gas.

Figure 1.1: Where gas is produced and used in Australia

2017-18 gas production/consumption in petajoules (PJ)



Notes: JPDA imports are the gas produced in the Joint Petroleum Development Area (a section of the Timor Sea between Australia and Timor-Leste); the gas is piped to Darwin where it is turned into LNG. In this figure, 'East' refers to all states and territories except WA. 2017-18 data is used for consistency with other data in Chapter 3. The most significant changes since 2017-18 include the Ichthys LNG and Prelude Floating LNG projects beginning production. National gas production and exports based on Australian Government (2019a). State level production based on Australian Government (2019b). Gas use by category based on Australian Government (2019c). WA usage by user category adjusted using Gas Bulletin Board WA (2020); 'cogeneration' facilities (where gas is used to produce both electricity and heat for industrial purposes) are classified as manufacturing rather than electricity generation. 'Other' includes domestic gas processing, commercial offices and shops, some non-LNG mining uses, and any remaining demand. Almost all gas is used on the same side of Australia that it is produced, reflecting the fact WA does not have a gas pipeline connection to the rest of the country.

Sources: Grattan analysis based on the sources cited above.

1.2 Gas use in Australia

Natural gas provides about 26 per cent of the energy consumed in Australia (Figure 1.2).¹¹

Of the gas not used for export, about 38 per cent is used for power generation and 35 per cent for manufacturing (Figure 1.1).¹²

Households use a further 14 per cent. The remaining 14 per cent is used in a mix of sectors including domestic gas processing, minerals processing, commercial offices and shops, institutional buildings such as hospitals and schools, transport, and construction.¹³

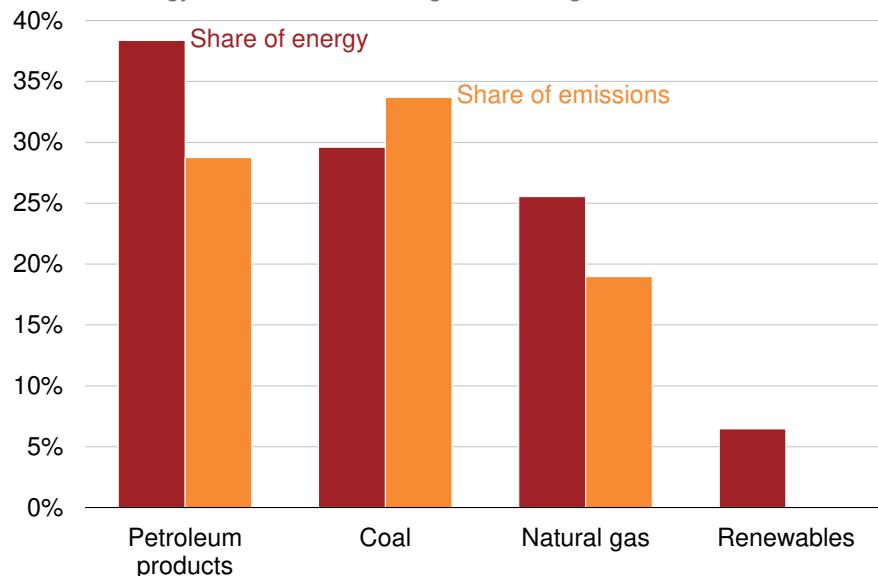
1.3 Burning gas produces greenhouse gas emissions

The widespread and varied use of gas across the economy shows its value, and suggests it will remain part of Australia's energy mix for some time. But gas has an Achilles' heel – it is a fossil fuel, and ongoing and widespread use is inconsistent with the need for Australia and the world to reduce greenhouse gas emissions over time. Australia, along with 187 other countries, has signed up to the Paris Agreement on climate change,¹⁴ which sets a target of net zero emissions during the second half of this century. And all Australian states and territories have committed to achieve net zero emissions by 2050.

About 19 per cent of Australia's greenhouse gas emissions come from natural gas (Figure 1.2). This consists of about 14 per cent of total emissions from burning the gas, and a further 5 per cent from so-called

Figure 1.2: Gas provides about 26 per cent of Australia's energy, and produces about 19 per cent of its emissions

Share of energy consumed; share of greenhouse gas emissions



Notes: Emissions shares do not add to 100 due to non-energy emissions sources.

Emissions include fugitive emissions. Energy use by fuel estimated based on Australian Government (2019d). Emissions estimated using Australian Government (2019e) for energy emissions and Australian Government (2019f) for fugitive emissions.

Sources: Grattan analysis based on the sources cited above.

11. Excludes gas exports as liquefied natural gas.

12. Gas use in manufacturing includes both where gas is burnt for heat and where it is used as a chemical feedstock – that is, some of the gas molecules are incorporated in the product being made. Chapter 3 provides more detail.

13. A number of mines use gas for on-site power generation, particularly in Western Australia. Figure 1.1 counts this gas use in power generation, rather than mining.

14. UNFCCC (2020).

'fugitive emissions' that arise during producing, processing, and transporting gas. Gas produces a smaller share of national emissions than either coal or petroleum products, but is nevertheless a significant source of emissions.

Though gas is a fossil fuel, gas producers often argue that it can reduce emissions by displacing coal. This 'transition fuel' argument is true in some contexts, and is most commonly made in relation to electricity. Burning gas produces less emissions than burning an equivalent amount of coal.¹⁵ And the most efficient gas-fired power stations are also more efficient than coal power stations at turning fuel into electricity.¹⁶ But there is debate about how much unmeasured leaks of methane – a powerful greenhouse gas – undermine the emissions advantage of gas over coal.¹⁷

The transition fuel argument should not distract from the fact that Australia, and the rest of the world, must consume less gas over time to reduce the effects of climate change. In some cases gas may be so valuable that it makes sense to keep using it in a net zero emissions world, and to offset the resulting emissions by, for example, planting trees or increasing the amount of carbon stored in soils. In other cases, carbon dioxide produced by burning natural gas may be able to be captured and stored in stable geological formations. But all of these carbon storing activities have practical and economic limits, and so gas use also has limits.

The International Energy Agency's recent World Energy Outlook highlights the uncertain future of gas. Based on current trends and policies, global gas demand will increase until at least the 2030s.¹⁸ But in a scenario where global governments target net zero emissions

15. Measured by energy content, based on Australian Government (2019e).

16. Graham et al (2020, p. 43).

17. See for example Union of Concerned Scientists (2014).

18. IEA (2020a, p. 338).

by 2070, gas use peaks around 2025.¹⁹ New gas production sources will be needed to replace declining gas fields even if gas demand declines,²⁰ but major new gas fields or major gas-using industry both appear to be risky investments in a decarbonising world.

1.4 Solving the gas puzzle

The future of gas is a puzzle. Its important uses today must be considered against the real environmental limits to its ongoing use.

This report unpicks the puzzle. Chapter 2 examines the state of Australia's gas markets, and finds that it is unreasonable to expect significantly lower gas prices in the eastern Australian gas market. This conclusion informs our analysis of the future role of gas in manufacturing (Chapter 3), power generation (Chapter 4), and in the home (Chapter 5).

19. IEA (*ibid*, p. 339). In that scenario Asia-Pacific gas demand does not decline, but demand from the rest of the world does. This advantages Australian gas exporters, but does not fully insulate them from global trends, because gas can be traded between regions.

20. IEA (2020b).

2 East coast gas prices have risen, and are not going back down

East coast gas prices have risen significantly in recent years, and gas users, union representatives, and politicians – and even the Australian Competition and Consumer Commission (ACCC) – are not happy about it (Box 2).

Rising gas prices primarily reflect rising costs. Eastern Australia still has plenty of gas, but it does not have a lot of cheap gas – especially in the southern states. Large new resources exist, but are either relatively expensive – such as Santos' Narrabri coal seam gas field in NSW – or far from major markets – such as the NT's Beetaloo Basin shale gas fields.

The east coast market is not perfect, but it is far from broken. Contrary to some claims, Australians do not pay more for gas than the countries we export to. Gas users can hope for some price relief, but should not expect significant and sustained price reductions.

Policy efforts to reduce gas prices are swimming against the economic tide. Chief among these is the Federal Government's aim of a 'gas-fired' COVID recovery, driven by lower gas prices. Some of its policies – such as extending the Australian Domestic Gas Security Mechanism – are welcome, but modest in scope. More concerning is the Government's threat to underwrite or directly invest in gas infrastructure if private investors don't deliver the projects it thinks are needed. If such a threat were implemented, it could prove very expensive for taxpayers, because significant and ongoing subsidies would be needed to materially reduce prices.

Meanwhile, investors are busy solving the market's most pressing problems. For example, proposed LNG regasification terminals will improve competition and greatly reduce the risk of winter shortfalls in the gas-poor southern states.

Box 2: Many stakeholders have argued that eastern Australian gas prices are too high

'[Recent] pricing behaviour raises questions about the degree of competition that currently exists in the supply of gas in [the] east coast gas market, at both the producer and retailer levels' – ACCC Gas Inquiry interim report, July 2020

'The current gas situation in this country simply does not pass the pub test. Australia is proudly the world's largest LNG exporter, yet we are unable to support our own economy with available and affordable gas' – Stephen Bell, CEO, Qenos, June 2020

'It is absolutely insane that the Japanese buyers buy much cheaper gas than a domestic buyer in Australia' – Alberto Calderon, CEO, Orica, September 2020

'The extent of the domestic gas price gouge is such that it is now economic to import gas into Australia. Global players have identified a high price market in Australia and the opportunity to supply that market with gas that collapsed in price in the world market' – Senator Rex Patrick, May 2019

'Australians find themselves paying more for our own gas than we charge our customers overseas. It's crazy!' – Daniel Walton, National Secretary, Australian Workers' Union, May 2020

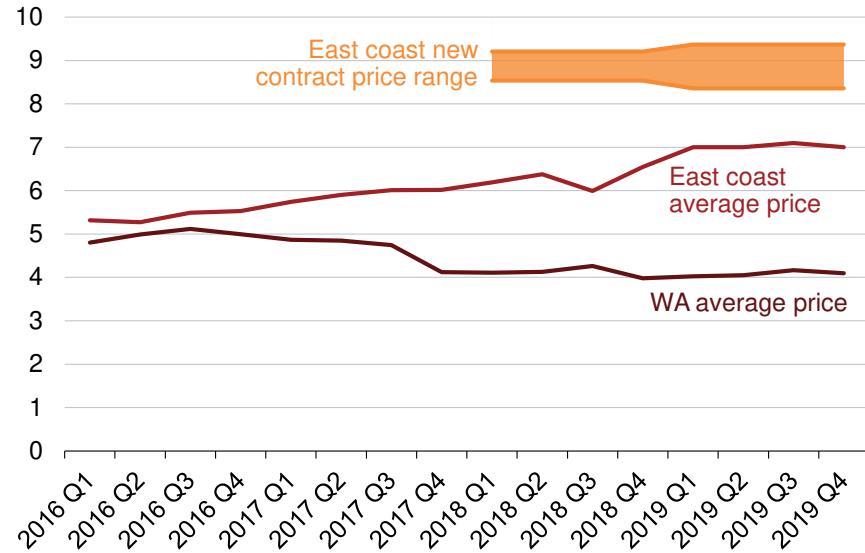
'[The east coast gas market is] a broken market, I think, certainly from a domestic point of view. Clearly there needs to be some intervention to come up with a policy' – Richard Harris, WA DomGas Alliance, July 2019

2.1 What does gas cost?

Gas prices in eastern Australia have undoubtedly risen in recent years (Figure 2.1). In early 2017 east coast gas buyers started receiving much higher-priced offers for new gas contracts. Commercial and industrial users were receiving offers between \$10 and \$16 per gigajoule, and many reported having only one willing supplier.²¹ By 2018 wholesale gas prices had risen dramatically from historic levels of between \$4 and \$6 per gigajoule, such that new wholesale contracts were priced between \$8 and \$10 per gigajoule (Figure 2.1), and commercial and industrial customers were paying about \$10 per gigajoule.²² This shift has made east coast gas prices much higher than WA contract prices, which are about \$4 per gigajoule for wholesale purchasers.

It is no coincidence that the rapid increase in east coast gas prices occurred just as the last of six new LNG export terminals at Gladstone, Queensland, reached full production.²³ These LNG exporters have contracted large volumes of gas to Asian customers over many years, effectively increasing demand for eastern Australian gas. This increase in demand requires an increase in supply, including from some more expensive gas sources. In this way, linking the east coast market to a larger and higher-priced international gas market has pushed up domestic prices. This effect goes beyond just contracted gas – spare

Figure 2.1: East coast gas prices have risen well above those in WA
Gas price, dollars per gigajoule



Notes: The east coast new contract price range is the expected price for the period in question, under new contracts only, based on ACCC (2018a, pp. 27–28) and ACCC (2018b, p. 67). The east coast contract range is derived from the average of Queensland prices (the lower bound) and the average in southern states (the upper bound). East coast and WA average prices cover all gas delivered in the period in question, and are based on WA Government (2020, EnergyQuest data).

Sources: Grattan analysis based on the sources cited above.

21. ACCC (2017, p. 19). Media and industry sources reported offers of more than \$20 a gigajoule: AIG (2018, p. 9). But it is not clear whether any contracts were actually struck at this level.
22. ACCC (2020a, p. 63). Prices paid by commercial and industrial customers vary significantly depending on their size, location, and requirements.
23. The first LNG terminal, or ‘train’, began producing in early 2015: Hagemann (2015). The last, the second Australia Pacific LNG train, reached full production in the first half of 2017: Origin Energy (2017).

gas can now be sold into the international market as a ‘spot’ cargo, giving producers a flexible alternative to selling gas to domestic users.²⁴

Prices are no longer rising, but remain much higher than before. There is some evidence that prices have fallen slightly during 2020, in part due to falls in international gas prices. The ACCC has observed that some gas contracts in southern states have been priced at \$7 to \$8 per gigajoule since February 2020, and some even below \$7 in Queensland.²⁵ But the ACCC has emphasised that this fall does not match the falls in international spot prices and is not reflected in all new contracts, and argued that domestic consumers should be paying even less for new gas contracts.²⁶

Rising gas prices prompted significant and sustained concerns among gas users, unions, and politicians. And the ACCC has highlighted that a lack of competition contributes to these high prices.

The eastern Australian gas market is not perfect, but it is not broken as some gas users claim. A key basis for this claim is that Australian gas users pay more than international buyers of our LNG (Box 2).

But in general this is not true (Figure 2.2). It is occasionally true of LNG spot prices, including at present – the COVID-19 crisis has caused Asian spot gas prices to collapse to historic lows. But spot prices are not the best benchmark to compare the price of Australia’s gas exports and the price our domestic users pay.

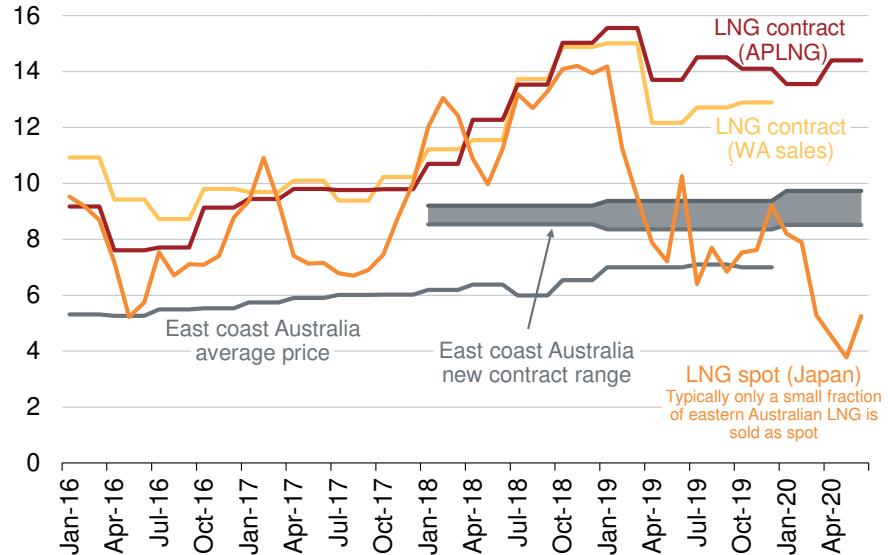
24. A ‘spot’ cargo is one sold without a long-term contract. The three Queensland LNG producers have made a commitment to the Federal Government to offer gas to the domestic market before selling it as a spot cargo: Canavan (2018a). Under some circumstances it may be easier for a producer to sell gas as an LNG spot cargo rather than to a domestic customer. Domestic gas typically requires delivery of steady volumes and must work around pipeline and storage constraints: ACCC (2020a, p. 69).

25. Ibid (p. 54).

26. Ibid (p. 57).

Figure 2.2: Eastern Australian gas prices are consistently lower than Asian LNG contract prices

Gas prices, Australian dollars per gigajoule



Notes: The east coast new contract price range is the expected price for the period in question, under new contracts only, based on ACCC (2018a, pp. 27–28), ACCC (2018b, p. 67) and ACCC (2020b, p. 66). The east coast contract range is derived from the average of Queensland prices (the lower bound) and the average in southern states (the upper bound). East coast average prices cover all gas delivered in the period in question, and are based on WA Government (2020, EnergyQuest data). APLNG is Australia Pacific LNG, a Queensland LNG project owned by Origin Energy, ConocoPhillips, and Sinopec. Japan LNG spot prices are based on the date that LNG cargoes arrive, unless no data is available for a given month in which case the price of spot cargoes contracted in that month is used: Government of Japan (2020). WA and APLNG LNG prices are calculated ‘free on board’ at the export port: Origin Energy (2020a) and WA Government (2020). An additional US\$0.8/mmbtu shipping cost is added: Origin Energy (2019, p. 43).

Sources: Grattan analysis based on the sources cited above.

Firstly, spot prices are very volatile and exhibit strong seasonal variability. Temporarily low spot prices, such as those seen during 2020 in response to the COVID-induced economic shock, do not indicate that domestic gas users are getting a bad deal.

Futures markets indicate that spot gas prices will rebound quickly from current lows.²⁷ But, as the ACCC emphasises, if Australian LNG producers continue to sell spot cargoes at prices below the general domestic contract price, this would be cause for concern and could justify government action, such as strengthening agreements between the Federal Government and gas exporters on how exporters will serve the domestic market.²⁸

Secondly, more than 90 per cent of eastern Australian LNG is not sold as spot cargoes but under long-term contracts.²⁹ This means that LNG spot prices do not reflect the typical price paid for exported Australian LNG. And the price of Australian LNG sold under these contracts has not fallen below typical Australian contract prices at any time over the past five years. LNG contract prices are linked to oil prices with a lag, and so are likely to fall over coming months in line with recent oil price falls. But even then they are likely to remain above eastern Australian contract prices.

2.2 Policy has helped moderate price increases

Governments have responded to concerns from gas users by introducing a range of policies to stabilise the eastern Australian gas market and moderate price increases.

27. Macdonald-Smith (2020a).

28. ACCC (2020a, p. 6).

29. About 95 per cent, based on the nameplate capacity of the three Queensland and two NT LNG projects, and maximum annual contracted quantity as reported in GIIGNL (2020, p. 13). Buyers typically have some flexibility to take less than the contracted volume, so the share of gas actually sold under those contracts would be somewhat less than 95 per cent in practice.

On balance, these policies have been appropriate, measured, and successful. Gas prices remain higher than those of recent history, but this primarily reflects the realities of the eastern Australian market, not a broken market. Targeted policy action has helped the market function well, by focusing the attention of large LNG exporters on the needs of domestic gas users, and supporting competition at limited cost to taxpayers.

2.2.1 Australian Domestic Gas Security Mechanism

During the gas market upheavals of early 2017, the Federal Government announced the Australian Domestic Gas Security Mechanism (ADGSM), which allows the federal resources minister to restrict gas exports if domestic gas demand is forecast to exceed supply – a so-called ‘gas shortfall’. This mechanism took effect on 1 July 2017 and is legislated to end on 1 January 2023.³⁰

The ADGSM includes a requirement that the resources minister consider whether an ‘industry-led solution’ is in place to manage the risk of shortfalls.³¹ In September 2017 then Prime Minister Turnbull secured a heads of agreement with the three east coast LNG exporters, guaranteeing gas would be prioritised for the domestic market rather than uncontracted LNG sales in the event of a domestic shortfall.³² This heads of agreement was updated under Prime Minister Morrison in October 2018,³³ and the Federal Government’s September 2020 announcements indicate that it intends to extend and strengthen this mechanism.³⁴

The ADGSM has never been triggered, but still has probably helped stabilise gas prices and moderate concerns about excessive prices and

30. Australian Government (2020b); and Australian Government (2020c, p. 6).

31. Australian Government (2020b).

32. This followed a similar, informal agreement at a March 2017 roundtable.

33. Canavan (2018a).

34. Morrison et al (2020).

unreasonable contract terms. Gas suppliers were probably motivated to enter heads of agreement on domestic supply with the government to reduce the risk that the ADGSM would be triggered. Suppliers also appear to have engaged more constructively with domestic customers recently.³⁵ But it is hard to isolate the effect of the ADGSM from other market events.³⁶

2.2.2 Funding to support the gas market and gas production

The 2017 federal Budget included funding to provide grants worth up to \$29 million to help bring forward small-scale gas production for the domestic market.³⁷ In March 2018 the Government announced funding for four projects – three in Queensland and one in South Australia.³⁸

Additional production by smaller producers is generally good for the functioning of the east coast market. But it is unlikely that government funding is needed to support gas production given recent increases in gas prices, and it is not clear that these projects needed support to proceed. Overall, grants to support new gas production are unlikely to be a good use of government funds.

2.2.3 Queensland domestic-only gas releases

Since 2017 the Queensland Government has issued leases for 15 oil and gas fields on the condition that they be used to supply the domestic market.³⁹ Of these, one project – Senex Energy's Project Atlas – is already delivering gas.⁴⁰ Recent fields have included a specific

requirement that all gas produced be made available to domestic manufacturers.⁴¹

The Queensland Government commissioned a review of this program in 2020.⁴² This review indicates that the program has not hindered investment and is largely accepted by both gas users and producers.⁴³ The program also appears to favour smaller producers, which may increase competition.

2.2.4 Removing bans on gas exploration and production

Over the past decade several state and territory governments banned various forms of onshore gas exploration and production. Generally these bans were motivated by concerns about the environmental effects of unconventional gas production, particularly fracking, and also about the effects that these activities have on rural landholders.

More recently several of these bans ended. A NSW Government review of CSG and associated restrictions on gas development led to a new regulatory framework being established in 2014, under which the Narrabri coal seam gas project has recently received planning approval.⁴⁴ The NT Government's fracking ban was overturned in 2018,⁴⁵ allowing exploration for shale gas in the Beetaloo Basin. And the Victorian Government's moratorium on onshore conventional gas exploration and development will end in 2021, though its ban on unconventional gas will remain.⁴⁶

The existing bans restrict gas production and so will increase gas prices.⁴⁷ But these restrictions often appear to not be based on the best

35. ACCC (2020a, p. 73).

36. Australian Government (2020c, p. 3).

37. Australian Government (2018a, p. 95).

38. Canavan (2018b).

39. Aurecon (2020, p. 18).

40. Senex Energy (2019).

41. Dick and Lynham (2018).

42. Aurecon (2020).

43. Ibid.

44. NSW Government (2020).

45. NT Government (2018).

46. Victorian Government (2020a).

47. Daley et al (2018).

scientific advice, and so these gas price increases are unnecessary. Comprehensive government reviews for the NSW, WA, and NT governments have all concluded that the impacts of unconventional gas production, including fracking, can be managed through careful regulation.⁴⁸ Unwinding these bans is generally positive for the gas market, and will support fair and cost-reflective gas prices.

2.3 But proposed policies will not materially reduce prices without significant ongoing subsidies

The stabilisation of eastern Australian gas prices since 2018 has not satisfied gas users (Box 2). Nor has it satisfied the Federal Government, which has announced a range of measures designed to deliver more gas at lower prices, and threatened further market interventions if the private sector does not ‘step-up’ to make investments.⁴⁹

These measures are in six broad categories, considered in turn below. In each case, the proposed measures will either make little to no difference to gas prices, or would require significant ongoing taxpayer subsidies to do so. The Federal Government may wish for lower gas prices, but the increasing costs of production mean that these measures are swimming against the economic tide.

2.3.1 Underwriting new production

The Federal Government has committed about \$30 million to develop ‘basin plans’ for five new gas basins, including Beetaloo (NT), Galilee (Queensland), and North Bowen (Queensland).⁵⁰

Of itself, this funding will do little to bring on new gas supply or to lower its cost. A less clear – but more troubling – part of the announcement

48. O’Kane (2014); Hatton et al (2018); and Pepper et al (2018).

49. Morrison et al (2020).

50. Ibid.

was that if the private sector did not make particular investments, the Government would ‘step in... to back these nation-building projects. This may include through streamlining approvals, underwriting projects, or the establishment of a special purpose vehicle with a capped Government contribution.’⁵¹

All investments involve risk. If government takes some risk on behalf of an investor by underwriting an investment, it is effectively subsidising that investment. Even if the government never pays the investor a cent under the arrangement, it has reduced its risk and increased its effective profit, by enabling it to get lower-cost funding.

These policies do not reduce the cost of getting gas out of the ground, they just change who pays for it. Given that the cost of gas production in eastern Australia is steadily rising, significant and ongoing taxpayer subsidies would be needed to materially reduce gas prices, let alone to get them down to \$4 to \$6 per gigajoule as suggested by the NCCC’s manufacturing taskforce.⁵²

It is hardly surprisingly that the cost of gas production is rising over time. Gas producers develop lower-cost gas reserves before moving on to higher-cost sources. And gas exploration companies drill in the most prospective places, and only explore in less-attractive fields or in deeper waters once better sources have been exhausted or if gas prices are very high.

Where once gas could be supplied for \$4 per gigajoule or less, today eastern Australian gas fields will struggle to supply gas for less than \$6 per gigajoule (Figure 2.3 on the next page). Existing fields can supply gas at \$4 per gigajoule for a period – as has occurred on Australian spot gas markets for much of 2020 – but at these prices producers

51. Ibid.

52. Page 18 of the NCCC manufacturing taskforce’s interim report, as reported in Long (2020).

are not earning a return on past capital expenditure, and cannot justify developing new fields. Coal seam gas fields require continual drilling of new wells to sustain production, and undeveloped wells generally cost \$6 a gigajoule or more – including the Narrabri gas field that the Prime Minister has highlighted as a key source of new supply.⁵³ The Australian Energy Market Operator predicts that new gas fields will need to be developed by between 2023 and 2025 to maintain gas supply in eastern Australia,⁵⁴ so it is very unlikely that multi-year gas contracts will be priced below \$6 a gigajoule.

Some of the lowest-cost gas fields in eastern Australia have traditionally been in Victoria's Bass Strait. For many decades the cost of Bass Strait gas was kept low because it was effectively a byproduct of crude oil production. Through the 1980s, more than 70 per cent of the energy extracted from all Victorian oil and gas fields was in the form of crude oil rather than gas (Figure 2.4 on the following page). But crude oil production from these fields has been in decline for decades. Gas prices must increasingly pay for the full cost of gas exploration and production, and have been rising in real terms since the late 1990s. Recent offshore exploration drilling in Victoria has been unsuccessful, and the two original developers of the largest gas field – ExxonMobil and BHP – are both looking to sell out of these activities.⁵⁵

2.3.2 Underwriting new pipelines

The Federal Government has announced an \$11 million National Gas Infrastructure Plan, and says it will use this plan to 'highlight where the Government will step in if the private sector doesn't invest'.⁵⁶

The case for the Government to follow through on its threat to 'step in' is not strong. Private pipeline developers have shown that they

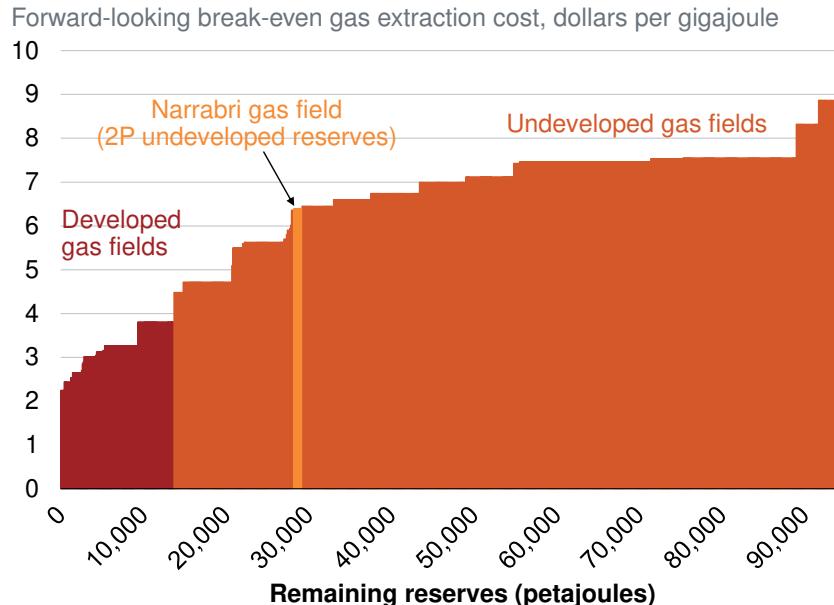
53. Morrison (2020a).

54. AEMO (2020a, p. 9).

55. Macdonald-Smith (2020b); and Macdonald-Smith (2020c).

56. Morrison et al (2020).

Figure 2.3: The cost of producing new gas is now generally above \$6 per gigajoule



Notes: Break-even costs for developed gas fields do not include past capital expenditure. 2P means 'proven and probable' and refers to gas that is either very likely (90 per cent probability) or fairly likely (50 per cent probability) to be produced under prevailing market and regulatory conditions. The Narrabri gas field has about 3,000 petajoules of additional 'contingent' reserves, additional to the highlighted 2P reserves, that are not included in this chart, and for which AEMO (2020b) does not provide an explicit cost estimate.

Source: Grattan analysis of AEMO (*ibid*).

are willing to build ‘missing links’ in the gas network, to help get gas to market – for example, in 2019 Jemena completed the Northern Gas Pipeline connecting the NT and Queensland gas grids, and in 2009 Epic Energy built a link between Ballera and Moomba to connect Queensland to the southern states.⁵⁷ Private investors also built the SEAgas Pipeline connecting SA and Victoria in 2003, and the Eastern Gas Pipeline connecting Victoria and NSW in 2000.⁵⁸

It is not clear why the private sector could not build other proposed linking pipelines – such as from Wallumbilla to the Hunter Valley – if these links stack up economically. Australian governments stopped directly funding pipeline investments during the 1990s. There is no strong reason why governments should begin funding gas pipelines now, having not done so for about 30 years.⁵⁹

The Government may try to use its infrastructure plan to justify subsidising longer-distance pipelines. This justification would be weak. If gas basins, such as Galilee or Beetaloo, are a long way from their customers, then it makes sense that the customers should pay the full cost of transporting the gas. And though a transcontinental west-to-east pipeline has been proposed by a range of people – including NCCC Chair Nev Power, former Western Australian Premier Colin Barnett, and NCCC special adviser Andrew Liveris⁶⁰ – this project would not bring down east coast gas prices (Box 3).

2.3.3 Domestic gas reservation and export restrictions

WA has lower gas prices than eastern Australia (Figure 2.1). It also has a policy to reserve a nominal 15 per cent of new LNG-focused gas

57. Jemena (2020a); and Wilkinson (2009).

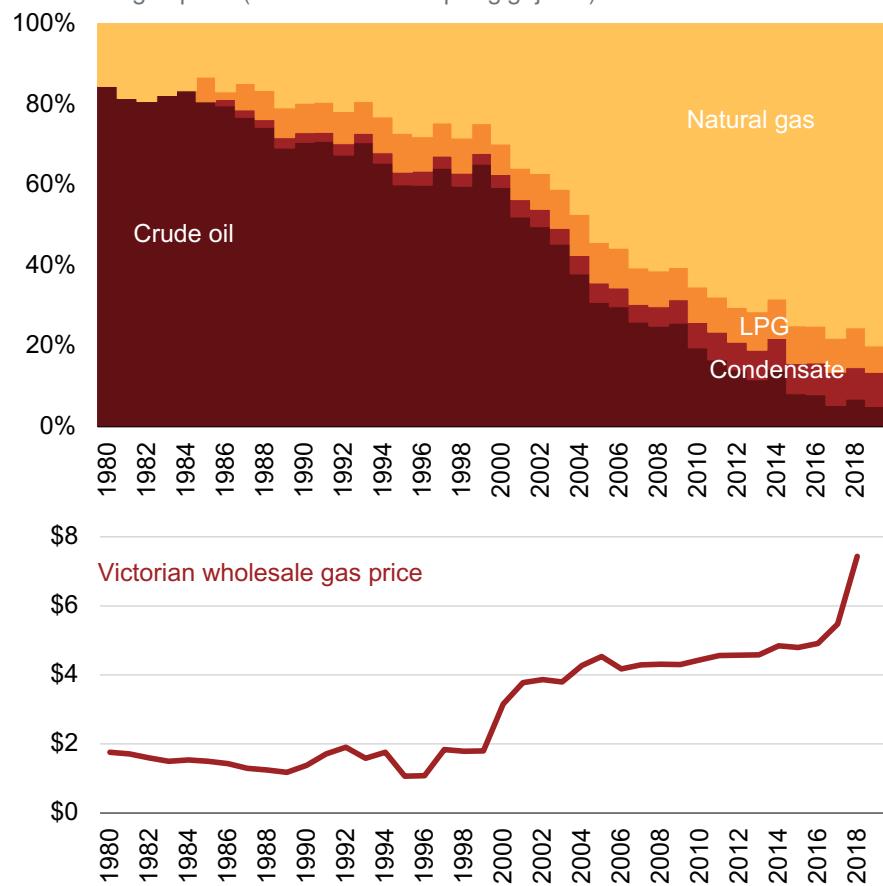
58. AEMC (2020a); and AEMC (2020b).

59. The last major pipeline to be substantially underwritten by government was the Queensland Gas Pipeline, from Wallumbilla to Gladstone, which started operating in 1990: Jemena (2020b).

60. Thompson (2019); Barnett (2019); and Gottliebsen (2018).

Figure 2.4: As oil output has fallen, Victorian gas prices have risen

Share of energy extracted from Victorian oil and gas fields and Victorian wholesale gas price (real 2020 dollars per gigajoule)



Notes: LPG is liquefied petroleum gas. Condensates are hydrocarbon liquids that are heavier than LPG, but lighter than crude oil. Data excludes ethane.

Sources: APPEA (2014), APPEA (2017), APPEA (2018), APPEA (2020), Gas and Fuel Corporation of Victoria (1986), Gas and Fuel Corporation of Victoria (n.d.), WA Government (2006, p. 8), Jacobs (2017, p. 55) and ACCC (2019a, p. 56).

production for the domestic market. These two facts have prompted some commentators and stakeholders to argue that eastern Australian governments should adopt the same policy.⁶¹

The Federal Government has been considering a domestic gas reservation policy since mid-2019,⁶² and it re-announced its intention to consider such a policy in September 2020.⁶³ It has since released an issues paper for discussion.⁶⁴

But domestic gas reservation is not the only difference between the WA and east coast markets. WA also has larger, lower-cost conventional gas reserves. The forward-looking cost of production in WA is currently about \$2 per gigajoule, and will remain below \$4 per gigajoule for the rest of the decade even as new production sources are developed.⁶⁵ Simply copying the WA policy will not give eastern Australia WA-level gas prices.

A critical question is whether a reservation would apply only to new projects ('prospective') or also to existing projects ('retrospective'). The Federal Government has indicated that it is only willing to consider prospective reservation.⁶⁶

It is good that a retrospective policy has been ruled out. Such a policy would be legally complex and politically fraught, because it would effectively override the contracts that underpinned about \$70 billion

61. See for example: AWU (2020) and Verrender (2017).

62. Australian Government (2020d).

63. Morrison et al (2020).

64. Australian Government (2020e).

65. AEMO (2019, p. 62). Forward-looking production costs exclude past capital expenditure, but include capital expenditure on new sources. This means that forward-looking costs will tend to increase as new projects are developed.

66. Australian Government (2020d); and Morrison et al (2020).

Box 3: A transcontinental west-to-east pipeline will not help gas consumers

WA has abundant and relatively cheap gas. This has led to calls for a large-scale west-to-east transcontinental gas pipeline to supply the high-priced east coast gas market.

WA gas may be cheap, but long-distance pipeline transport is expensive. The Federal Government's pre-feasibility study found that it would cost more than \$5 billion to build a pipeline from WA to Moomba in central Australia, requiring tariffs of about \$5.3 per gigajoule to be commercially viable.^a Gas users would need to pay a further \$0.7 to \$2 per gigajoule to get the gas from Moomba to major east coast markets.^b

Even on the optimistic assumption that gas could be purchased at WA's current prices of about \$4 per gigajoule (Figure 2.1), a transcontinental pipeline would deliver gas to the east coast at roughly \$10 to \$11 per gigajoule, higher than recent east coast prices of \$8 to \$10.

It is cheaper to transport WA gas to eastern Australia as LNG. This would cost from \$3 to \$5 per gigajoule – up to \$1 for liquefaction,^c \$1 for shipping,^d and \$1 to \$3 for regasification.^e The cost of pipeline transport to Moomba is at the upper end of this range, but still leaves gas far from the intended markets. And the LNG option is less risky because it does not require decades of continuous operation to recover the upfront cost.

a. ACIL Allen (2018, pp. ii, vi).

b. ACCC (2020a, p. 82).

c. Excludes LNG capital costs. Based on an estimate for Gladstone LNG plants: AGL (2020a, p. 21).

d. Assuming the same cost as shipping from Australia to Asia, about \$1 per gigajoule: Origin Energy (2019, p. 43).

e. Australian Government (2018b, p. 105).

of investment in the Gladstone export terminals,⁶⁷ and could damage relations with key trading partners in Asia.⁶⁸

A prospective reservation policy may give gas consumers some comfort, but the benefits are likely to be modest. The policy would have most effect while producers are proving up gas reserves to support a new LNG export project. But another LNG export train is highly unlikely to ever be built in eastern Australia, because the global LNG market is currently over-supplied and eastern Australia is a relatively high-cost source of gas. A large share of the resources needed to supply the existing LNG trains have already been leased and proven up, and would not be affected by a prospective policy. Requiring some new gas fields to supply the domestic market only – such as the Queensland Government’s domestic-only gas releases (Section 2.2.3) – may help domestic users to some degree, but large producers have significant flexibility to divert other gas sources between the domestic and export markets, limiting the effect of any restrictions on new fields.

The ADGSM, and the associated heads of agreement between government and exporters, offers many of the benefits of a domestic gas reservation scheme, but without introducing significant risks to gas producers. It gives the Federal Government the power to restrict exports, but under limited conditions. The Government has proposed extending this agreement and strengthening price commitments.⁶⁹ This appears to be a reasonable balance, provided any supply and price triggers are consistent with good market outcomes – such as preventing large-scale LNG spot cargo exports at prices lower than those offered to domestic customers. If this policy is maintained, any

benefits from a prospective domestic gas reservation policy appear limited.

2.3.4 Use it or lose it provisions

When state and territory governments grant the right to explore for or produce gas, they require producers to meet a range of conditions. Typically these set out what activities the leasee will do to assess the field’s technical and economic potential, and over what time.

The Federal Government wants to tighten requirements on gas producers, to implement so-called ‘use it or lose it’ provisions,⁷⁰ as recommended by the NCCC’s manufacturing taskforce.⁷¹ These provisions are intended to increase gas supply by imposing costs on producers who do not develop gas reserves, or by threatening to take away their development rights.

Putting stricter conditions on a gas production lease can increase risk for gas producers and deter exploration.⁷² There are a range of circumstances under which it will make sense to delay exploration or an investment decision to bring a field into production, and this could see a leasee breach conditions. It is unclear how much further the conditions sought by the Federal Government will go beyond those already established, nor how it will work with the states and territories to achieve this outcome.

The scope of such a policy is probably limited to new gas fields, because it is unlikely that state or territory governments will be willing to impose new conditions retrospectively on existing leases. This greatly limits the potential benefit of this approach, and it is unlikely to materially reduce gas prices.

67. Macdonald-Smith (2015).

68. The foundation customers of the eastern LNG projects include China’s Sinopec and CNOOC, Japan’s Tokyo Gas, JERA, and Kansai Electric, Korea’s KOGAS, and Malaysia’s PETRONAS: GIIGNL (2020, p. 13).

69. Morrison et al (2020).

70. Ibid.

71. Page 19 of the NCCC manufacturing taskforce’s interim report, as reported in Long (2020).

72. Productivity Commission (2019, p. 4).

2.3.5 Reforming pipeline regulation

The Federal Government has proposed to reform pipeline regulations to help gas consumers.⁷³

Gas pipeline regulation has recently been tightened. Since 2017 unregulated pipelines have been required to disclose key financial information. And terms for pipeline use can be imposed through a binding independent arbitration if pipelines and gas users do not reach a commercial agreement.

The ACCC has reviewed this regime and recommended improvements,⁷⁴ and reforms are being considered by the COAG Energy Council.⁷⁵ The Federal Government's intention is understood to be to accelerate the adoption of these reforms, not to explore more significant changes to regulations. The reforms being considered are likely to be beneficial, but only offer modest savings on a small share of end-user gas costs.

The Government has also flagged that it will work to improve the secondary trading of unused pipeline capacity. The government's intention is understood to be to review the capacity trading arrangements that commenced in March 2019,⁷⁶ and implement any improvements that are identified in this review. Any benefits from these improvements are likely to be modest.

2.3.6 Providing market information

The Federal Government's September 2020 announcements included a range of measures to provide information to and support the functioning of the gas market. These measures including improving

73. Morrison et al (2020).

74. ACCC (2019b, pp. 128–160).

75. COAG Energy Council (2019a).

76. AEMO (2020c).

the ACCC's method for estimating 'netback' LNG pricing, a voluntary industry code of conduct, and establishing a gas hub at Wallumbilla, Queensland.

These measures could help the operation of the market and give buyers more confidence that they are getting a fair deal. But their benefit should not be over-stated. The ACCC already publishes netback prices, and it acknowledges that many factors other than the netback price affect domestic contract prices.⁷⁷

The Federal Government has not explained how its proposed Wallumbilla hub will differ from, or improve on, the wholesale trading hub that has been operating at that location since 2014.⁷⁸ In any case, gas users appear to prefer to buy gas under longer-term gas contracts with a greater degree of price certainty, rather than at a spot or index-linked price.⁷⁹

In general, improved transparency will help the gas market deliver fair and efficient outcomes. Governments have recently endorsed a range of measures to improve transparency, and these are being implemented.⁸⁰ These measures are welcome, but further measures are likely to offer only modest benefits.

2.4 Policy tweaks and incremental investments will reduce prices, but not dramatically and not enough for a gas-led recovery

The range of policies put forward by the Federal Government to reduce gas prices will, in general, either unnecessarily transfer cost and risk from gas users to taxpayers, or offer fairly modest benefits (Table 2.1).

77. ACCC (2020b, pp. 57–58).

78. AEMO (2020d).

79. ACCC (2019b, p. 79).

80. COAG Energy Council (2020).

Table 2.1: Most policies to support gas supply either offer modest benefits, or would be counter-productive

Policy area	Proposed policies	Assessment
Gas production	<p>Federal Government funding for basin plans.</p> <p>Possible Federal Government underwriting or direct co-investment.</p> <p>The Federal Government wants to enforce 'use it or lose it' provisions.</p> <p>The Victorian Government will remove its moratorium on onshore conventional gas production in 2021.</p>	<p>Will do little to bring on new supply or reduce costs.</p> <p>Unnecessarily transfers cost and risk from gas buyers to taxpayers.</p> <p>Could increase risk for gas exploration companies. Unclear how it will be implemented by states and territories.</p> <p>The lifting of the conventional gas moratorium is positive. Victoria's unconventional gas moratorium should also be lifted, as should similar restrictions in SA and Tasmania.</p>
Pipelines and infrastructure	<p>Federal Government infrastructure plan.</p> <p>Possible Federal Government underwriting or co-investment if private investors do not build strategic pipelines.</p> <p>Federal Government reforms to pipeline regulation.</p> <p>Federal Government reforms to the pipeline capacity trading arrangements introduced in 2019.</p>	<p>Will do little to bring on new infrastructure or reduce costs.</p> <p>Unnecessarily transfers cost and risk from gas buyers to taxpayers.</p> <p>The Government's intention is understood to be to accelerate reforms that are already under consideration. These are helpful but offer only modest benefits.</p> <p>The Government's intention is understood to be a review and refinement of existing arrangements. Any benefits are likely to be modest.</p>
Export restrictions	<p>Extending and strengthening the Federal Government's heads of agreement with east coast gas exporters, which requires producers to offer gas to domestic buyers before selling export spot cargoes.</p> <p>Some Queensland gas tenement releases include a requirement to supply the domestic market.</p> <p>The Federal Government is considering a prospective reservation scheme.</p> <p>The Federal Government has ruled out a broad-based retrospective reservation policy.</p>	<p>Continuing and strengthening these arrangements should reinforce good market outcomes.</p> <p>This policy appears to be supporting domestic supply and improved competition without adverse consequences.</p> <p>The scope of this scheme is likely to be limited, due to the low chance of new east coast LNG projects.</p> <p>This is positive, given the legal and political complexities of such a policy.</p>
Market transparency	<p>The COAG Energy Council is implementing a range of new rules to improve market transparency.</p> <p>The Australian Energy Regulator will take over the ACCC's role in publishing contract price data from 2025.</p> <p>Federal Government reforms to ACCC netback prices methodology.</p> <p>Federal Government reforms to implement a new Wallumbilla trading hub.</p>	<p>These reforms appear helpful, but offer only modest benefits.</p> <p>More regular and timely publication of de-identified contract data than implemented by the ACCC would further help market transparency.</p> <p>Netback prices are only one way to assess appropriate pricing levels. Any benefits from reform are likely to be modest.</p> <p>It is unclear what improvements will be made over existing arrangements. Any benefits are likely to be modest.</p>

Policy tweaks and smart, flexible, private investments can help to improve the functioning of the market and keep wholesale prices at fair and cost-reflective levels. But they cannot achieve miracles. Policy makers and gas users should accept that eastern Australian gas prices will never return to the ‘good old days’ of \$4 per gigajoule. The cost of supply has increased as low-cost sources have become depleted and with additional demand from LNG exports. Even \$6 per gigajoule does not appear realistic, given that most new gas supplies cost more than this.

2.4.1 Removing remaining gas moratoria would help

Several states and territories have imposed restrictions on onshore gas development. These bans reflect genuine concerns about the impacts of gas production, but restrict gas supply far more than a well-targeted, science-based gas regulatory regime would require (Section 2.2.4).

Though many restrictions have been repealed or softened, a number remain – most notably in Victoria. Victoria’s moratorium on onshore conventional gas will end in 2021, but its ban on unconventional gas will remain.⁸¹ Victoria should move to a science-based regulatory regime for onshore gas – both conventional and unconventional.

The ACCC estimates that significantly increased gas production in Victoria or other southern states could reduce domestic gas prices by \$2 to \$4 per gigajoule due to avoided transport costs and increased competition.⁸² It is unclear whether onshore Victorian gas supply could be developed at the scale necessary to move prices to this extent – partly because the Government’s restrictions have prevented any exploration to assess the scale and commercial prospects of Victorian onshore gas.

81. Victorian Government (2020a).

82. ACCC (2018c, p. 20).

South Australia and Tasmania also have restrictions on unconventional gas. SA placed a 10-year moratorium on fracking in the south-east of the state in 2018,⁸³ and Tasmania has implemented a state-wide moratorium on fracking until 2025.⁸⁴ These restrictions should also be replaced with appropriate science-based regulatory regimes to manage the impacts of fracking.

2.4.2 Market transparency can be improved

Information on longer-term domestic gas contracts is currently provided through the ACCC’s gas inquiry. This inquiry finishes in 2025, and the COAG Energy Council has agreed that the Australian Energy Regulator will perform a similar role to the ACCC after then.⁸⁵

Publishing this data more regularly would better facilitate commercial negotiations. The ACCC’s reports are published infrequently and tend to reflect data some months after they are collected. Provided the data is appropriately aggregated to avoid disclosing pricing strategies of individual market participants, a regularly updated index of contract prices would give a meaningful reference point for negotiation.

2.4.3 LNG regasification terminals will help gas consumers

Five LNG regasification terminals are proposed for Australia’s south-east (Box 4). Each is being developed by entities that do not have large gas reserves, and so each should increase competition.

Some commentators have criticised these proposals, arguing that they indicate a broken market, and that it doesn’t make sense for Australia to both export and import gas.⁸⁶ But this ignores the fact that liquefying and shipping gas is often a lower-cost transport option than

83. SA Government (2020).

84. Tasmanian Government (2018).

85. COAG Energy Council (2020, p. vi).

86. Barnett (2019); Patrick (2019); Lannin (2019); and Hepburn (2019).

a long-distance pipeline. There is no rule that LNG must be exported, or that a regasification terminal must take LNG from another country – despite the fact that regasification terminals are often mistakenly referred to as ‘import terminals’. Australia routinely ships alumina and iron ore between the east and the west coasts, and if the economics make sense it can also do this with gas.

Shipping and regasifying LNG is a much cheaper way to transport WA gas to south-east Australia than by pipeline (Box 3). And AGL, a proponent of one of the LNG regasification terminals, considers this a cost-effective way to bring Queensland gas to Victoria. AGL estimates that gas purchased from Gladstone and delivered to Victoria would be almost \$2 per gigajoule cheaper than the same gas purchased at the Wallumbilla supply hub at a LNG netback price, and transported to Victoria by pipeline.⁸⁷ Regasification would cost a further \$1 to \$3 per gigajoule,⁸⁸ making regasified LNG broadly cost-competitive with pipeline transport from Queensland to Victoria.

Regasification terminals have numerous benefits beyond a simple cost comparison. They enable gas users to buy from a range of sellers, both in Australia and overseas. Regasification terminals are also flexible – they store gas in liquid form, and the amount regasified can vary significantly from day to day depending on demand. Even better, southern seasonal peaks occur during the northern hemisphere summer, when Asian gas demand and prices typically fall – reducing the cost of bringing spot LNG cargoes into southern Australia.

The idea that regasification terminals keep gas prices high is based on faulty economics. The owners of these facilities are not guaranteed

Box 4: Proposed LNG regasification terminals

Regasification terminals take LNG and warm it to turn it from a liquid back to a gas, so it can be put into a pipeline.

Five regasification projects being considered in Australia – two in NSW, two in Victoria, and one in SA. An independent group known as Australian Industrial Energy has all necessary approvals for its regasification project at Port Kembla, NSW, but has not yet made a final investment decision.^a The other four projects – at Crib Point (Victoria), Newcastle (NSW), Geelong (Victoria), and Outer Harbor (SA)^b – are still going through early design and approvals processes. None of the proponents are major gas producers, but the developer of the Crib Point project, AGL, is a major electricity and gas retailer.

All five proposed regasification units are designed as floating units, housed on a ship with a fixed jetty mooring.^c This design reduces the risk and cost of installation – if they are no longer needed, they can be floated to an alternative location, rather than being stuck in a fixed location like a new pipeline or gas field.

- a. Australian Industrial Energy (2020).
- b. AGL (2020b); EPIK (2020); Viva Energy (2020); and Venice Energy (2020).
- c. This ship is moored in place, and is separate to the tankers that transport gas to the terminal.

87. AGL (2020a, p. 21). Pipeline charges are likely to be under-estimated because the analysis assumes full utilisation. The seasonal pattern of gas demand means that pipeline charges would probably be higher, improving the relative economics of regasified LNG: AGL (*ibid*, p. 20).

88. Australian Government (2018b, p. 105).

a return on their investment, so they cannot force users to pay prices above what others in the market can offer.

The regasification terminal proponents are not major gas producers, and so their entry would bring an additional source of supply and improved competition to the east coast market.

Regasification does strengthen the link between international and domestic prices, but this link already exists and is not going away. And, as current experience shows, international prices are not always high. As the LNG market is currently over-supplied, regasification terminals are well placed to supply eastern Australian gas users at a reasonable price.

3 Gas will not fuel a manufacturing renaissance

Hopes for a gas-fired recovery rest heavily on manufacturing. The Prime Minister and many other stakeholders have emphasised the importance of gas to manufacturing (Box 5). But gas will not fuel a manufacturing renaissance. The Government's policies are unlikely to materially reduce gas prices (Chapter 2). And even if they did, the benefits would be very narrow.

The Prime Minister has justified his talk of a gas-fired recovery on the basis that gas-reliant manufacturers employ about 225,000 workers. But this relies on a very broad definition of a gas-reliant business. Australia's truly gas-reliant manufacturers make polyethylene, ammonia, and alumina, where gas makes up more than 10 per cent of inputs costs. But these sectors employ only a little more than 10,000 workers and make up just over 0.1 per cent of the national economy. By contrast, more than 750,000 workers are employed in manufacturing sectors where gas makes up less than 1 per cent of input costs on average.

Policy efforts to ensure a well-functioning gas market are welcome. But these efforts do not equal a gas-fired recovery, which would require heavy-handed and expensive measures that effectively subsidise gas prices. This would be a poor use of government resources, and prove a losing bet in eastern Australia.

The Government should instead promote Australia's transition to lower-emissions manufacturing. Gas-intensive industries will require government help to develop and adopt new technologies, including hydrogen. Government should also help less gas-intensive manufacturers, such as food processors, understand their energy options, including energy efficiency and electrification. These efforts will both reduce emissions, and ration increasingly expensive gas for those manufacturers that really need it.

Box 5: A range of stakeholders claim that gas can boost manufacturing

'An estimated 225,000 Australians work in manufacturing firms that rely heavily on gas as a feedstock or fuel source, according to APPEA – in sectors such as fertilisers, chemicals, metals, bricks, cement, and parts of food processing and beverage manufacturing... [If] you want to change manufacturing in this country, you've got to deal with gas' – Scott Morrison, Prime Minister, September 2020

'I do believe we can create a manufacturing industry which is a very significant portion of our GDP. That will mainly come from those very large manufacturing opportunities where currently we import fertiliser and petrochemicals and agrichemicals into Australia... we have abundant energy, particularly in the form of gas that we can deploy to make sure that we can manufacture all those large volume products ourselves' – Nev Power, Chair, NCCC, May 2020

'Shoring up our gas supply and delivering affordable energy would not only preserve those jobs under threat, it would lead to a manufacturing renaissance with many more highly skilled and highly paid jobs across the country' – Daniel Walton, National Secretary, Australian Workers' Union, May 2020

'Affordable gas and energy are essential to maintain and stimulate jobs and growth in the economy. The direct and indirect contribution of manufacturing throughout the economy cannot be understated, including the significant value added to gas by the chemistry industry and other advanced manufacturing processes' – Samantha Read, CEO, Chemistry Australia, July 2019

3.1 How gas is used in manufacturing

The largest use of gas in manufacturing is for process heat. This can be as simple as heating water, for example for washing food and food processing equipment. It can involve boiling water to produce steam for more energy-intensive chemical and industrial processes, such as the ‘digestion’ of bauxite in caustic soda as part of the alumina refining process, or for pulping wood chips. Gas can also be burnt to produce high temperatures needed to fire bricks, decompose limestone to cement clinker, or calcine aluminium hydroxide to make alumina.⁸⁹

Natural gas is also used as a feedstock in some chemical processes. This means that some of the molecules that make up natural gas become part of the product being made, rather than simply being burned for heat and released into the air as exhaust. The largest use of gas as a chemical feedstock in Australia is to produce ammonia and related chemicals such as urea and ammonium nitrate, which are in turn used to make fertilisers and explosives. In this process, hydrogen is extracted from gas and combined with nitrogen from the air.

3.2 Australia cannot copy the US gas-led manufacturing ‘renaissance’

Much of the focus on natural gas use in Australian manufacturing comes from comparisons with the United States, which is often described as having had a manufacturing ‘renaissance’.⁹⁰ NCCC special adviser Andrew Liveris has linked this renaissance with the growing development of US shale gas, since at least as far back as 2012,⁹¹ but this link can be overstated (Box 6).

89. Aluminium hydroxide is extracted from bauxite through digestion, and then heated (‘calcined’) to drive off water and make alumina (aluminium oxide).

90. See for example Guillot (2017).

91. Navarro (2012).

Box 6: Shale gas has not fuelled the US manufacturing renaissance, but it has helped the petrochemicals industry

About 15 years ago, US gas producers began widely using new drilling techniques to develop unconventional gas resources, primarily shale gas. US natural gas production has almost doubled since 2005, and production of ‘natural gas liquids’ such as ethane, propane, and butane has almost tripled.^a The US went from being a net gas importer to an exporter, and gas prices fell dramatically.

Shale gas does not appear to be key driver of broader US manufacturing growth. An IMF study examined the effect of natural gas prices on US manufacturing between 2009 and 2013.^b It found that when changes in real exchange rates and labour costs were accounted for, the difference in gas prices between the US and other G7 economies did not appear correlated with changes in manufacturing output. US manufacturing growth over this period was concentrated in computers and electronics, motor vehicles, and machinery, rather than in gas-intensive sectors.

But shale gas has spurred significant growth in the US petrochemical industry, especially in more recent years. In the decade to February 2020 about US\$87 billion has been invested in new US petrochemical plants to take advantage of lower-cost feedstocks, and a further US\$27 billion has been committed to plants currently under construction.^c

a. Natural gas production is ‘dry’ natural gas excluding plant liquids: EIA (2020a). Natural gas liquids production is based on EIA (2020b).

b. Celasun et al (2014, p. 6).

c. American Chemistry Council (2020).

But there are many important differences between Australia and the US, which mean that we cannot copy its growth in petrochemicals.

The most important of these is geology – the US and eastern Australia produce very different kinds of gas. Most US gas is produced from shale, and, as well as methane, often includes large volumes of gases such as ethane, propane, and butane – sometimes called ‘natural gas liquids’ because they form a liquid under pressure and separate from methane – and sometimes also crude oil. This liquids-rich ‘wet’ US shale gas can be used to make a broad range of petrochemicals – methane can be used to make ammonia-derived fertilisers and explosives, ethane can be used to make polyethylene plastics, and propane can be used to make polypropylene plastics. Propane and butane can be bottled and sold as liquefied petroleum gas. And butane, heavier natural gas liquids, and crude oil, can be transformed into a variety of valuable chemicals, polymers, and liquid fuels. Ethane, not methane, has been the largest driver of petrochemical manufacturing in the US, underpinning more than US\$60 billion of investment (Appendix A).

By contrast, the primary source of natural gas in eastern Australian, coal seam gas, is almost entirely methane. This ‘dry’ gas is only useful for energy, and to make ammonia-derived petrochemicals, and so Australia cannot replicate the US petrochemical boom. Ethane supply in Australia is entirely from the declining Gippsland and Cooper Basins. Even if the Beetaloo Basin or other Australian shale gas reserves were found to contain large volumes of natural gas liquids, many other factors supporting the US petrochemical boom are not present. Large volumes of shale gas have been developed close to the US gulf coast’s world-scale petrochemical industry, but the Beetaloo Basin is thousands of kilometres from Australia’s major industrial hubs.

3.3 Cheaper gas will be a narrow and ineffective economic stimulus

The east coast gas market may not be perfectly efficient. But even if it were operating perfectly, it would not reduce gas prices enough to deliver a meaningful boost to manufacturing (Chapter 2). Even if the Government implemented policies that it has hinted at but not committed to – such as underwriting new gas pipelines or gas production – the benefits would be very narrow, and too small to materially help the economy recover after the COVID recession. And these investments take a long time, making them poorly suited to a rapid economic recovery. Another argument against government support for the energy and manufacturing sectors is that the COVID recession disproportionately affected services sectors.⁹²

3.3.1 Highly gas-intensive manufacturing

Australia has three highly gas-intensive manufacturing sub-sectors – polyethylene, ammonia and related chemicals, and alumina (Table 3.1). The 15 major facilities in these sub-sectors, detailed in Appendix B, are certainly very sensitive to gas prices, and could benefit from government policies that bring down gas prices. Gas makes up well over 10 per cent of their input costs, and they consume more than 60 per cent of the gas used in Australian manufacturing.

The benefits of any gas-focused stimulus will be heavily concentrated in these sub-sectors, and so would be very narrowly focused. These three sub-sectors employ just over 10,000 people, or about 1.3 per cent of Australian manufacturing workers. And they represent just 2.4 per cent of manufacturing activity, or 0.1 per cent of the national economy.⁹³

The Federal Government’s gas policies focus on east coast gas prices rather than those in WA. This reflects the recent increases in east coast

92. D. Wood et al (2020).

93. Economic activity is measured on the basis of gross value added.

Table 3.1: Only a handful of industry sub-sectors are gas-intensive

Industry	Key products	Gas as a share of input costs (per cent)	Gas use (peta-joules)	Direct employment	Share of manufacturing employment (per cent)	Share of manufacturing activity (per cent)	Share of national economy (per cent)
Polyethylene	Plastics	30.9	32	1,000			
Ammonia and related chemicals	Explosives and fertilisers (including urea)	19.6	78	1,900			
Alumina	Alumina	14.3	164	7,700			
Highly gas-intensive industry		16.6	274	10,600	1.3	2.4	0.1
Non-metallic mineral products	Glass, bricks, cement, plasterboard	2.1	46	42,400			
Pulp and paper	Wood pulp, paper products	1.6	16	15,300			
Moderately gas-intensive industry		1.9	62	57,700	6.9	9.2	0.5
Petroleum and coal products	Liquid fuels	1.1	16	4,900			
Iron and steel	Iron and steel	0.8	15	22,300			
Food, beverages, and tobacco	Food, beverages, and tobacco	0.5	38	246,800			
Primary metals (other than alumina and iron and steel)	Nickel, copper	0.4	16	9,900			
Mildly gas-intensive industry		0.6	86	283,900	33.8	35.0	2.0
All other manufacturing	Various products	0.2	23	488,000	58.1	53.5	3.1
All manufacturing	Various products	1.0	445	840,100	100	100	5.8

Notes: 2017-18 data. Gas use includes ethane use in polyethylene manufacturing, and so is higher than the manufacturing estimate in Figure 1.1. Column totals may not sum due to rounding. Data for highly-gas intensive sectors compiled from individual facility data set out in Appendix B. Data for all other sectors drawn from ABS (2019a), ABS (2019b) and ABS (2019c). Gas use by sector refined using AEMO (2020e), Gas Bulletin Board WA (2020) and ACIL Allen (2019, p. vii).

Sources: Grattan analysis of the sources cited above.

prices, and WA's relatively cheap gas (Figure 2.1). But more than half of Australia's very gas-intensive industry is located in WA, and already enjoys low gas prices. This further narrows the potential benefits of gas-focused stimulus to facilities employing about 4,500 people. The number of workers would be higher if indirect economic effects are taken into account, but estimates of these effects are often inflated by using problematic assumptions (Box 7).

Lower gas prices could prevent closures of existing gas-intensive east coast manufacturing. But the cost and difficulty of achieving those lower gas prices needs to be weighed against the benefits of alternative policies.

Hopes of expanding manufacturing on the back of lower gas prices appear forlorn, at least in eastern Australia. A leaked report indicates that the NCCC manufacturing taskforce advised the Government that 37,000 to 69,000 new direct jobs could be created in petrochemicals, urea, and ammonia manufacturing.⁹⁴ But this advice appears to be based more on wishful thinking than careful analysis.

If expansion of this scale was likely to happen in Australia due to lower gas prices, it would have already happened in WA. But many factors other than gas prices affect investment, including commodity prices, exchange rates, construction costs, and the cost and availability of skilled labour. Without these other factors also being in place, lower gas prices will not deliver investment. Even WA, with its low-cost gas, has had only modest recent investment in gas-intensive industry – the last such investment was an ammonia plant in the Pilbara built in 2006.⁹⁵

Further investment in gas-intensive industry is possible, even without government support. Perdaman Chemicals has heads of agreement

with gas suppliers to build two new urea fertiliser plants – one near Karratha in WA and a smaller plant in Narrabri, NSW.⁹⁶ No doubt, if these plants are built they will provide welcome local economic activity, but on a small scale – the Narrabri plant would create about 200 direct jobs.⁹⁷ Large-scale government support for gas supply may simply subsidise investments that would have happened anyway.

3.3.2 Moderately and mildly gas-intensive manufacturing

Gas is used widely across the manufacturing sector, but generally it is a much smaller share of input costs than it is for polyethylene, ammonia, and alumina producers. Across the broad range of less gas-intensive sectors, policy efforts to reduce gas prices will be welcome, but will not drive new investment or boost production.

The non-metallic mineral product and pulp and paper sub-sectors appear to be moderately gas-intensive. Gas makes up about 2 per cent of input costs in these sub-sectors, and they employ almost 60,000 people (Table 3.1).

The iron and steel, petroleum and coal product, food, beverage, and tobacco processing, and remaining primary metals sectors are even less gas-intensive. Gas makes up between 0.5 and 1.1 per cent of input costs in these sub-sectors, and they employ about 285,000 people (Table 3.1).

Most of the Prime Minister's estimated 225,000 manufacturing jobs in heavily gas-reliant sectors (Box 5) appear to be in the food, beverage, and tobacco processing sector. But gas makes up only 0.5 per cent of input costs for the typical business in that sector – far too low to be a major driver of investment and closure decisions.

94. Page 34 of the NCCC manufacturing taskforce's interim report, as reported in Long (2020).

95. Yara (2020).

96. Perdaman (2018); Woodside (2018); and Perdaman (2019).

97. Perdaman (2019).

Box 7: Estimates of indirect economic effects often exaggerate the flow-on effects from plant closures or new investments

Industries often publish estimates of their economic importance that include ‘indirect’ effects. These indirect effects have two main components: the output of industries that supply goods and services to that industry (the ‘supply chain effect’), and that of industries that produce goods and services that their employees consume (the ‘induced consumption effect’).

Gas-intensive industries have included indirect effects in their estimates of the number of jobs at risk from higher gas prices. For example, Chemistry Australia argues that the Federal Government’s gas policies ‘are important to ensure the Australian chemistry industry continues to underpin more than 212,000 jobs across the economy’.^a This estimate is based on indirect effects stemming from about 61,000 direct jobs in the wider chemistry industry,^b implying a multiplier of about three and a half direct and indirect jobs for every direct job. Similarly, Incitec Pivot has argued that a failure to reduce gas prices will put 30,000 jobs at risk,^c which also appears to include indirect jobs.

These estimates use an economic technique known as ‘input-output multipliers’. As their name implies, these multipliers translate the direct economic effects of an industry into a larger estimate including indirect effects. This translation is not inherently incorrect – industries are interlinked, and effects in one will flow through to another.

The problem with these estimates is that they rely on unrealistic assumptions that exaggerate the indirect economic effects.^d In fact, the ABS was so concerned at how input-output multipliers were being used that it stopped publishing them.^e

- a. Chemistry Australia (2020).
- b. ACIL Allen (2019, p. iii).
- c. Macdonald-Smith (2020d).
- d. ABS (2010) and Gretton (2013).

Two assumptions are particularly unrealistic. The first relates to the supply chain effect. Input-output multipliers effectively assume that there is no competition for resources in the economy, so the increased supply chain effects of a growing industry does not draw resources away from other industries. Conversely, this assumption means that the companies that supply a declining industry will not be able to sell their goods and services to other parts of the economy.^f

Assumptions relating to induced consumption effects are also very unlikely to hold in practice. Including the effect of induced consumption effectively assumes that any employee of a growing industry was previously unemployed and not consuming anything, or conversely that the workers who become unemployed when an industry shrinks will never work or consume again.^g

Even allowing for indirect jobs, the true number of jobs at risk from high east coast gas prices is far below the 30,000 estimated by Incitec Pivot, let alone the 212,000 estimated by Chemistry Australia. Applying the 3.5 jobs multiplier that underpins Chemistry Australia’s estimate to the 4,500 jobs in eastern Australian gas-intensive industries implies that about 16,000 direct and indirect jobs might be at risk from high gas prices. Using a more realistic multiplier of 2.5 that excludes induced consumption effects,^h implies about 11,500 jobs might be at risk. But even this estimate reflects unrealistic assumptions about the ability of those businesses that supply gas-intensive industries to adjust to plant closures, suggesting a best estimate somewhere in the range of 4,500 to 11,500 jobs.

- e. ABS (2010). Multipliers can still be derived from underlying input-output tables.
- f. Gretton (2013, p. 5).
- g. McLennan (1990, p. 24).
- h. ACIL Allen (2019, p. iii).

Some companies and facilities within these sectors will be more gas-dependent than the average. For example, not all brick and cement manufacturers use gas, and those that do will be more gas-intensive than the averages imply. But Appendix C details a range of businesses that undertake moderately or mildly gas-intensive manufacturing, and finds only a handful where gas makes up more than 3 per cent of their input costs. And several moderately gas-intensive businesses are exploring alternative fuels – such as waste, landfill gas, and biomass – to reduce their gas bills (Box 8).

These investments to move away from natural gas indicate that recent increases in gas prices cause difficulties for a range of moderately and mildly gas-intensive manufacturers. And switching to alternative fuels can involve significant upfront costs, as well as ongoing fuel cost savings. But it does not follow that policy action on gas is required to avoid widespread business closures and job losses. Most businesses have scope to adjust, and governments should help with this adjustment (Section 3.4) rather than promising to achieve unrealistic reductions in gas prices.

3.3.3 The rest of manufacturing is not sensitive to gas prices

Almost 60 per cent of manufacturing workers work in sectors where gas comprises about 0.2 per cent of input costs on average (Table 3.1).

This finding undercuts the Government's argument that gas is 'foundational' to manufacturing.⁹⁸ The data indicate that for many – indeed most – manufacturers, gas is a very small cost, and a reduction in gas prices would have almost no effect. Presenting gas as critical to the viability of manufacturing in Australia is incorrect, and is likely to lead to poorly targeted and ineffective policies.

98. Morrison (2020b).

Box 8: Some manufacturers can move away from gas

Maryvale pulp mill

Opal (part of the Nippon Paper Group) is planning a waste-to-energy facility at its Maryvale pulp mill in Victoria's Latrobe Valley. The new facility would burn household garbage rather than gas to raise steam for the pulping and paper-making process. The mill currently uses about 6 petajoules of gas a year, but using waste for energy would reduce this by about 60 per cent.^a

Birkenhead cement plant

Adelaide Brighton uses gas as its primary energy source at its cement clinker plants in Birkenhead and Angaston (SA). But at the Birkenhead plant, waste-derived fuel is also used, reducing natural gas consumption by about 25 per cent. The company has plans to increase this to 50 per cent.^b

Austral bricks at Longford and Horsley Park

Austral bricks (owned by Brickworks) uses about 4 petajoules of gas a year in its brick kilns. But it also gets about 0.5 petajoules from biomass – sawdust at its Longford plant in Tasmania, and landfill gas at its Horsley Park plant in NSW.^c

Botany paper mill

Opal and SUEZ are exploring options for a waste-fired cogeneration plant to produce steam and electricity for the Botany paper mill in NSW. If approved and built, this plant would reduce natural gas use at the mill by about 1.5 petajoules per year.^d

-
- a. Opal (2020).
 - b. Adelaide Brighton (2019, pp. 7, 28).
 - c. Brickworks (2019, p. 24).
 - d. SUEZ and AECOM (2019, p. v).

3.4 Policy should focus on reducing gas use, not increasing it

The case for governments intervening to support natural gas use in manufacturing is not strong. Pro-gas policies offer unrealistic promises of lower gas prices – which are inconsistent with both the rising cost of gas supply in eastern Australia and the need to reduce emissions.

In general, governments should help industry use less gas, rather than more. This would both reduce emissions and ration increasingly expensive gas for those businesses least able to move to alternative energy sources.

A broad-based emissions reduction policy, such as a carbon price, would be the most efficient way for manufacturers to trade off the emissions and cost of different fuel sources. Unfortunately, such a policy does not appear to be politically feasible in Australia at this time. Even if it were, there would still be a good case for governments helping manufacturers to overcome a range of challenges they face in moving to lower-emissions energy sources.

Government funding is important to develop some relatively immature technologies, including hydrogen – which was identified as a priority technology in the Federal Government's recent low-emissions technology statement.⁹⁹ This is particularly important for gas-intensive sectors such as alumina and ammonia-based chemicals, where hydrogen and other emerging technologies may achieve large emissions reductions. Polyethylene manufacturing cannot readily switch to hydrogen, and its low-emissions pathway looks more challenging.¹⁰⁰

99. Australian Government (2020f, p. 6).

100. Plastic can be made from biomass but this approach may not scale globally. A multi-pronged approach will probably be needed, including biomass feedstock, increased recycling, long-term waste storage, and offsetting emissions: ETC (2018, p. 28).

Smaller gas users, such as the food processing sector, also need help to move to lower-emissions production. The Federal Government should help these manufacturers obtain the knowledge they need to make good energy choices, and provide finance to help them implement major changes.

3.4.1 Moving to low-emissions alumina

Australia is a major producer of both alumina and bauxite (the ore from which alumina is derived). Australia is the world's largest bauxite miner, and the second-largest producer of alumina.¹⁰¹

Australia can play an important role in decarbonising alumina, and therefore aluminium production. As a continent rich in both bauxite and renewable resources, Australia is likely to remain a highly competitive producer of alumina in a carbon-constrained world.

Today, the lowest-cost way to produce alumina with near zero emissions in Australia is unclear. One approach would be to use electricity for the lower-temperature digestion process,¹⁰² and renewable hydrogen for the high-temperature calcination process. Economics may favour electrifying both processes. Solar thermal energy could also play a role.

Researchers are examining these questions.¹⁰³ For example, the University of Adelaide and a range of prospective industry partners are seeking government funding for a new cooperative research centre looking at low-emissions technologies for heavy industry, including alumina.¹⁰⁴

101. USGS (2020, p. 31).

102. The most likely way to do this is a technology known as mechanical vapour recompression. This involves an electrically-driven compressor taking steam from the low-temperature end of the digestion process, and recompressing it to give it more energy, suitable for re-use in the process: Chatfield (2020).

103. ARENA (2020a).

104. HILT CRC (2020).

And the Federal Government's recent low-emissions technology statement identifies low-carbon materials, including aluminium, as a priority.¹⁰⁵

Further government funding appears justified in this area, given Australia's interests and opportunity, through both the proposed research centre and other bodies. An important next step will be turning the Federal Government's stated focus on low-carbon materials, and low-emissions aluminium costs, into a more focused research and investment agenda for aluminium, and particularly for alumina.

3.4.2 Reducing emissions from ammonia

There are two clear technical pathways to low-emissions ammonia production. Currently, natural gas is reacted with steam to produce carbon dioxide and hydrogen (steam methane reforming), and the hydrogen is reacted with nitrogen to produce ammonia. This process can be decarbonised by either capturing and sequestering the carbon dioxide it creates, or by substituting fossil-based hydrogen with renewable hydrogen.¹⁰⁶

These processes are reasonably well understood and do not face any major technical barriers. Producing hydrogen from natural gas creates a relatively pure stream of carbon dioxide, so the cost of capturing this gas is not very high. The main barrier to this approach will be the availability and cost of carbon dioxide storage. The main barrier to using renewable hydrogen will be cost. Renewable ammonia is very expensive at high hydrogen prices, but will be significantly cheaper if hydrogen costs fall.¹⁰⁷ The economics of using carbon capture and

storage in ammonia production will vary greatly depending on local geology.

The policy objective here should be to decarbonise Australia's ammonia production in line with broader global actions, while building broader technical capabilities. Existing ammonia plants are likely to prove a good place to do small trials of renewable hydrogen to build local knowledge, and ARENA has supported four feasibility studies looking at this opportunity.¹⁰⁸

3.4.3 Iron and steel could use more gas in the near term, and eventually move to hydrogen

Gas use in the iron and steel sector is modest today, at about 0.8 per cent of input costs (Table 3.1). This is because coal is the main fuel used in the energy-intensive primary steel-making process in Australia. Gas is mainly used to re-heat metal for casting and fabricating – a less energy-intensive task.

In a recent report we argued that moving from coal to gas could provide a cost-effective and flexible way of reducing emissions in Australia's iron and steel sector.¹⁰⁹ Gas can be used to make steel through a commercially-proven process known as 'direct reduction', which creates fewer emissions than traditional coal-based steel-making. And, importantly, low-emissions hydrogen can be readily blended into this process, giving producers a flexible way to further reduce emissions over time.

Despite the relatively high cost of eastern Australian gas, it could provide an affordable and flexible path to lower-emissions steel in Australia. GFG Alliance has plans to replace its main steel-making

105. Australian Government (2020f, p. 6).

106. Renewable hydrogen is made by using renewable electricity to power an electrolyser, which splits water into hydrogen and oxygen.

107. T. Wood et al (2020).

108. ARENA (2020b).

109. T. Wood et al (2020).

facilities at Whyalla, SA, with gas-based direct reduction, and then move to renewable hydrogen over time.¹¹⁰

3.4.4 Less gas-intensive sectors

As discussed above, the vast majority of Australian industry is either moderately gas-intensive, or not gas-intensive at all. And some businesses have started substituting expensive gas for lower-cost fuels, such as biomass or waste (Box 8).

In the long-term, as the electricity grid is decarbonised, electrification will be a critical low-emissions energy option for many smaller gas users. Electric heat pumps can readily replace gas boilers for businesses that only require low-temperature heat. The economics of such a switch will vary from site to site depending on relative gas and electricity prices, local weather,¹¹¹ electrical connection capacity, and equipment costs. It is also possible that these processes will be converted to biomethane or low-emissions hydrogen.¹¹²

But small industrial gas users are often focused on other aspects of their business, and may not have the knowledge to weigh up the benefits and costs of electrification. Some gas users may also be capital constrained, and unwilling to invest in alternatives with higher upfront costs, even if such alternatives offer ongoing savings.

ARENA has already funded four feasibility studies to help overcome these barriers,¹¹³ and has funding to support five more such studies.¹¹⁴ These studies examine electrification of gas use at various smaller industrial facilities, mainly in the food and beverage sector. The

economics of the projects identified were generally good, but not always good enough to support immediate implementation.¹¹⁵

The Clean Energy Finance Corporation (CEFC), in partnership with the Australian Industry Group and the Energy Efficiency Council, has also published a guide to potential gas-use efficiency investments in manufacturing.¹¹⁶

Policy can go further to efficiently reduce industrial gas use. ARENA should continue to fund feasibility studies and knowledge sharing on renewable heat options over a number of years, and ensure that this work includes energy efficiency. Projects that are not viable today may be viable in future when boilers and other equipment need replacing. This means that the pool of potential projects will change over time, and rolling funding rounds will be needed to reach a broad range of manufacturing businesses across the country. This will also help to spread knowledge of alternative energy sources, and help the Australian industrial heat pump market to mature.¹¹⁷

Work to date indicates some small manufacturing businesses have a conservative attitude to capital investments, and will invest in new equipment only if this pays for itself in three years or less.¹¹⁸ This is a very difficult financial hurdle to clear, and indicates that many economically attractive projects might not be pursued. The CEFC could provide finance to help small Australian manufacturers capture these opportunities. The CEFC is well-placed to work with ARENA to develop specialist knowledge about these projects that private sector lenders may not have, and to share information across the manufacturing sector.

110. GFG Alliance (2020).

111. Heat pumps for heating water are more efficient in warmer climates.

112. Biomethane is methane made from biomass sources. These alternatives are discussed further in the context of households in Chapter 5.

113. A2EP and Climate KIC (2020).

114. ARENA (2020c).

115. A2EP and Climate KIC (2020, p. 9).

116. CEFC, AIG and EEC (2018).

117. A2EP and Climate KIC (2020, p. 10) identifies Australia's small current market for industrial heat pumps as a constraint on equipment supply, and therefore on the use of renewable heat in Australia.

118. Ibid (p. 9).

4 Gas will be a backstop in the power sector, not a transition fuel

A decade ago, it was plausible that gas could have played a substantial role in reducing Australia's power-sector emissions. Gas-fired power is cleaner than coal power, gas prices were low, and solar and wind were expensive. Some considered that gas could be the critical 'transition fuel', with gas generation taking over from coal generation as a key source of power, before a later transition to renewables or other lower-emissions sources.

But today, the dream of gas as the critical transition fuel is dead, at least in eastern Australia. Gas is expensive, and will stay that way (Chapter 2). The cost of renewables has fallen at a remarkable rate. And the world is fast running out of time to tackle climate change. Investing in a large new fleet of gas generators may make it harder, not easier, for Australia to reduce emissions consistent with the Paris Agreement.

Large-scale use of gas as a transition fuel – supplying 'baseload power' with lower emissions than coal – does not stack-up economically or environmentally. This view is widely held within the power sector (Box 9).

Gas does have an important role to play, but as a backstop, to support the power system during demand peaks and persistent periods of low wind and sun.

Gas will naturally fill this role as coal plants are retired and investment in renewables continues. Governments should focus on measures that clarify the timing of coal closures and ensure that wholesale electricity markets are working effectively. Heavy-handed attempts to force more gas and other dispatchable generation sources into the market, such as the Federal Government's target of 1000 MW of new dispatchable generation in NSW, are unhelpful and unnecessary.

Box 9: The power sector sees gas as a flexible power source, not as a baseload power source

'The energy transition we have all been anticipating will skip "big baseload gas" as a major component of the [National Electricity Market's] base-load generation and instead largely be a case of moving from "big coal" to "big renewables"' – Brett Redman, then CFO (now CEO), AGL Energy, May 2017

'The market does need gas. Industry is responding to gas. Interestingly enough, the biggest source of gas in the last 12 months has been as baseload gas-fired generation has moved to running low capacity factors. It's that gas that is being freed up to go to customers, as gas increasingly moves to more of a peaking operation and therefore running less hours through the year' – Frank Calabria, CEO, Origin Energy, October 2019

'As we make the transition, there's a clear potential role for gas balancing increases in renewable energy. Don't assume that's an easy role, either. At current price points, we see gas being used for intermediate or peak supply – not for base-load generation' – Mark Collette, then Executive (Energy), EnergyAustralia, March 2017

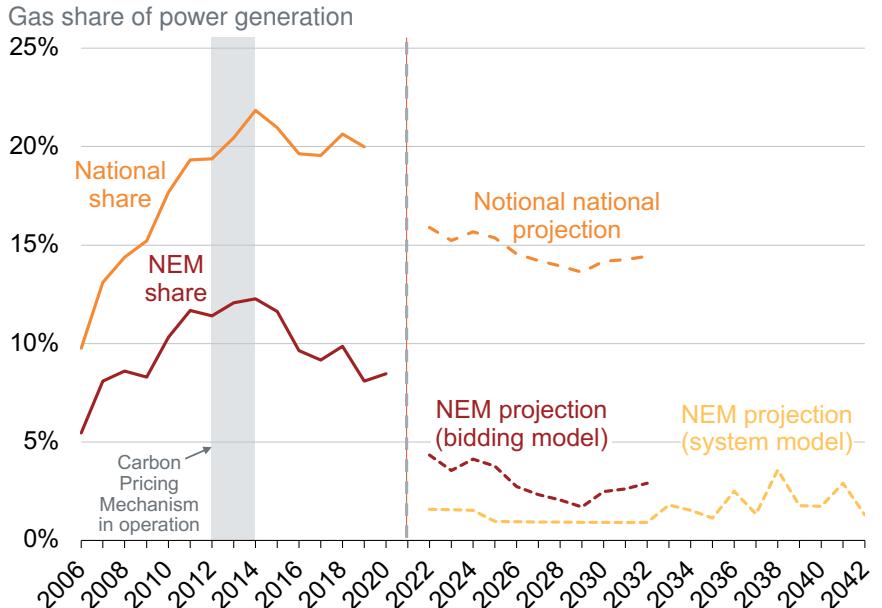
4.1 After growing for many years, gas-fired power is now in decline

The role of gas in the power sector has changed significantly over the years. During the 1980s and 1990s it was primarily used in WA, SA, and the NT, where it provided a significant share of power needs (alongside coal in WA and SA). A few flexible gas generators provided small amounts of power in Victoria. In 1988-89, gas provided 8.5 per cent of Australia's power.¹¹⁹

During the first decade of this century, electricity companies increasingly used gas to supply power during short spikes in demand, particularly on hot summer afternoons. And gas generation expanded in previously coal-dominated Queensland and NSW. From 2005 the Queensland Government required electricity retailers to buy 13 per cent of their power from gas generation through the Queensland Gas Scheme, with the aim of reducing power-sector emissions and supporting gas production.¹²⁰ In NSW, as a result of growing peak demand and the need for more flexible generation sources, several gas peaking power stations were built, as well as the Tallawarra combined-cycle gas turbine which was intended to run more regularly.

Gas-fired power reached its peak in 2014 – at about 22 per cent of national generation, and about 12 per cent of the east coast National Electricity Market (Figure 4.1).¹²¹

Figure 4.1: Gas-power generation is likely to continue to decline as a share of national power supply



Notes: NEM = National Electricity Market. Historic NEM data drawn from OpenNEM (2020). NEM projections drawn from two projections developed for the Australian Energy Market Operator's Integrated System Plan: AEMO (2020f, p. 28) and AEMO (2020g). These projections use different methodologies: a 'bidding model' that is more closely based on market behaviour, and a 'system model' that focuses on long-run outcomes. The bidding model is likely to provide a better representation of gas dispatch, and is more comparable with historical outcomes. Across both methods, gas generation can vary between scenarios and depending on weather patterns modelled. The national projection is referred to as notional because projections are not available for WA, the NT, or Mt Isa. The notional projection presented assumes that WA and NT gas generation remain at 2018-19 levels drawn from Australian Government (2020g). Mt Isa generation assumed to remain at 2011-12 levels drawn from Australian Government (2013, p. 32).

Sources: Grattan analysis based on the sources cited above.

119. IC (1991, p. 29).

120. Wilson (2007). The required share of gas generation was increased to 15 per cent in 2010. The scheme was repealed in 2013.

121. The NEM comprises most electricity customers in NSW, Victoria, Queensland (except Mount Isa), SA, Tasmania, and the ACT. WA and the NT rely heavily on gas, and as a consequence the national average is well above the NEM average.

Around this time Queensland's coal seam gas industry was ramping up to supply large export facilities that were still under construction, making lots of low-cost gas available, including for power generation.¹²² And the short-lived national Carbon Pricing Mechanism gave gas a cost advantage over coal between July 2012 and June 2014, boosting its market share.

Gas generation has been declining in Australia since 2014 (Figure 4.1). Gas prices rose as east coast exports began, squeezing gas out of the power market. Government subsidies and falling costs have prompted households to install rooftop solar at increasing rates, and energy companies to invest heavily in utility-scale renewables – first wind, and later solar – further displacing gas. The closure of two large coal-fired power stations – Northern (SA) in 2016 and Hazelwood (Victoria) in 2017 – has slowed, but not stopped, the decline of gas-fired power.

Gas-fired power in the NEM will continue to decline over the next few years as yet more renewable generators are commissioned, and is likely to remain at historically low levels for at least a decade (Figure 4.1). Even assuming that the share of gas generation in WA and the NT holds constant – and renewable generation is squeezing gas in those places too – over the next 10 years the national share of gas generation is likely to fall to levels not seen since the first decade of this century. It may never return to 2014 levels.

Not only is gas an increasingly expensive source of power, it is also becoming a relatively emissions-intensive source. In the past gas probably would have benefited from efforts to reduce emissions, as occurred between 2012 and 2014 in Australia. This is because gas provides lower-emissions power than coal – both because the fuel has a lower carbon content and because the design of some gas power stations is much more efficient than the design of coal power

stations.¹²³ But as renewable generation becomes cheaper and grows as a share of power supply, efforts to reduce emissions will increasingly favour renewables over gas, more than they will help gas displace coal. If a new gas-fired generator were built today, it would become a relatively high-emissions source of power well before the end of its life (Figure 4.2).

4.2 The role of gas in Australia's power sector

Despite its declining share of generation, gas will retain an important role in Australia's power sector for years to come. Chief Scientist Alan Finkel has stated that: 'Gas has much, much more scale than batteries. And gas is effectively the perfect complement to solar and wind. We can build a lot of solar and a lot of wind, and use gas for times when we don't have the sun shining and the wind blowing to deliver the energy we need... The reality is we're going to need to rely on it for 10, 20, perhaps 30 years.'¹²⁴

Finkel's comment has attracted some criticism. Twenty-five scientists signed a letter which argued that 'there is no role for an expansion of the gas industry'.¹²⁵ But nothing Finkel said implies an expanding role for gas. Some may hope for a quicker transition to a fully renewable power system, but Finkel's assessment is realistic. He is essentially describing gas as a 'backstop' for the power system – used for relatively short bursts to maintain reliability, but generally as little as possible due to the high cost of fuel.

123. A stand-alone gas turbine has similar, or even slightly lower, efficiency as a coal-fired power station. But the waste heat from the exhaust of a gas turbine can be captured and used to drive a steam turbine. In this 'combined cycle' configuration, gas generators can produce more electricity per unit of fuel than coal generators.

124. ABC (2020).

125. Abram et al (2020).

122. Australian Government (2015, p. 32).

This contrasts strongly with the idea of gas as a ‘transition fuel’. This is where the power system transitions first from coal to gas, taking advantage of the fact that gas is both more flexible and lower-emissions than coal. And later a second transition would occur from gas to renewables.¹²⁶

For eastern Australia the transition fuel idea died about five years ago, when the Carbon Pricing Mechanism was repealed and LNG export plants at Gladstone started operating, locking in higher east coast gas prices (see Chapter 2). Eastern Australian gas prices will remain high, and renewable generation costs have fallen dramatically, and so gas is simply too expensive to be a viable transition fuel.

4.2.1 Gas-fired generation does have an important role as a ‘backstop’ for reliability...

Today, and into the future, gas will continue to perform a ‘peaking’ role, able to be turned on for a few hours to meet daily demand peaks, typically in the evening.¹²⁷

But in the future gas is likely to also perform a new role at times of low renewable energy generation. On a low-wind night, for example, gas may well be needed to run overnight and into the morning.¹²⁸

Gas generation is much better suited to both of these roles than coal. Gas power stations are much more flexible than coal; they can be turned on quickly to provide peak power for a few hours a day.¹²⁹ And, compared to coal, gas power stations have lower overhead costs such

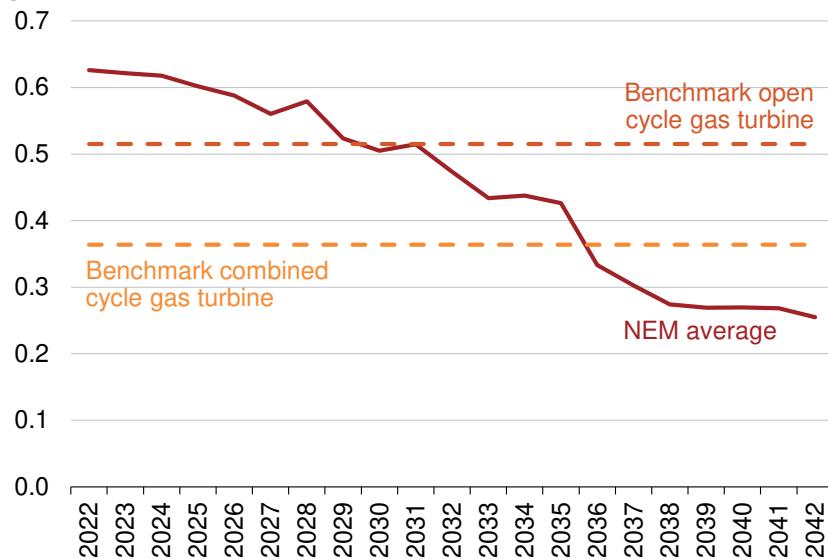
126. This term is commonly, but not always, used in this way. See for example IEA (2020c). In the US the term ‘bridge fuel’ is often used in the same way. See for example Obama (2014) and Weissman (2016).

127. AEMO (2020h, p. 53).

128. Ibid (p. 53).

129. Some new gas plant can reach full capacity within five minutes of starting, whereas a coal plant will often need more than a day: AER (2020a, pp. 76–77).

Figure 4.2: A new gas generator is likely to be more emissions-intensive than the grid well before the end of its life
Emissions intensity of power generation, tonnes of CO₂-equivalent per megawatt-hour



Notes: NEM is National Electricity Market. An open cycle gas turbine is a stand-alone gas turbine. A combined cycle gas turbine captures waste heat from an open cycle gas turbine’s exhaust, and uses it to run a steam turbine – this improves its efficiency and reduces its emissions intensity. Generators’ efficiencies are from Graham et al (2020, p. 43). Natural gas fuel emissions factors are for direct combustion only (exclude fugitive emissions): Australian Government (2019e, p. 12). NEM emissions intensity is based on analysis of AEMO (2020g, Development Path 1, Central scenario).

Sources: Grattan analysis based on the sources cited above.

as staff and maintenance, allowing them to sit idle for much of the year but still be ready to run when renewable output is lower than normal.

This role doesn't need lots of gas or cheap gas, but it does require flexible gas. The Federal Government's recently announced policies focus on supporting new gas production and pipelines (Chapter 2), but these require relatively constant gas demand to keep average costs as low as possible. This makes them poorly suited to the emerging role of gas in power generation. By contrast, LNG regasification terminals (Section 2.4.3) are very well suited to this role, because they can quickly change the rate at which they deliver gas to meet the highly variable needs of gas power generation.¹³⁰

4.2.2 ...but gas cannot bring prices down

The Federal Government's hopes that it can lower gas prices and so 'drive down electricity prices'¹³¹ are forlorn. Gas will continue to play a role in the power system for many years, supporting reliability and moderating price spikes, but it cannot materially drive prices down.

The Government has targeted electricity prices of \$70 per megawatt-hour,¹³² but new gas generation can only reach this price with unrealistically low gas prices – below \$6 per gigajoule – and unrealistically high capacity factors – over 80 per cent.¹³³

130. Pipeline 'linepack' can also provide storage to manage variability in gas demand for power generation. Linepack is the amount of gas in a pipeline. If more gas is withdrawn from the pipeline than is injected, the pipeline can, within limits, continue to operate. This drawdown of linepack effectively provides gas storage.

131. Morrison et al (2020).

132. Taylor (2019).

133. A capacity factor is the amount of energy a power plant produces divided by the amount it could produce if it constantly ran at full capacity. These assumptions are based on the lower-range estimate of combined cycle gas generation costs in Graham et al (2020, pp. 24, 43). Higher capacity factors result in lower per-unit power costs, because capital costs are spread over more units of output. For example, over the past five years the combined cycle Tallawarra gas power

Some commentators argue that recent falls in gas prices have been the largest factor driving electricity prices down during 2020.¹³⁴ This argument can be tested quite simply.

If gas generators were indeed the key factor driving prices down, they would do so by bidding at lower prices in the market and so increasing their share of power supply. Other generators would respond to this competition by reducing their prices to moderate their own loss of market share. But it is extremely unlikely that the response by other generators would be large enough to wipe out and reverse the initial shift to gas.

But gas generation is actually losing market share. Across the NEM gas generation fell by about 17 per cent in the first nine months of 2020 compared to the same period in 2019 (Figure 4.3). Gas generation has declined more in relative terms than any other fuel source.¹³⁵

The lower gas price is just one factor among many helping to reduce electricity prices – and it is far from clear that it is the most important. Solar, wind, hydro, and brown coal generation have gained market share, in contrast to gas. All these generation types have low or zero fuel costs, and so are cheap to run. When more of these sources become available – whether through new investment, increased rainfall, or improved reliability – they will tend to bring average prices down. All of these factors have helped reduce wholesale power prices during 2020 – new solar and wind generators have started operating, rainfall in

station in NSW has run at a capacity factor of 23 per cent to 43 per cent: Victoria Energy Policy Centre (2020).

134. See for example Reputex (2020). These falls have primarily been in short-term spot gas markets, not for gas contracts. Gas power stations are well placed to take advantage of cheap spot gas.

135. Black coal has declined more in absolute terms, reflecting its larger overall share of the generation mix.

hydro catchments has been higher than in 2019, and Victoria's brown coal generators have been more reliable.¹³⁶

Lower gas prices have reinforced electricity price falls, and electricity prices would undoubtedly be higher today if gas prices were still at 2019 levels. And the cost of gas generation can influence the cost of other sources, through a practice known as 'shadow pricing'.¹³⁷ But the link between gas and power prices can be easily overstated, and policies to reduce gas prices are likely to prove an indirect and expensive way to target lower power prices.

4.3 Gas generation doesn't deserve policy support, but does need clear market signals

Gas generation is a mature and well-understood technology, with a clear, albeit changing, role in Australia's power sector. There are no material barriers to gas playing this role that justify specific policy action or support.

The Federal Government's September 2020 announcement targeting 1000 MW of new dispatchable capacity¹³⁸ is the most heavy-handed of its recent attempts to force more dispatchable generation into the system. The Federal Government's earlier Underwriting New Generation Investments program also targeted additional generation, with a particular emphasis on gas-fired peaking power stations. These interventions, and particularly the threat to direct Snowy Hydro to build power stations if the private sector does not, may well be counter-productive, because they increase uncertainty and could delay investment by other parties.¹³⁹ If the design of the energy market is

136. AEMO (2020i, p. 11).

137. Shadow pricing is where one generator bids prices that are just below what it expects its competitors will bid at. For example, coal generators often shadow price gas generation: T. Wood et al (2018).

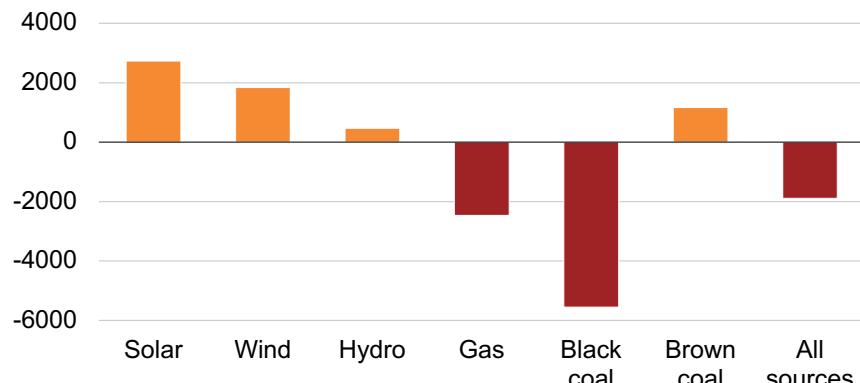
138. Morrison and Taylor (2020).

139. T. Wood et al (2019).

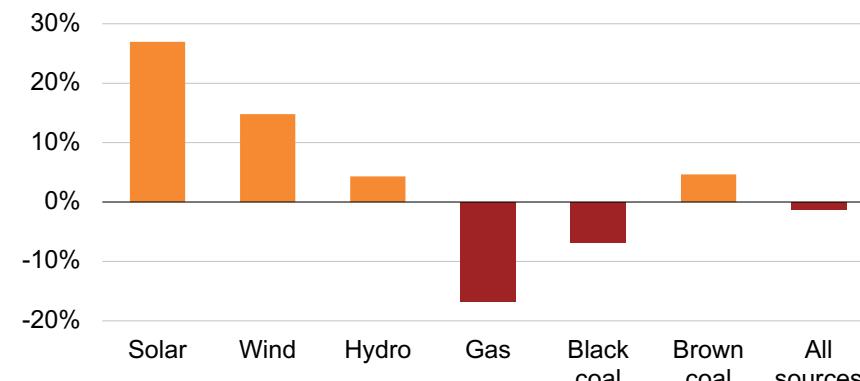
Figure 4.3: Renewables and brown coal, not gas, have been expanding their market share and driving prices down

Change in power generation by energy source between the first nine months of 2019 and the same period in 2020

Absolute change (gigawatt-hours)



Percentage change



Notes: Solar includes rooftop solar. Numbers do not add to the 'All generation' share because other generating categories are not included in the chart.

Source: Grattan analysis of OpenNEM (2020).

not sufficient to support gas-fired generation or other flexible power sources, this should be debated and addressed through the Energy Security Board's ongoing review of the design of the National Electricity Market – which will set out the problems and proposed solutions by early 2021¹⁴⁰ – not through ad hoc subsidies and interventions.

Investment in new gas-fired generation, like investment in other generators, would benefit from greater clarity on when large coal power stations will close. Existing market rules require power station owners to provide three-and-a-half years' notice of closure, but these rules are difficult to enforce.¹⁴¹ This makes the timing of large generator closures uncertain, and in turn makes it hard for investors to build new generators before, rather than after, a closure. The inflexibility of coal generators makes them particularly likely to close unexpectedly. Timely replacement investment will be supported by requiring the owners of coal-fired generators to nominate clear 'windows' during which they intend to close, and to provide financial security to support this outcome by holding funds in escrow.¹⁴² This policy would help provide sufficient flexible generation, including gas, as coal plants close and as renewables supply a larger share of our power.

140. ESB (2020).

141. T. Wood et al (2019, pp. 29–30).

142. Ibid (pp. 32–33).

5 Natural gas use at home must decline

Natural gas is widely used in Australian homes. But the need to reduce greenhouse gas emissions means that this must change in coming years. This will be confronting for many people, because changing the cooktops on which many of us make dinner is more personal than switching from fossil fuel to renewable electricity.

There are three main ways to reduce emissions from household gas use. One is to switch to electricity, and take advantage of Australia's decarbonising power grids. The other two involve switching to low-emissions gas substitutes – either biomethane or hydrogen.

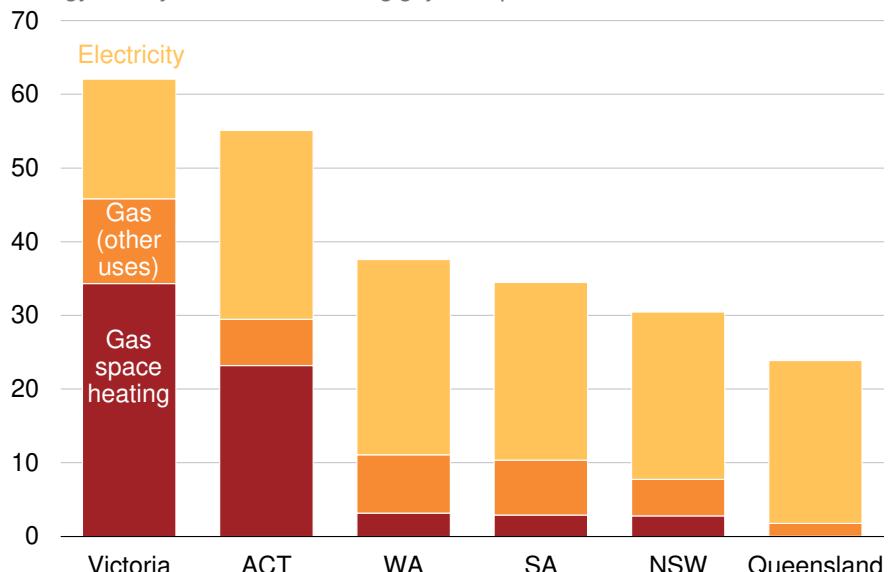
All three pathways have challenges. Electric appliances are very efficient, but are generally more expensive to buy than gas appliances. And switching from gas to electricity in places like Victoria and the ACT that use lots of gas for winter heating (Figure 5.1) could require expensive grid upgrades. Low-emissions gas substitutes may prove expensive to use. And a switch to hydrogen would require a rapid, coordinated change of gas burners to cope with a different gas.

The best long-term pathway is not clear, and will vary between places. Governments should investigate the economic, technical, and regulatory aspects of these pathways over the coming years.

But uncertainty is not an excuse for inaction. New houses in NSW, Queensland, SA, and the ACT are better off today using electricity for all their energy needs, and this choice will also reduce emissions. A moratorium on new gas connections in these places is a no-regrets option that saves money and emissions. And it does not preclude a longer-term switch of existing gas-using households to low-emissions gas substitutes rather than electricity, if it becomes clear that this is the most cost-effective way to deliver low-emissions energy to households.

Figure 5.1: Homes in Victoria and the ACT use much more gas than other states, especially for space heating

Energy use by fuel and end use, gigajoules per household, 2017-18



Notes: Use per household is calculated on the basis of all households, not just households with a gas connection. Gas use per gas-connected household will be higher, particularly in states with low gas penetration. Household energy use by state from Australian Government (2019c), except for NSW and ACT electricity demand, which were estimated based on AusGrid (2019), Endeavour Energy (2019), Essential Energy (2020) and Evoenergy (2019); ACT gas demand, which was estimated using CIE (2020, pp. 36, 51, 80); and SA gas demand, which was estimated using Core Energy (2020, p. 35). Energy use by application estimated based on EnergyConsult (2015). Household numbers from ABS (2019d).

Sources: Grattan analysis based on the sources cited above.

5.1 How we use gas in the home

How Australians use gas, and how much, varies greatly depending on where they live (Table 5.1).

Gas cooktops are commonplace in Australia, but consume less than 5 per cent of household gas use.

Water heating uses more gas than cooking, at about 33 per cent. Gas is the most common way to provide domestic hot water in Victoria, WA, SA, and the ACT.¹⁴³ Some gas water heaters store hot water in a tank; ‘instantaneous’ systems heat water when required.

Space heating is by far the largest use of gas by Australian households, at about 60 per cent. The vast majority of this occurs in Victoria – in fact, almost half of all gas used in Australian homes is used for heating in Victoria. In cold climates such as Victoria and the ACT, many houses have central gas heaters with ducting to take warm air to multiple rooms.¹⁴⁴ In other, warmer states most houses have single-room gas wall furnaces, or use electricity.¹⁴⁵

5.2 Reducing emissions from household gas use

Clearly, Australian households value gas. But their use of gas causes greenhouse gas emissions. Gas was once a lower-emissions energy option than electricity. Some still claim this is true, and by a large margin – for example Energy Networks Australia, which represents electricity and gas networks, claims gas typically produces about 75 per cent less emissions than electricity.¹⁴⁶

143. EnergyConsult (2015).

144. EnergyConsult (*ibid*). Gas has only been available in Tasmania since 2003: Tas Gas Networks (2020). This, plus cheap and abundant hydropower, means that Tasmanian households have traditionally used very little gas, despite that state’s cold climate.

145. EnergyConsult (2015).

146. ENA (2020). Based on average NEM electricity emissions.

Table 5.1: How Australian households use gas, by state

State	Cooking	Space heating	Water heating	Other appliances	Total
Share of state household gas use, %					
New South Wales	9	34	52	5	100
Victoria	2	74	24	0	100
Queensland	29	2	49	21	100
Western Australia	6	27	63	4	100
South Australia	7	26	64	2	100
Tasmania	37	30	26	6	100
ACT	2	77	21	0	100
Northern Territory	38	0	18	45	100
Share of national household gas use, %					
New South Wales	1	5	8	1	15
Victoria	1	48	16	0	65
Queensland	1	0	2	1	3
Western Australia	0	2	5	0	7
South Australia	0	1	3	0	5
Tasmania	0	0	0	0	0
ACT	0	3	1	0	4
Northern Territory	0	0	0	0	0
Australia	4	60	33	2	100

Notes: Numbers may not add due to rounding. Estimates are based on projections for 2020 calculated in 2015. Gas is natural gas only, and so excludes LPG.

Source: EnergyConsult (2015).

This claim is exaggerated at best, and incorrect at worst. Gas would be cleaner than electricity if gas appliances were as efficient as electric appliances. But this is not true – electric appliances are generally much more efficient than equivalent gas appliances. Induction cooktops are more than twice as efficient as gas cooktops,¹⁴⁷ reverse-cycle air-conditioners are more than three times as efficient as gas heaters,¹⁴⁸ and heat-pump water heaters are generally four times as efficient as gas water heaters.¹⁴⁹

The efficiency of electric appliances means that electricity is already a cleaner household fuel than gas in renewable-rich South Australia (Figure 5.2) – provided households use efficient appliances. Over time this will become true elsewhere, as coal generators close and new renewable generators are built. Electricity will be cleaner than gas in NSW and Queensland by 2025, and in the ACT by 2030. Even in Victoria, with its emissions-intensive brown coal power generators, electricity is likely to be cleaner than natural gas by 2035.¹⁵⁰

This analysis assumes that natural gas emissions stay constant over time. Rather than reducing emissions by switching from gas to electricity, another approach is to put an alternative, lower-emissions, gas substitute through the same gas pipelines.

147. Frontier Energy (2019).

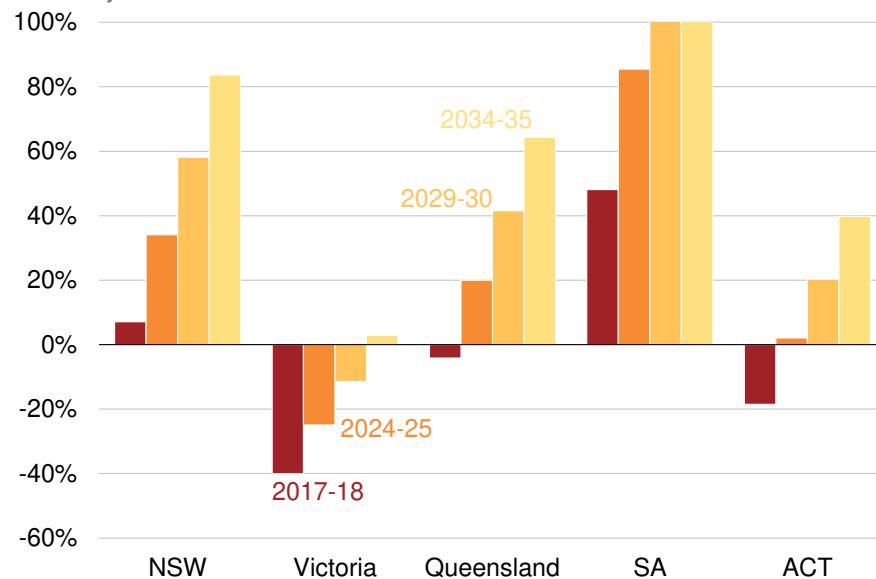
148. Efficiency varies with temperature, ranging from about twice as efficient at ambient temperatures of 0 °C or below, to more than three times as efficient above 4 °C: ATA (2014, p. 75). Temperatures in mainland Australian capital cities will deliver average annual efficiencies at least three times higher than gas heaters.

149. At ambient temperatures higher than 8 °C, but lower at lower temperatures: ATA (2018, p. 49). Temperatures in mainland Australian capital cities will deliver average annual efficiencies at least four times higher than gas water heaters.

150. The modelled rate of electricity emissions reduction reflects assumptions made in AEMO (2020h). The Victorian Government is considering state-wide emissions reduction targets: Victorian Government (2020b). This could result in policies that accelerate this reduction in electricity emissions.

Figure 5.2: All-electric homes with efficient appliances increasingly produce fewer emissions than homes with gas

Change in emissions when choosing gas instead of electricity, as a share of electricity emissions



Notes: Axis limited to 100 per cent. SA values are 119 per cent for 2029-30 and 154 per cent for 2035. Gas and electricity emissions include 'scope 3' emissions relating to the production of fuels (a 'full fuel cycle' basis): Australian Government (2019e).

State-based electricity emissions factors are assumed to reduce over time in line with National Electricity Market emissions intensity calculated using AEMO (2020g, Development Path 1, Central scenario). Electricity emissions factors are based on physical power flows, and so ignore, for example, the ACT Government's contracting arrangement with renewable generators outside the ACT to offset ACT grid emissions. Grid emissions intensity factors and household energy use are both calculated assuming no rooftop solar. Energy use per gas-using household is estimated using appliance installation rates in EnergyConsult (2015). Gas using households are assumed to have gas heating, except in NSW and Queensland. Heating and hot water appliance efficiency calculated based on ambient temperatures in different locations using ATA (2014, p. 75), ATA (2018, p. 49) and BoM (2020). Electric (induction) cooking efficiency calculated using Frontier Energy (2019, p. 22).

Sources: Grattan analysis based on the sources cited above.

The two main options are biomethane – methane derived from biomass – and low-emissions hydrogen. Biomethane is technically mature. In 2015 it supplied 0.3 per cent of Europe's natural gas.¹⁵¹ Low-emissions hydrogen can be produced in two main ways. One uses low-emissions electricity to power a process known as electrolysis which splits water into hydrogen and oxygen. The second is to extract hydrogen from a fossil fuel such as gas or coal, and to capture and store underground the carbon dioxide created by this process. Both approaches are technically mature, but further work is needed to determine a set of standards to ensure household appliances and fittings can run on hydrogen, and to convert these as necessary.¹⁵²

The trade-offs between electrifying gas use or moving to low-emissions gas substitutes are discussed further in Section 5.4.

5.3 Household economics

As Chapter 2 shows, eastern Australian gas is no longer cheap. Where gas was once a clear money saver for households, rising wholesale gas prices, the reducing costs and improving efficiency of electric appliances, and widespread adoption of rooftop solar means that this is generally no longer the case.

In Sydney, Melbourne, Brisbane, Adelaide, and Canberra, households that move into a new all-electric house with efficient appliances will save money compared to an equivalent dual-fuel house (Table 5.2), although this could change if electricity prices increase faster than gas prices. Households with rooftop solar would be even better off going all-electric than suggested by the estimates in Table 5.2, which assume all electricity is supplied from the grid.

The story is slightly more complicated in WA. A Perth household will be better off using gas for cooking and hot water rather than electricity,

151. Scarlat et al (2018).

152. COAG Energy Council (2019b, p. 42).

due to the low retail cost of gas and the lower upfront cost of gas stoves and water heaters than efficient electric appliances. But if the same household chooses gas for heating they will be worse off, because they will need to spend money on gas heaters as well as on electric cooling appliances.

This analysis compares a situation where all appliances are bought at the same time – as would be true of a new house. The conclusions do not necessarily hold for existing houses, which face additional costs in switching from gas to electricity. These include the cost of replacing functioning gas appliances, additional plumbing and rewiring costs (including, in some cases, the need to upgrade the house's electrical connection), and the cost of safely disconnecting from the gas network.

5.4 System costs

Even if new all-electric homes are both cleaner and cheaper to live in than dual-fuel houses, it doesn't necessarily follow that governments should move to phase out gas use in all homes. A broad switch away from gas could push up electricity prices, for example due to the need to reinforce the power grid. This would mean that a switch that makes sense for an individual household based on today's prices might not make sense for all households. And the cost of switching an existing house from gas to electricity is generally higher than building it with all-electric appliances in the first place. Changes to household energy consumption could also affect prices for commercial and industrial consumers, and this needs to be factored in when determining the best overall outcome for all consumers.

5.4.1 Switching small gas users to electricity will stretch Victoria's grid, but not NSW's or SA's

A good indication of the potential for a broad gas-to-electricity switch to push up electricity costs is the effect it would have on peak electricity

Table 5.2: A new all-electric house is generally cheaper to live in than a dual-fuel house

City	All-electric house		Dual-fuel house			Savings for all-electric house relative to dual-fuel house (dollars)		
	Heating and cooling choice	Uses for gas	Heating choice	Cooling choice	Capital cost savings	Annual running cost savings	Savings over 10 years	
Sydney	3 RCAC units	Cooking, hot water	3 RCAC units	3 RCAC units	-2,500	371	935	
Brisbane	3 RCAC units	Cooking, hot water	3 RCAC units	3 RCAC units	-2,500	612	3,177	
Perth	3 RCAC units	Cooking, hot water	3 RCAC units	3 RCAC units	-2,500	134	-1,259	
Adelaide	3 RCAC units	Cooking, hot water	3 RCAC units	3 RCAC units	-2,500	505	2,183	
Sydney	3 RCAC units	Cooking, hot water, space heating	2 wall furnaces	3 RCAC units	1,300	416	5,160	
Perth	3 RCAC units	Cooking, hot water, space heating	2 wall furnaces	3 RCAC units	1,300	134	2,546	
Adelaide	3 RCAC units	Cooking, hot water, space heating	2 wall furnaces	3 RCAC units	1,300	459	5,556	
Perth	3 RCAC units	Cooking, hot water, space heating	2 wall furnaces	Ducted evaporative	2,700	48	3,145	
Adelaide	3 RCAC units	Cooking, hot water, space heating	2 wall furnaces	Ducted evaporative	2,700	362	6,052	
Melbourne	Ducted RCAC	Cooking, hot water, space heating	Ducted gas	3 RCAC units	950	38	1,305	
Canberra	Ducted RCAC	Cooking, hot water, space heating	Ducted gas	3 RCAC units	950	863	8,955	
Melbourne	Ducted RCAC	Cooking, hot water, space heating	Ducted gas	Ducted evaporative	2,350	-35	2,028	
Canberra	Ducted RCAC	Cooking, hot water, space heating	Ducted gas	Ducted evaporative	2,350	802	9,787	

Notes: RCAC = reverse cycle air-conditioner. Electricity and gas price assumed to increase with inflation. Savings over 10 years calculated as a present value using a 1.4 per cent real discount rate. Real discount rate calculated based on prevailing 2.7 per cent mortgage rate for major banks, adjusted for inflation of 1.3 per cent: RBA (2020). Running costs assume all electricity is supplied from the grid, with none from rooftop solar. An RCAC unit is a split system reverse cycle air-conditioner. Dual-fuel houses have gas stoves and instantaneous gas hot water. All-electric houses have induction stoves and heat-pump water heaters. All-electric houses avoid gas connection and usage charges, and these savings are included in the annual running cost savings. Dual-fuel houses with evaporative cooling assumed to use 300 kWh less per year than an all-electric house using RCACs: Victorian Government (2020c). Running costs calculated for a single year using 2020 gas and electricity tariffs, as detailed in Table D.2. Energy use per gas-using household is estimated using appliance installation rates in EnergyConsult (2015). Gas use converted to electricity using coefficients of performance derived from ATA (2014), ATA (2018) and Frontier Energy (2019), and temperature data from BoM (2020). Appliances costs detailed in Table D.1.

Sources: Grattan analysis based on the sources cited above.

demand. Figure 5.3 shows that the effect of electrifying small-user gas demand differs greatly depending on the location. On one hand, Victoria's large household winter gas heating load means that switching small-user gas loads would have significant effects on its electricity system. This shift would move peak electricity demand from summer to winter and increase it by about 40 per cent.¹⁵³

On the other hand, NSW and SA do not have very large winter peaks in gas use, and converting all gas use to electricity would increase peak electricity demand by only about 2 per cent. This peak demand would still occur in summer, and so the increase is due to cooking and water heating rather than space heating.

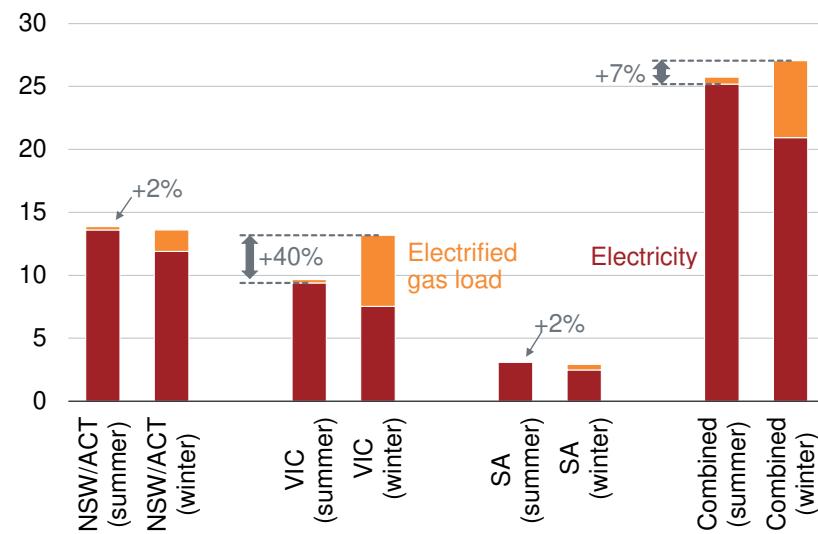
NSW, Victoria, and SA are joined as part of the National Electricity Market, and are likely to become more strongly linked over time.¹⁵⁴ Peak demand across these three states would only increase by about 7 per cent – much less than the potential 40 per cent increase in Victoria. This indicates that wholesale costs need not increase greatly, even for Victoria, if generation capacity is shared across the states through investment in long-distance transmission. But, even with that sharing of generation capacity, Victoria's local distribution network would still need to be strengthened.

The ACT is part of the NSW NEM region. Unlike NSW, the ACT's gas load is very high in winter. If converted to electricity, the ACT's new, higher winter peak electricity demand would be relatively easy to meet from across the NSW generation fleet, but – as in Victoria – it would require significant reinforcement of the ACT's distribution network.

153. This methodology could overstate peak electricity demand because it ignores the potential for load-shifting. For example, moving heat-pump water heating to overnight or during the midday solar peak.

154. AEMO (2020h).

Figure 5.3: Electrifying small-user gas loads would significantly increase peak demand in Victoria, but have a modest effect in other states
Peak demand by season, gigawatts



Notes: Gas loads are for small, distribution-connected customers only. Small-user gas load estimated from all-user gas loads, less estimated manufacturing loads. Victorian gas load analysed from 1 July 2016 to 30 June 2020 using hourly data provided by AEMO (personal communication, 6 August 2020). NSW and ACT gas load analysed for 2019-20 only using Jemena (2020c) and Evoenergy (2020a). SA hourly gas load estimated for 2019-20 only, based on daily gas data from AEMO (2020e), excluding dedicated industrial connection points, and shaped to a daily pattern based using daily gas use patterns in NSW. Electricity load based on AEMO (2020j). Manufacturing loads estimated using Australian Government (2019c). Cooking gas loads converted to electricity using a coefficient of performance of 2.7: Frontier Energy (2019). Heating and hot water appliance coefficient of performance calculated based on ambient temperatures in different locations using ATA (2014, p. 75), ATA (2018, p. 49) and BoM (2020).

Sources: Grattan analysis based on the sources cited above.

5.4.2 Appliance costs and connection upgrades, not grid upgrades, are the main barrier to electrifying NSW and SA small-user gas loads

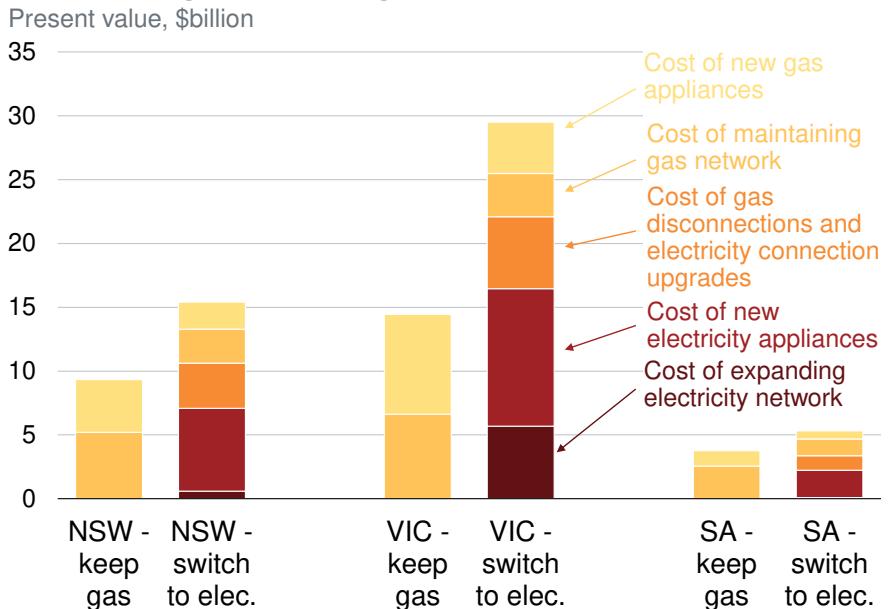
Figure 5.4 compares two scenarios, one where the gas network operates unchanged for 20 years ('keep gas'), and the other where small-user gas load is progressively converted to electricity over 20 years ('switch to electricity'). This analysis indicates that switching to electricity is more expensive in NSW and SA – about 65 per cent more in NSW and 40 per cent in SA.

The cost of new electric appliances is the key factor in making a system-wide switch to electricity in NSW and SA more expensive. This switch avoids some of the cost of maintaining the gas network, and reduces the amount of gas appliances that need to be replaced, but these cost savings are not enough to offset the increased cost of electric appliances. The costs associated with disconnecting from the gas grid, and upgrading electrical connections, are also significant. By comparison, the cost of augmenting the power grid is negligible, because of the very small increases in peak electricity demand (Figure 5.3). In fact, switching small-user gas loads to electricity improves the average level of utilisation of the NSW and SA power grids – by about 2 per cent and 6 per cent respectively – and so will tend to reduce power prices.¹⁵⁵

This finding differs from that for new houses (Table 5.2) primarily because in a broad switch some new electric appliances must replace functioning gas appliances. This reduces the net saving to consumers. There is no gas appliance to replace when building a new all-electric house, making that choice more cost-effective.

155. Average level of utilisation is calculated as the average load divided by the peak load. An increase in utilisation reduces prices because grid costs are more sensitive to peak demand, which drives capital expenditure, than average demand. If capital expenditure and grid costs increase less than the average level of demand, costs per unit and prices should reduce.

Figure 5.4: Switching all small users to electricity is more expensive than continuing to use natural gas



Notes: The cost of expanding the power grid is calculated as each network's estimated long-run marginal cost multiplied by the increase in peak demand caused by electrifying small-user gas loads (Figure 5.3), plus a proportionate increase in operating expenditure. The cost of maintaining gas network is the present value of future capital and operating expenditure calculated over 20 years, assuming current rates of capital and operating expenditure continue and that small users contribute 80 per cent of the cost of the network. In the switch-to-electricity scenario, these gas networks costs are phased out linearly over 20 years. Appliance costs and disconnection and connection upgrade costs are detailed in Table D.1. New electricity appliance costs are phased in over 20 years in the switch-to-electricity scenario. Gas appliances are replaced every 25 years, but there are fewer to replace in the switch-to-electricity scenario. Present values calculated using a 2.4 per cent discount rate based on AER (2020b, p. 34).

Sources: Grattan analysis of AER network determinations, network tariff structure statements, calculations in Figure 5.3, and the sources cited above.

Any electricity-to-gas switch could happen faster or slower than the 20 years modelled here. But the same broad outcomes still hold. Faster transitions will incur less cost in maintaining the gas network, but higher appliance replacement costs.¹⁵⁶ Slower transitions will delay appliance replacement costs, but increase the cost of maintaining the gas network and replacing gas appliances.

5.4.3 A broad gas-to-electricity switch in Victoria looks expensive...

A broad gas-to-electricity switch looks more expensive in Victoria than in NSW and SA. As in those states, significant expenditure would be needed to install new electric appliances in place of existing gas appliances – far more than the reduction in expenditure on the gas network and gas appliances. But Victorian electricity distribution networks would also need significant and expensive upgrades to cope with an increase in peak demand of about 40 per cent, further increasing costs.¹⁵⁷ Overall, the gas-to-electricity switch is about twice the cost of sticking with gas.

The same analysis cannot be done for the ACT with available data.¹⁵⁸ But the patterns are likely to be similar to Victoria – electricity appliance costs and grid upgrade costs will probably exceed the cost of continuing to use gas.

5.4.4 ... but a gas-to-electricity switch may still be in consumers' long-term interests

The findings in Figure 5.4 do not rule out a future broad gas-to-electricity switch.¹⁵⁹ Simply sticking with gas will not achieve the important task of reducing the emissions that currently come from natural gas use in the home. The ‘keep gas’ scenario would leave consumers facing one of three pathways to lower emissions, each of which involves significant costs and uncertainties.

Having continued to use natural gas, one decarbonisation option is to move to low-emissions hydrogen. But the wholesale cost of hydrogen will almost certainly be much higher than the wholesale cost of natural gas, and this additional cost will flow through to hydrogen users. If low-emissions hydrogen is made from gas, then it must be more expensive than the gas it is made from, due to the additional costs of ‘reforming’ methane into hydrogen and carbon dioxide, and the costs of storing that carbon dioxide. It is possible, but unlikely, that low-emissions hydrogen made from coal or renewable energy could approach the cost of gas. For example, the Federal Government’s ‘stretch goal’ is to get the cost of clean hydrogen to below \$2 per kilogram¹⁶⁰ – which translates to more than \$16 per gigajoule of energy, or about twice today’s gas price. Further, while hydrogen can be blended with natural gas at low concentrations, a complete switch to hydrogen would require changes to household appliances and fittings, and would be incompatible with today’s high-pressure pipelines.¹⁶¹

156. In present value terms, because the replacements are brought forward in time.

157. A range of factors could reduce these grid augmentation costs, including improved energy efficiency, price signals, or incentives for consumers to reduce power consumption at peak times ('demand-side management') or widespread take-up of household batteries. This analysis does not factor in these potential effects.

158. Hourly ACT electricity demand is not available because it is reported as part of the NSW NEM region.

159. This is not just due to the inherent uncertainty of long-term scenario analysis, and the sensitivity of the conclusions to the assumptions. Very large movements in assumptions would be needed to change the high-level conclusions.

160. Australian Government (2020f, p. 6).

161. Most low-pressure gas pipelines are made with polyethylene, and are compatible with hydrogen. But hydrogen can cause high-pressure steel pipelines to become brittle.

A second option is to move to biomethane. A major advantage of this approach is that it can happen progressively, as more biomethane is blended into the gas network over time. Biomethane is chemically the same as natural gas, so there would be no need to switch appliances or high-pressure pipelines. But biomethane is not likely to be cheap – biomethane costs in Europe are generally at least \$14 per gigajoule and often more than \$30 per gigajoule¹⁶² – roughly two to three times the price of wholesale gas in eastern Australia today.

The third option would be a belated move to electricity. As with an earlier switch to electricity, this option would incur significant costs from new electricity appliances, as well as the cost of significant grid expansions in Victoria and the ACT. These costs would have been deferred but not avoided. Outside of Victoria, keeping gas and moving to electricity belatedly would also have resulted in higher emissions during the period where consumers continued to use gas.

It is not possible today to make definitive judgements about whether or when to electrify gas loads, or move to low-emissions gas substitutes. The factors that will determine the best approach for consumers are too uncertain and, in any case, will vary significantly between places and over time.

Energy Networks Australia has recently published analysis that indicates that the system-wide costs of electrification are twice as high as using low-emissions hydrogen produced from gas.¹⁶³ But this analysis does not provide clear answers on the best approach for specific user types, because it does not provide separate estimates for the benefits and costs of electrifying different user types. It may well be that, in some locations, larger commercial and industrial gas users are better off using low-emissions gas substitutes, but households and smaller commercial users are generally better off using electricity.

162. ENEA Consulting (2019, p. 38).

163. Frontier Economics (2020).

If small users do switch to electricity, larger users that prefer to use low-emissions gas substitutes would face higher pipeline costs due to lost economies of scale. But small users typically pay more than 90 per cent of gas distribution network costs.¹⁶⁴ The best outcome for the group paying 90 per cent of the network cost is likely to be the best network-wide outcome. It would be unfair to force small users to use a more expensive fuel to avoid modest price increases for another set of users.

5.5 Policy conclusions

5.5.1 Gather more information about the best long-run approach

The ideal mix of electricity, gas, and low-emissions gas substitutes will vary over time, between places, and between user types. Given the long-term uncertainty over the best approach, policy makers should start work to better understand the merits and limitations of each of these options.

The costs of biomethane, hydrogen, and electricity will become clearer over time. But this process can be accelerated through focused policy analysis and research. This in turn will help governments craft policies that work for their particular circumstances in the long-term.

A key priority is to better understand the technical and economic viability of low-emissions gas substitutes. Work is being done on the costs of biomethane, such as through ARENA's bioenergy roadmap.¹⁶⁵ But more work and small-scale trials will be needed to better understand the costs of biomethane and how this would change with increased scale. Similarly, understanding the economics of hydrogen supply is important. Small-scale trials are investigating blending hydrogen into gas distribution networks.¹⁶⁶ Hydrogen storage

164. Grattan analysis of AusNet (2017), Jemena (2020d) and AGN (2020).

165. ARENA (2020d).

166. COAG Energy Council (2019b).

will be particularly important given the highly seasonal pattern of household gas consumption today. And the COAG Energy Council's National Hydrogen Strategy work on regulatory and technical issues should continue.¹⁶⁷

The effect of fuel choices by smaller users on larger users needs further analysis. Larger users will face higher gas costs if many smaller users switch to electricity, but the size and impact of these costs are not clear. And a range of commercial and industrial users will be able to cost-effectively switch to electricity (Section 3.4.4).

5.5.2 A moratorium on new household gas connections is a 'no regrets' measure

Uncertainty should prompt caution, but it should not lead to inaction. We already know enough to begin tentative moves to electrifying gas use in some locations.

It is clear today that households that move into a new all-electric home in NSW, Queensland, SA, and the ACT will save money compared to moving into an equivalent house with gas. And within the next five years these all-electric houses will also produce fewer emissions than houses with gas – even earlier for houses with rooftop solar.

Governments in these places should put a moratorium on new household gas connections. This would be a 'no-regrets' measure – households would both save money and reduce emissions over the next decade.

And we can be confident that these households would not regret this choice further into the future. Low-emissions gas substitutes are likely to be more expensive than natural gas is today. Similarly, although electricity prices may rise as the grid decarbonises, electricity is still the

safer bet. Electric appliances are more efficient and moderate the effect of rising energy prices compared to gas appliances. This advantage could increase further if electric appliances continue to get cheaper and more efficient.

Even if biomethane or hydrogen turned out to be the best long-term system-wide outcome and was widely used, it is unlikely that owners of all-electric houses would be worse off. If most small energy users end up using biomethane or hydrogen, this will avoid disproportionate increases in electricity prices due to, for example, large-scale grid reinforcement. This prevents those all-electric houses from facing the costs that would arise if everyone moved to electricity.

A moratorium would not prevent a jurisdiction from moving to widespread use of low-emissions gas substitutes in the long-term. The housing stock turns over only gradually, and so a critical mass of gas-using households will remain if it became clear that it is in consumers' long-term interests to lift the moratorium and move towards biomethane or low-emissions hydrogen.

A moratorium will also reduce the cost of any future, broader move to electrify household gas use. A broader phase-out of gas use involves significant costs from disconnecting customers from gas, from upgrading electrical connections, and from replacing functioning gas appliances (Figure 5.4 on page 48). It is better to avoid these costs by not installing gas connections and appliances in the first place, and instead installing electrical connections with the capacity to meet the needs of an all-electric house.¹⁶⁸

A similar policy is already being considered in the ACT. The owner of the ACT gas network, Evoenergy, has proposed a moratorium on

168. Typically this will involve installing a three-phase connection rather than a single-phase connection. A three-phase connection has higher capacity because it shares power over multiple wires.

167. Ibid.

gas connections in new Canberra suburbs (but this would not stop gas connections for new houses in established suburbs).¹⁶⁹ This particular moratorium appears appropriate for the ACT's circumstances. Given that ACT households can save \$9,000 or more over 10 years by not installing gas, limiting new gas connections makes sense for individual households. New all-electric suburbs can be designed with sufficient local electricity network capacity. The challenge for the ACT will be the system-wide effects of maintaining this policy over the long-term, because it would create a significant new winter power peak and require wider grid reinforcement. Evoenergy's plan allows for a possible future shift to hydrogen if that is the most cost-effective long-term approach.

The case for moratoria in Victoria and WA is much weaker. In Victoria, encouraging households to use electricity rather than gas will generally increase emissions over the coming decade. Though households may still save money by going all-electric, the case for policy action to support this choice is weaker because of the cost to the environment. And the system-wide effects of electrifying Victoria's large winter gas load make full electrification less likely to be the best outcome, compared to other states. In WA, individual households are better off using gas for cooking and hot water in their new homes today. A moratorium would impose immediate costs on WA consumers with uncertain long-term benefits.

5.5.3 Favouring electricity over gas is not 'picking winners'

Governments are often warned not to 'pick winners' in policy-making, on the grounds that they often make poor choices and, in any case, inadvertently create 'losers' in doing so. But this argument does not undercut the case for a gas moratorium.

169. Evoenergy (2020b, p. 12).

A gas connection moratorium is neither a case of picking a winner – electricity – nor a loser – gas. There are well established public policy rationales for a moratorium.

One is the unpriced benefit of reducing emissions. Switching household gas use to electricity can reduce emissions in many parts of Australia. Several jurisdictions have policies that affect appliance and fuel choices by households, but these policies do not always apply broadly and consistently across multiple appliances. For example, the Australian Government supports heat-pump water heater use through the Small-scale Renewable Energy Scheme, but has no equivalent incentives for space heating.¹⁷⁰ And – importantly, in the context of our proposed moratoria – SA's Retailer Energy Efficiency Scheme supports the installation of some gas appliances.¹⁷¹ This policy does not appear to be consistent with rapidly reducing emissions from electricity in SA (Figure 5.2). The SA Government should amend this scheme to remove support for gas appliances.¹⁷²

Reducing emissions is not the only issue at stake. Consumers also struggle to get the information they need to make good long-term financial decisions. Trading-off upfront costs and running costs is particularly hard. Governments commonly regulate to help consumers make good long-term choices. Important Australian examples are mandatory energy efficiency standards for household appliances, and

170. Clean Energy Regulator (2018).

171. ESCOSA (2020). It supports only relatively efficient gas appliances. It also supports efficient electric appliances.

172. The Victorian Energy Upgrades scheme operates in a broadly similar way to the SA scheme. It supports replacing inefficient gas and electric water or space heating with efficient alternatives: Victorian Government (2018). But, because electricity is currently a more emissions-intensive energy source for Victorian households than gas – unlike in SA – there is not a clear case for changing the Victorian scheme.

the phase-out of incandescent light globes from 2009.¹⁷³ Appliance efficiency labels and fuel economy ratings for cars are similar, but lighter-touch, policies used in Australia.¹⁷⁴ A range of international jurisdictions regulate the efficiency of vehicles for similar reasons.¹⁷⁵ Even Australia's superannuation policy is based on the rationale that consumers tend to focus too much on the short term, leading many to save less for their retirement than they really should¹⁷⁶ – yet another case of trading-off upfront costs and long-term benefits.

Gas connections in new houses may also be supported due to 'split incentives' (Box 10). This is most important in places such as Sydney, Brisbane, and Adelaide, where a house with gas connected for cooking and water heating will be about \$2,500 cheaper than one with all-electric appliances, but will have higher running costs (Table 5.2). This split incentive is reinforced by the fact that developers do not typically pay for the upfront cost of connecting gas – this is paid for by gas networks and recovered from ongoing daily and usage charges.¹⁷⁷ This means that a property with gas has a lower 'sticker price' and so may be easier to sell, despite its higher ongoing costs. It is unrealistic to expect home-buyers to anticipate the running cost of a house they do not yet live in – and that may not yet be built – and factor this in to what they are willing to pay for a new home, alongside the many other factors they would be considering.

173. *Greenhouse and Energy Minimum Standards Act 2012 (Cth)*, Energy Rating (2020a).

174. Energy Rating (2020b); and Australian Government (2020h).

175. CCA (2014, p. 33).

176. Coates and Nolan (2020, p. 7).

177. The National Gas Rules allow networks to recover the cost of new connections as part of their capital base, but only if they have a reasonable expectation that the connection will pay for itself over its life. If this is not the case, the network should charge any excess to the developer (Rule 119M).

Box 10: 'Split incentives' can lead to poor energy choices

Split incentives arise when one party makes decisions on behalf of another, but does not receive the benefits or pay the costs of those decisions.

A commonly discussed example is between landlords and tenants. Landlords pay the cost of fixed appliances such as cooktops, water heaters, and air-conditioners, and would pay the cost of improving energy efficiency through improved insulation. But tenants benefit if landlords pay more to put in efficient appliances or better insulation.

These incentives would be aligned if landlords received higher rents when letting more energy efficient properties. But landlords cannot be confident this will happen, in part because tenants may struggle to estimate their future energy bills.

The split incentives between commercial landlords and tenants has been addressed through a national scheme requiring energy efficiency ratings to be published when letting commercial tenancies.^a

Split incentives also exist between those selling and buying property. An important example is between the developer of a new property and its first owner – the developer makes a range of important decisions about what appliances to install. The ACT has addressed this by requiring home sellers to publish energy efficiency ratings.^b Mandatory appliance energy efficiency ratings also help to address this split incentive.^c

a. NABERS (2020).

b. *Civil Law (Sale of Residential Property) Act 2003 (ACT)*.

c. *Greenhouse and Energy Minimum Standards Act 2012 (Cth)*.

5.5.4 The effect of a moratorium on consumer choice can be reduced

More than 30 municipalities in California have banned or restricted new residential gas connections.¹⁷⁸ The gas industry has argued that these policies restrict consumer choice.¹⁷⁹

A moratorium explicitly reduces choice. And it works against the preference of many people to cook with gas (Box 11). Governments could preserve an element of choice, particularly for cooking, by ensuring that moratoria only cover mains gas connections, but not bottled gas.¹⁸⁰

Allowing bottled gas would not undermine the policy intent of the moratorium. Unlike mains gas, bottled gas can be removed without the cost of disconnecting from the main gas network (though plumbing costs would be incurred). Bottled gas also does not have meters that need to be read or replaced periodically. This means that bottled gas is relatively easy to replace if environmental requirements, consumer preferences, or costs change in future.

Bottled gas may not be an ideal choice in all environments, such as high-rise apartments. But it would still help to retain a degree of choice for many customers, such as those in freestanding houses with sufficient space for gas bottles.

178. Dooley and Kay (2020). Brookline, Massachusetts, implemented a similar ban but it was overturned by the state attorney-general on the grounds that it was inconsistent with state law: Abel (2020). A range of other municipalities, including New York City, are considering similar restrictions: DiChristopher (2020).

179. American Gas Association (2020).

180. Bottled gas is also known as liquefied petroleum gas, or LPG. It consists mainly of propane and butane, and so forms a liquid under modest pressure and can be stored safely in a metal cylinder at typical outdoor temperatures. This could not be done with mains gas, which is mainly methane and only forms a liquid at much lower temperatures.

Box 11: Consumer choice, ‘cooking with gas’, and the great Aussie barbecue

The marketing slogan ‘cooking with gas’ has been very effective since it was introduced in the United States in the late 1930s or early 1940s.^a And for good reason – cooking with gas is faster and more responsive than cooking with old-fashioned electric cooktops.

These old-fashioned ‘resistance’ cooktops work by running electricity through a coil which heats up due to electrical resistance. These coils take time to heat up and even longer to cool down, making it hard to cook at just the right temperature.

But modern electric induction cooktops use a different technology. They create electromagnetic vibrations that directly transfer energy into magnetic cookware, such as that made from iron or steel. These vibrations are easier to control, making cooking quick and responsive – comparable to, if not better than, gas cooktops.

Many people are not aware of induction cooktops. It is likely that many people who currently prefer to cook with gas would, with direct experience, be happy with an induction cooktop.

Even with increasing awareness of induction cooking, some people may still prefer to cook with gas – for example, when using a wok. These people’s preferences can be accommodated by excluding bottled gas from the moratoria on new gas connections.

Similarly the moratoria would still allow the use of bottled gas for barbeques. Australians will always have barbeques, even in a decarbonised society – but if they use bottled gas the emissions from burning that gas will need to be offset.

a. Barba (2014).

5.5.5 Low-emissions gas supply should still be allowed

The portion of low-emissions gas blended into the general natural gas network will increase, albeit slowly, over time. But it is possible that in some locations – for example with good access to biomass sources, or with good prospects for making low-emissions hydrogen – stand-alone networks could emerge that exclusively use low-emissions gas substitutes.

Dedicated networks that can supply only low-emissions gas should be exempted from the gas connection moratorium. There would be no reason to prevent such projects from going ahead, provided customers have choice about whether to participate and are supplied with energy on reasonable terms.

5.5.6 Consider how to manage transitional issues

Transitioning from natural gas to alternative fuels may be difficult, but we cannot avoid the challenges by ignoring them. Transitional issues are not just about economic efficiency, but also about fairness and consumer acceptance. The best approach is to begin planning for that future early, with engagement from governments, the energy industry, and its customers. If we do not do this planning, we may have regrets later.

Moving to biomethane has the least transitional issues. For customers, this switch would be essentially seamless and unnoticed – except for any effects on energy costs.

But moving to hydrogen would require a rapid and coordinated changeover of appliances. This is because many gas appliances cannot be used with hydrogen, and so both the energy supply and appliances would need to be converted at the same time. Consumer acceptance of using hydrogen in the home – a key issue identified by

the National Hydrogen Strategy¹⁸¹ – would need to have been built well before such a broad transition was implemented.

A gas-to-electricity switch raises possibly the most difficult transitional issues. If it becomes clear that electrification is the best option for a broad range of customers in a given location, it will become difficult to safely operate the gas network on a purely commercial basis. It will be hard for private gas network owners to justify and finance investments that are necessary to maintain the safety of the network, but which are very unlikely to earn a commercial rate of return.

This will create an impasse between the private incentives of network owners, and the obligation on networks and governments to ensure public safety. It is likely that governments will need to step in to help coordinate a gas phase-out. One option would be to take over the gas networks and directly manage the winding down of their small-user connections. Another option would be to facilitate their sale to another entity. For example, owners of electricity networks may be better able to safely operate the gas network during this transition phase, and manage the transfer of gas customers to new electric appliances.

Some consumers may also find it hard to pay for the cost of new electric appliances in such a switch. For example, low-income households may struggle to obtain credit or enough cash to pay the upfront cost of new appliances. Governments could help low-income households through low-cost finance or grants. Another approach would be to allow electricity networks to pay the upfront cost of new electric appliances in switching households, and recover the cost over time through additional electricity charges levied to that household. This measure need not be limited to low-income households; it could be applied broadly.

181. COAG Energy Council (2019b, p. xi).

Appendix A: US ethane investments

Table A.1: US petrochemical investments since 2013 using ethane feedstock

Plant	Owners	Status	Start of operations	Capital cost (US\$bn)	Ethylene output (kt/year)	Sources
La Porte	LyondellBasell	Operating	2014	0.5	0.36	LyondellBasell (2015, p. 63)
Channelview	LyondellBasell	Operating	2015	0.2	0.11	LyondellBasell (<i>ibid</i> , p. 63)
Plaquemine	Dow Chemical	Operating	2017	2	N/A	Plaquemine Post South (2017)
Corpus Christi	LyondellBasell	Operating	2017	0.6	0.36	LyondellBasell (2015, p. 63) and LyondellBasell (2017)
Ingleside	OxyChem, Mexichem	Operating	2017	1.5	0.55	OxyChem and Mexichem (2017)
Baytown	Chevron Phillips	Operating	2018	6	1.5	Chevron Phillips Chemical (2018) and Businesswire (2018a)
Freeport	Dow Chemical	Operating	2018	6	1.5	Dow (2017a) and Dow (2017b)
Channelview II	LyondellBasell	Operating	2018	0.3	0.25	LyondellBasell (2015, p. 63)
Baytown/Mont Belvieu	ExxonMobil	Operating	2018	6	1.5	ExxonMobil (2019) and Businesswire (2018b)
Lake Charles	Westlake, Lotte Chemicals	Operating	2019	3.1	N/A	Raizada (2019)
Point Comfort	Formosa Plastics	Operating	2020	5	1.5	Pipoli (2020)
Plaquemine	Shin-Etsu	Operating	2020	1.4	0.5	Shin-Etsu (2015) and Brexford (2020)
Lake Charles	Sasol	Under construction	2020	12.9	1.5	Sasol (2019) and Burkhardt (2020)
Port Arthur	Total, Borealis	Under construction	2020	2.5	1	Total (2020)
Corpus Christi	ExxonMobil, SABIC	Under construction	2022	10	1.8	Gulf Coast Growth Ventures (2019) and Slowey (2019)
Monaca	Shell	Under construction	Early 2020s	6	1.5	Shell (2020) and Chang (2020)
Total				64		

Sources: Grattan analysis based on the sources cited.

Appendix B: Large gas-using facilities

Table B.1: Gas-intensive manufacturing facilities

Plant	Owners	Key product(s)	State	Gas use (PJ/year)	Revenue (\$m/year)	Staff and contractors
Botany/Altona	Qenos	Polyethylene	NSW/VIC	32.3	730	1,000
Polyethylene – total				32.3	730	1,000
Burrup	Yara, Orica	Ammonia, ammonium nitrate	WA	30.7	390	200
Gibson Island	Incitec Pivot	Urea	QLD	12.6	170	540
Kooragang Island	Orica	Ammonia, ammonium nitrate	NSW	12.2	500	250
Phosphate Hill	Incitec Pivot	Diammonium phosphate	QLD	7.9	480	300
Kwinana	Wesfarmers	Ammonium nitrate	WA	6.9	850	370
Moranbah	Incitec Pivot	Ammonium nitrate	QLD	5.1	470	130
Moura	Incitec Pivot, Wesfarmers	Ammonium nitrate	QLD	3.0	220	90
Ammonia and related chemicals – total				78.3	3,060	1,880
Pinjarra	Alcoa	Alumina	WA	57.4	1,740	1,370
Wagerup	Alcoa	Alumina	WA	28.1	1,050	840
Kwinana	Alcoa	Alumina	WA	24.7	900	1,200
Yarwun	Rio Tinto	Alumina	QLD	22.9	760	1,100
Worsley	South32	Alumina	WA	17.1	1,940	2,000
Gladstone	Rio Tinto, Rusal	Alumina	QLD	13.3	890	1,170
Alumina – total				163.5	7,280	7,680
Gas-intensive industry – total				274.1	11,070	10,560
Gas-intensive industry – WA				164.9	6,870	5,980
Gas-intensive industry – east coast				109.2	4,210	4,570
All manufacturing – total				445.4	381,450	840,080

Notes: Gas use is for 2017-18, except for Gibson Island, Phosphate Hill, Yarwun, and Gladstone, where 2017-18 data were not available and the data used are for 2019, using AEMO (2020e). WA gas use estimated from Gas Bulletin Board WA (2020). Pinjarra gas use includes cogeneration plant. Qenos gas use includes ethane. Comparisons of gas use across alumina plant are affected by the fact that Yarwun, Worsley, and Gladstone alumina plants also use significant quantities of coal. Revenue and staff numbers estimated using company websites and miscellaneous sources. Numbers may not add due to rounding.

Sources: Grattan analysis based on the sources cited above.

Appendix C: Moderately gas-intensive companies

Table C.1: Moderately gas-intensive manufacturers

Company	Manufacturing sub-sector(s)	Key product(s)	Gas share of input costs (%, upper bound)
Orora	Non-metallic mineral products; fabricated metal products	Glass, cans, paper packaging	4.9 [^]
Knauf Gypsum	Non-metallic mineral products	Plasterboard	4.4
CSR	Non-metallic mineral products	Glass, bricks, plasterboard, building products	4.2 [^]
Brickworks	Non-metallic mineral products	Bricks	4.1* [^]
Adelaide Brighton	Non-metallic mineral products	Cement	4.1* [^]
USG Boral	Non-metallic mineral products	Plasterboard, building products	2.9
Borg Manufacturing	Wood product manufacturing	Flooring, MDF, particleboard	2.8
Kimberly Clark	Pulp and paper	Paper products	2.4
Murray-Goulburn	Food, beverages, and tobacco	Dairy products	2.0 [^]
New Zealand Milk	Food, beverages, and tobacco	Dairy products	1.9
Ridley	Food, beverages, and tobacco	Animal feed	1.6
Simplot Australia	Food, beverages, and tobacco	Frozen and packaged food	1.5
McCain Australia	Food, beverages, and tobacco	Frozen and packaged food	1.3
George Weston Foods	Food, beverages, and tobacco	Packaged food	1.5
Bega	Food, beverages, and tobacco	Dairy and spreads	1.1* [^]
ABC Tissue	Pulp and paper	Paper products	1.0
Lilydale/Steggles	Food, beverages, and tobacco	Poultry products	0.9
Arnotts	Food, beverages, and tobacco	Biscuits	0.6
Lactalis	Food, beverages, and tobacco	Dairy products	0.5
Lion	Food, beverages, and tobacco	Beverages	0.5
Nestle	Food, beverages, and tobacco	Confectionery	0.5
Coca-Cola Amatil	Food, beverages, and tobacco	Beverages	0.3* [^]

Notes: The companies presented were chosen based on the availability of energy use and financial data for Australian operations only. Most estimates are upper bounds, determined by assuming that all Scope 1 emissions reported in Clean Energy Regulator (2019) are due to gas use; the exception is estimates marked with an asterisk (*), for which gas use was reported directly in company sustainability reports. Data is for the 2017-18 financial year. Some companies have changed name, ownership, or facility composition since then. In some cases, input costs have been inferred from revenue reported in ATO (2019) and sectoral ratios between revenue and gross value added in ABS (2019b); the exceptions are estimates marked with an circumflex (^), for which input costs were reported directly in company financial reports. Sector-specific gas prices derived from ABS (2019a, Table 5).

Sources: Grattan analysis based on the sources cited above.

Appendix D: Assumptions on household energy and appliance costs

Table D.1: Appliance costs

Appliance	Fuel	Cost (uninstalled)	Cost (installed)	Installation cost	Ducting	Total cost
Induction cooktop	Electricity	\$2,400		\$500		\$2,900
Gas stove	Gas	\$1,600		\$500		\$2,100
Heat pump water heater	Electricity		\$3,100			\$3,100
Gas instant water heater	Gas		\$1,400			\$1,400
Ducted RCAC	Electricity	\$4,750		\$1,000	\$5,000	\$10,750
Ducted gas furnace	Gas	\$1,600		\$1,000	\$5,000	\$7,600
RCAC split system	Electricity	\$1,500		\$700		\$2,200
Gas wall furnace	Gas	\$1,400		\$500		\$1,900
Evaporative cooler (ducted)	Electricity	\$2,000		\$1,000	\$5,000	\$8,000
Gas disconnection charge			\$800			\$800
Electricity connection upgrade			\$3,000			\$3,000

Note: RCAC = reverse cycle air-conditioner.

Sources: Air-conditioning Warehouse Sales (2020), Same Day Hot Water Service (2020), The Good Guys (2020), ActewAGL (2020) and Canstar Blue (2020).

Table D.2: Energy tariffs

City	Appliances	Gas network	Gas retailer	Elec network	Elec retailer	Daily gas charge c/day	Gas usage GJ/year	Average usage tariff \$/GJ	Usage cost \$/year	Total cost \$/year	Elec usage kWh/year	Elec tariff c/kWh	Elec cost \$/year
Brisbane	2	Allgas	Origin	Energex	Origin	115.4	10.1	33.2	335	757	683	21.5	147
Brisbane	2	Allgas	AGL	Energex	AGL	108.0	10.1	36.3	367	761	683	19.9	136
Brisbane	2	Allgas	Alinta	Energex	EA	114.1	10.1	33.3	336	753	683	22.0	150
Sydney	2	Jemena	Origin	Endeavour	Origin	59.8	12.9	29.5	381	599	862	25.0	216
Sydney	2	Jemena	AGL	Endeavour	AGL	59.9	12.9	25.9	334	553	862	23.2	200
Sydney	2	Jemena	EA	Endeavour	EA	55.1	12.9	30.2	390	591	862	23.9	206
Sydney	2	Jemena	Origin	Ausgrid	Origin	59.8	12.9	29.5	381	599	862	25.3	218
Sydney	2	Jemena	AGL	Ausgrid	AGL	59.9	12.9	25.9	334	553	862	24.6	212
Sydney	2	Jemena	EA	Ausgrid	EA	55.1	12.9	30.2	390	591	862	24.5	211

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Table D.2 – continued from previous page

City	Appliances	Gas network	Gas retailer	Elec network	Elec retailer	Daily gas charge c/day	Gas usage GJ/year	Average usage tariff \$/GJ	Usage cost \$/year	Total cost \$/year	Elec usage kWh/year	Elec tariff c/kWh	Elec cost \$/year
Sydney	3	Jemena	Origin	Endeavour	Origin	59.8	28.0	25.0	700	919	2,123	25.0	531
Sydney	3	Jemena	AGL	Endeavour	AGL	59.9	28.0	25.5	713	932	2,123	23.2	492
Sydney	3	Jemena	EA	Endeavour	EA	55.1	28.0	26.9	753	954	2,123	23.9	507
Sydney	3	Jemena	Origin	Ausgrid	Origin	59.8	28.0	25.0	700	919	2,123	25.3	537
Sydney	3	Jemena	AGL	Ausgrid	AGL	59.9	28.0	25.5	713	932	2,123	24.6	523
Sydney	3	Jemena	EA	Ausgrid	EA	55.1	28.0	26.9	753	954	2,123	24.5	521
Canberra	3	Evoenergy	Red Energy	Evoenergy	ActewAGL	85.8	49.2	28.0	1,375	1,688	4,312	21.0	907
Canberra	3	Evoenergy	Origin	Evoenergy	Origin	72.3	49.2	30.2	1,486	1,750	4,312	19.8	853
Canberra	3	Evoenergy	EA	Evoenergy	Red Energy	69.1	49.2	31.4	1,543	1,795	4,312	20.5	883
Adelaide	2	AGN	Alinta	SAPN	Powershop	76.6	13.5	36.9	499	779	915	29.4	269
Adelaide	2	AGN	Origin	SAPN	AGL	70.0	13.5	40.7	550	806	915	32.4	297
Adelaide	2	AGN	EA	SAPN	EA	75.3	13.5	40.5	548	823	915	35.7	326
Adelaide	3	AGN	Alinta	SAPN	Powershop	76.6	35.5	32.6	1,157	1,437	2,798	29.4	823
Adelaide	3	AGN	Origin	SAPN	AGL	70.0	35.5	29.9	1,061	1,316	2,798	32.4	908
Adelaide	3	AGN	EA	SAPN	EA	75.3	35.5	30.3	1,078	1,353	2,798	35.7	999
Melbourne	3	Multinet	Origin	United	Origin	61.6	75.8	16.5	1,254	1,479	6,257	25.2	1,575
Melbourne	3	Multinet	AGL	United	AGL	85.6	75.8	16.2	1,231	1,544	6,257	25.5	1,592
Melbourne	3	Multinet	EA	United	EA	63.2	75.8	17.4	1,317	1,548	6,257	25.8	1,612
Melbourne	3	AusNet	Origin	Powercor	Origin	68.6	75.8	18.3	1,389	1,640	6,257	23.5	1,470
Melbourne	3	AusNet	AGL	Powercor	AGL	95.1	75.8	16.0	1,210	1,557	6,257	23.0	1,437
Melbourne	3	AusNet	EA	Powercor	EA	75.9	75.8	17.5	1,325	1,602	6,257	23.2	1,454
Perth	2	ATCO	Origin	Western Power	Synergy	14.3	13.2	25.6	339	391	893	28.8	257
Perth	3	ATCO	Origin	Western Power	Synergy	14.3	24.7	25.2	623	675	1,876	28.8	541

Notes: Rows marked '2 appliances' refer to tariffs and costs for cooking and water heating only. Rows marked '3 appliances' refer to tariffs and costs for cooking, water heating and space heating. Melbourne and Sydney tariffs estimated for multiple locations to reflect different network zones with different tariffs. Retail electricity offers for Sydney, Brisbane, Adelaide, and Canberra from Australian Government (2020i); Melbourne offers from Victorian Government (2020d); Perth electricity tariffs from Synergy (2020); Perth gas tariffs from Origin Energy (2020b). One 'unit' in Origin Energy (*ibid*) is equivalent to one kilowatt-hour.

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