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The dash from gas. Could demand in New South Wales fall to half?

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Table of Contents

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About the University of Melbourne Energy Institute (MEI)

The University of Melbourne Energy Institute is an access point for industry, government and community groups seeking to work with leading researchers on innovative solutions in the following areas: new energy resources; developing new ways to harness renewable energy; more efficient ways to use energy; securing energy waste; and framing optimal laws and regulation to achieve energy outcomes.

Acknowledgement

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1. Summary

Gas transmission and distribution costs often make up the largest part of a consumer's gas supply bill [1]. Investments in gas supply infrastructure are based on estimates of future demand. If demand is overestimated, unnecessary infrastructure is built. Such poor investment decisions drive up the costs that small and large gas consumers must pay. Recent unprecedented electricity price increases in New South Wales (NSW) were partly due to overinvestment in network infrastructure that, in turn, was partly a result of year-after-year overestimation of electricity demand by the responsible planning bodies. A present danger is that future gas demand in NSW is now likewise being overestimated.

Rather than continuously growing over the next ten years, there are many reasons why NSW gas demand will decline. Wholesale gas prices in eastern Australia are forecast to increase at an unprecedented pace – doubling and even tripling - as a result of imminent coal seam gas exports to Asia from Gladstone, Queensland. Rising gas prices will dampen domestic gas demand across NSW and the other eastern states. Other factors will act in concert with rising gas prices to drive down gas demand. These include the carbon price repeal, ongoing energy efficiency schemes, environmental conservation efforts, warmer winter temperatures, technological advances, and the falling costs of alternatives to gas.

With respect to gas supply, NSW is situated in the middle of the interconnected eastern Australian domestic gas market. Since the mid 1970's, gas for NSW has largely been supplied via pipeline from the neighbouring states of South Australia and Victoria. More recently, significant quantities of recoverable coal seam gas have been identified within NSW itself. However, some farming and community groups are concerned about the impacts and risks posed by this industry.

The NSW state government has responded to the changing eastern Australian gas landscape by revising coal seam gas production regulations. The NSW state government and parliament are investigating how rising gas prices will impact consumers.

In order to inform this important issue, the University of Melbourne Energy Institute (MEI) has developed a plausible scenario that captures the effect of downward pressures on NSW gas demand. In this scenario over the next ten years (Figure 1), NSW annual gas demand declines to approximately half of the level seen in recent years. This scenario contrasts with forecasts such as those published by the Australian Energy Market Operator (AEMO) that suggest there will be little change in NSW gas demand (the dashed line on Figure 1).[1]

The MEI scenario examines each gas demand sector. The amount of gas used for electricity generation is at particular risk of falling dramatically because of rising gas prices, falling electricity demand, and the carbon price repeal. In other demand sectors, energy efficiency strategies used in recent years to reduce electricity demand are re-directed toward reducing gas use. In this scenario, cheaper fuels and alternatives to gas are used, such as electric air-source heat pumps that heat water and building spaces.

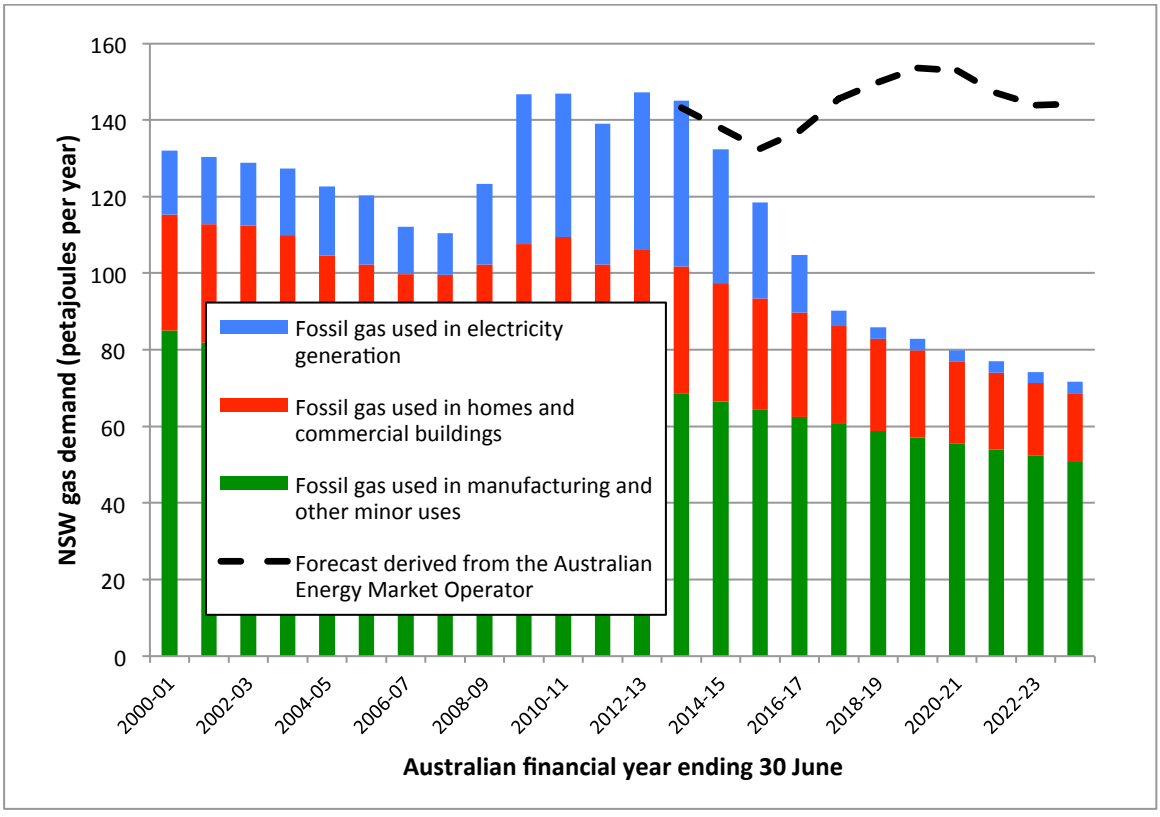

Figure 1: NSW declining annual fossil gas demand scenario (MEI)

[1] We adjusted AEMO's 2013 National Gas Forecast to account for the use of financial years versus calendar years and other bases differences that exist between AEMO and the Australian Government's Bureau of Resources and Energy Economics.

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MEI also investigated how declining gas demand eases the challenge of meeting consumer needs on peak winter days. In its 2013 Gas Statement of Opportunities, AEMO identified that winter daily supply shortfalls starting in 2018 could occur if all of the following conditions prevail:

- daily winter gas demand rises above 0.41 petajoules per day
- most South Australian gas is diverted to Queensland for export LNG production
- no significant new gas supply or storage infrastructure is built

and

- contractual peak-daily supply mechanisms are not employed.

In the MEI scenario, peak-daily winter gas demand in 2018 and later years can be adequately supplied from existing gas sources and supply pipelines. Importantly, no expansion of gas supply infrastructure is needed in this scenario because no supply shortfall appears. (Figure 2)

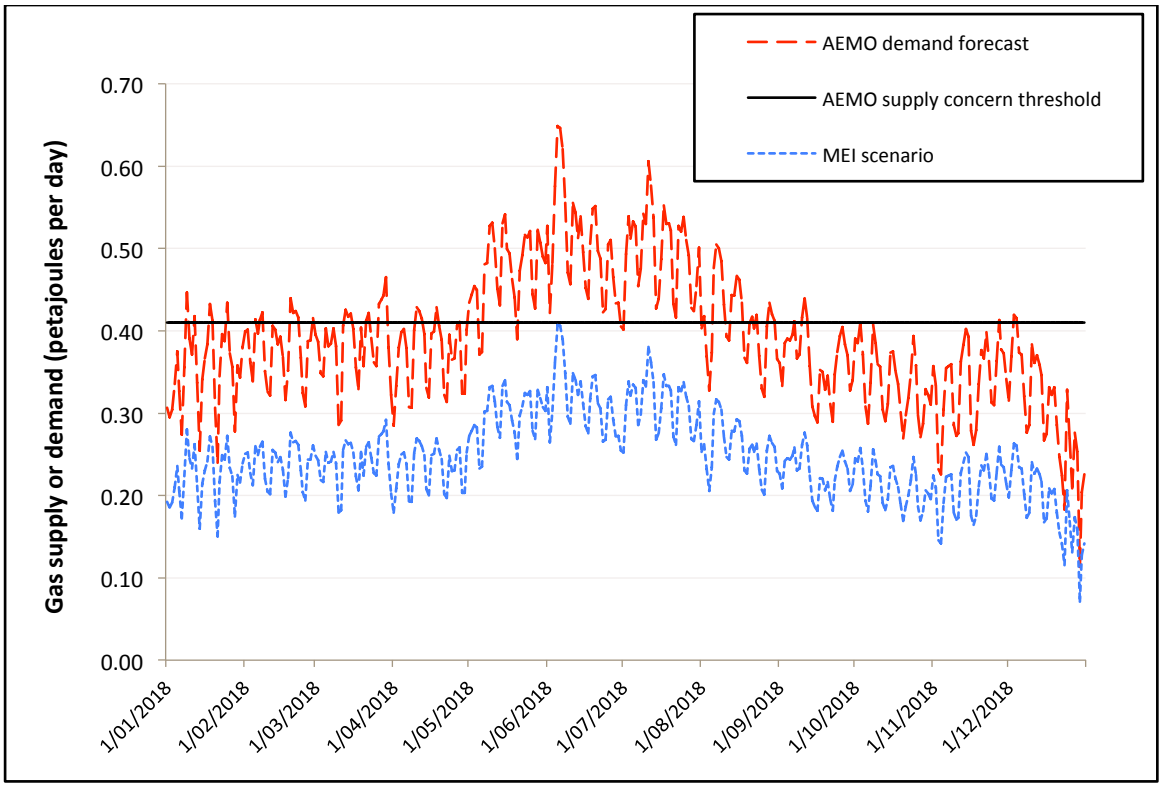

Figure 2: MEI scenario for NSW 2018 gas supply / demand, compared with AEMO forecast

The Australian Government, the New South Wales Government, and NSW local councils can pursue policies to ease the transition to higher gas prices. These include policies that would:

- act on recommendations such as those documented by the Alternative Technology Association with respect to residential fuel-switching from gas to electricity
- remove subsidies that encourage uneconomic use of gas where other options exist such as using efficient electrically-powered appliances
- remove subsidies that encourage uneconomic expansion of the gas grid
- inform gas consumers of the potential advantages of switching to other fuel sources and of applying energy efficiency measures
- strengthen the regulatory oversight of the sometimes-misleading marketing of gas and gas appliances
- facilitate identification and financing of economic fuel-switching and energy efficiency projects
- reduce infrastructure costs by rationalising the gas grid where economically advisable.

2. Historical New South Wales gas demand

For many years, eastern Australian consumers have been able to purchase some of the lowest-cost fossil gas in the developed world [2] and gas has found many uses.

Figure 3 illustrates historical NSW gas use by sector for the Australian financial year ending 30 June 2013 (FY 2012-13). The largest use of gas is for manufacturing. In residential and commercial buildings, gas is used along with electricity, roof-top solar thermal, and wood for space heating, water heating, and cooking. Gas is also used for electricity generation [3].

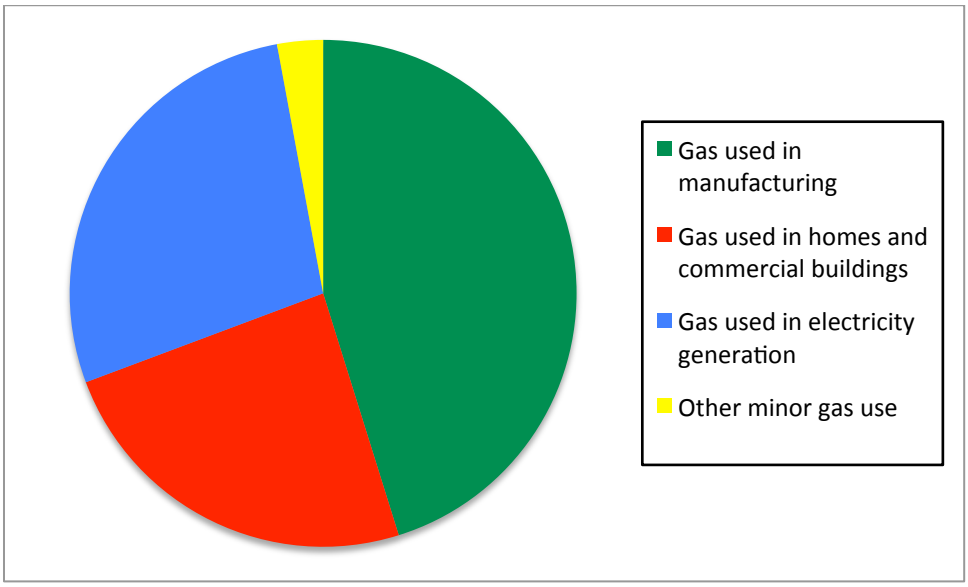

Figure 3: 2012-13 NSW gas use by sector (MEI)

Figure 4 shows historical NSW gas use by sector from FY 2000-01 to FY 2012-13 [3]. Over that period, gas demand in the manufacturing sector declined by 16%. Moving in the other direction, gas demand in the buildings sector increased by 18% while gas for electricity generation more than doubled, rising in particular since 2008-09. Historical gas demand in each of these sectors is discussed in more detail below.

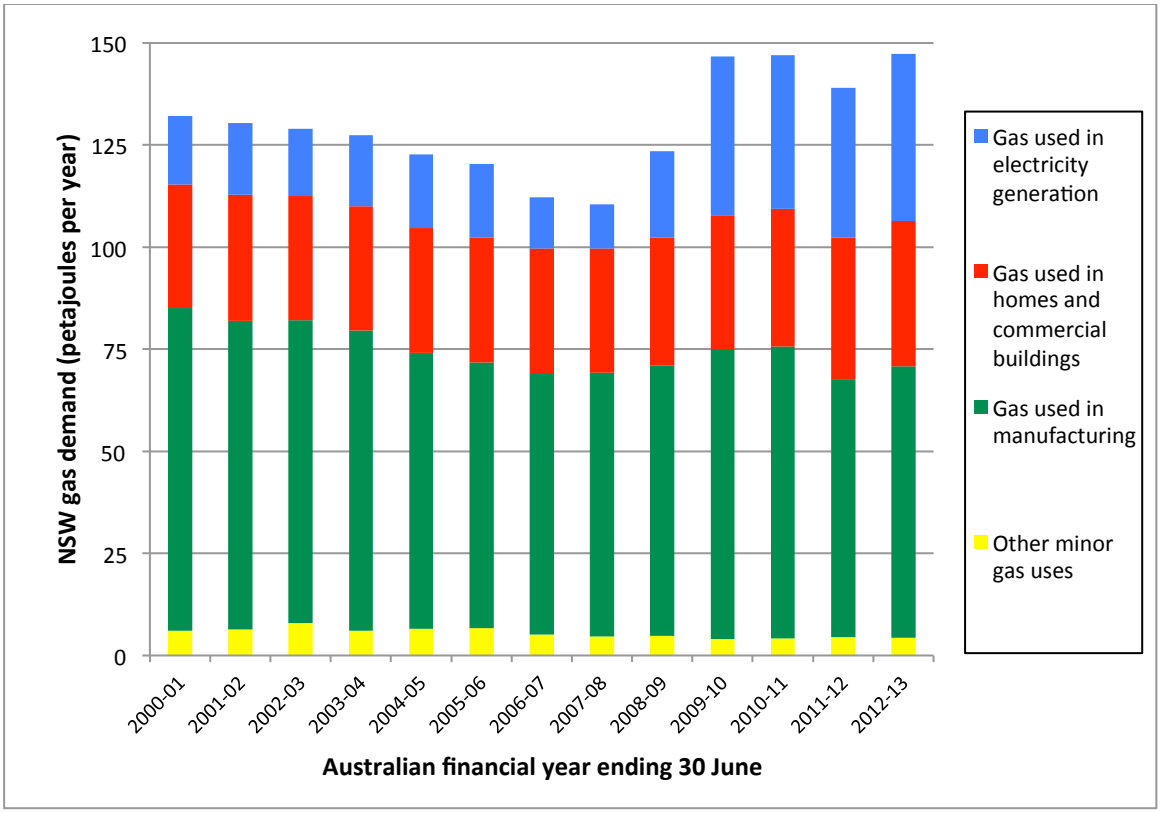

Figure 4: Historical NSW gas use by sector (MEI)

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Historical NSW gas demand in the electricity generation sector

The most significant change shown in Figure 4 occurred in the electricity generation sector. Over the last six years, the amount of gas used for electricity generation in NSW grew significantly as gas-fired electricity generation capacity expanded from 220 MW to 2,000 MW [4]. Gas use quadrupled over just two years from FY 2007-08 to FY 2009-10.

These gas-fired electricity generation investments were driven by factors such as:

- the experience of near-shortfalls of electricity supply (and therefore high National Electricity Market prices) due to a decade-long drought that reduced the output of hydro and coal generators,
- the expectation that annual electricity demand would continuously rise with population and economic growth,
- the expectation that peak electricity demand would increase each year with population and economic growth and ongoing summer heat waves,
- the assumption that low-cost gas would be widely available,
- the anticipation of climate-policy that would favour gas-fired electricity generation over coal.

However, even with these investments, electricity generated by burning gas has accounted for, at most, only 7% of all the electricity generated in NSW (FY 2012-13). Black coal remains the dominant fuel for electricity generation in that state [3,4].

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Historical NSW gas demand in the manufacturing sector

Figure 5 shows the amount of gas used in NSW for manufacturing from FY 2000-01 to FY 2012-13. This data is derived from energy statistics provided by the Australian government[2] [3].

Most gas used in NSW for manufacturing is burned to produce process heat at a range of temperature levels (see Section 6), with one main exception: the primary component of fossil gas, methane,[3] is used for chemical feedstock by Orica at Kooragang Island to make ammonia [5]. This methane feedstock volume of seven petajoules/yr, shown separately in black on Figure 5, makes up approximately 11% of all gas used in manufacturing, but just 5% of the all gas used in NSW.

Overall, gas used in NSW manufacturing has declined by 16% over the twelve-year period from FY 2000-01 to FY 2012-13 (an average decline rate of 1.3%/yr). ClimateWorks describes typical Australian industrial energy efficiency improvements of 1%/yr [6]. The potential for further demand reduction in this sector is described in Section 6.

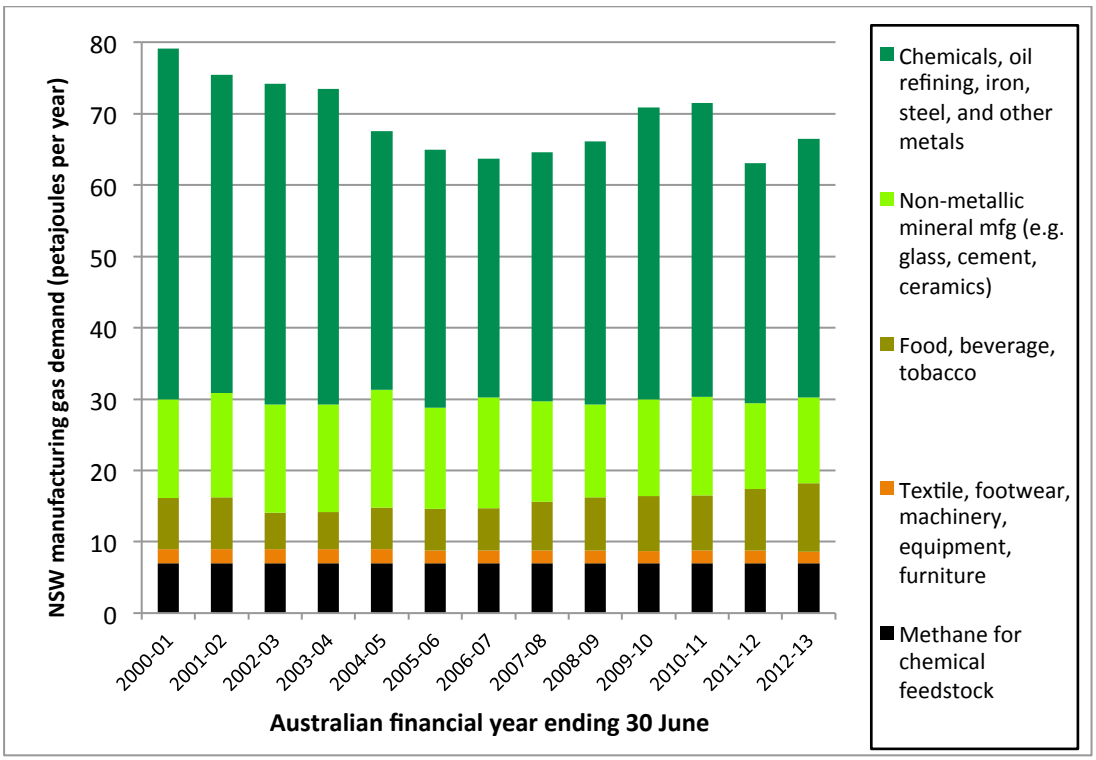

Figure 5: Historical NSW gas use for manufacturing (MEI)

[2] Some breakdown of demand within the manufacturing sector is provided by the Australian government, but for reasons of business commercial confidentiality, the gas used by the largest consumers must be aggregated into the category named "Chemicals, oil refining, iron, steel, and other metals".

[3] Chemical feedstock used by Qenos at Botany in the manufacture of plastics is predominantly made from the conventional fossil gas component ethane. This is delivered via a separate pipeline from Moomba, South Australia [7]. This separate specialty chemical feedstock, with a volume of 14 PJ/yr, has been excluded from all figures presented in this paper.

Historical NSW gas demand in the buildings sector

Gas is used in NSW buildings, along with electricity, roof-top solar thermal and wood, for space heating, water heating, and cooking. Figure 6 shows gas use in NSW commercial and residential buildings from FY 2000-01 to FY 2012-13 (derived from [3]).

Gas demand in the combined buildings sector increased by 18% over that full period, with most of this growth occurring just since FY 2007-08. This growth may be explained by:

- population and economic growth,
- rising affluence,
- anxiety about rising electricity prices and consequent fuel-switching from electricity to gas,
- views that gas may have better environmental outcomes than coal-based electricity,
- government incentives,
- active and sometimes misleading promotion of gas use in buildings by the gas industry [8].

Despite the above, Core Energy cites data from Jemena that indicates new dwellings in NSW use significantly less gas than the existing residential average [9].

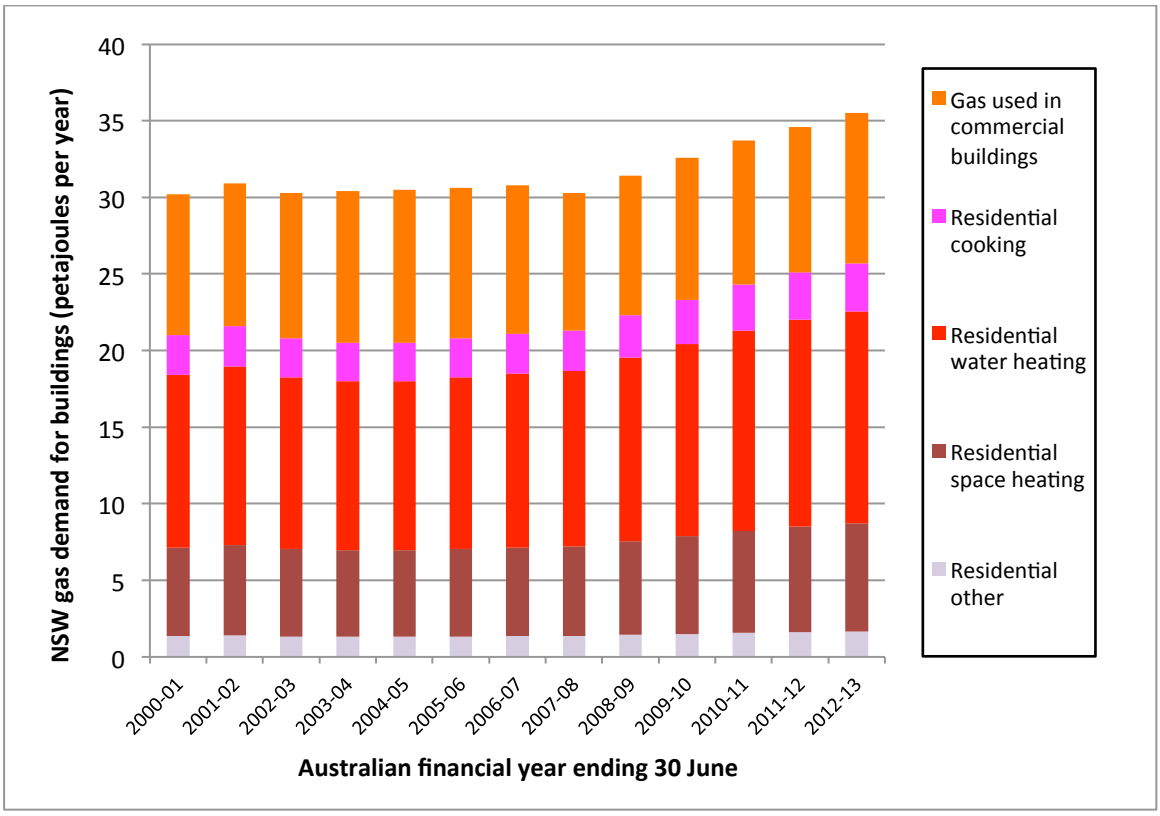

Figure 6: Historical NSW gas use in residential and commercial buildings (MEI)

Water heating

The largest sub-category of demand shown in Figure 6 is gas used for water heating. In NSW, the types of water heaters commonly employed include:

- gas,
- electric-resistive,
- electric air-source heat pump,
- roof-top solar thermal (boosted by gas or electricity).

Approximately 40% of residential water heaters in NSW are mainly fuelled by gas [10].

Electric air-source heat pump hot water heaters have been available in Australia for many years, yet many consumers and other stakeholders are unfamiliar with their operation and economics. As far back in time as 2006, 15% of new houses in NSW were being fitted with air-source heat pump hot water systems [11].

As reported by the NSW state government, air-source heat pump water heaters…

> "…are highly efficient, using around 70 per cent less electricity than other electric water heaters. They work by extracting heat from the atmosphere using a refrigerant gas and a compressor (similar to a fridge) to warm up water stored in a tank at ground level." [12]

Throughout Australia, air-source heat pump water heaters have represented up to 10% of total water heater sales; however, with a reduction of some government incentives, sales have fallen [13]. As is the case for solar-thermal water heaters, air-source heat pump hot water heaters remain eligible for small-scale renewable energy technology certificates (STCs) [14].

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Space heating

Figure 7 illustrates the penetration of the various types of space-heaters used in residential buildings [9]. (Note that the percentages shown on Figure 7 sum to more than 100% because multiple types of systems can be used in a given home.)

The space heater most commonly found in NSW homes is the electric reverse-cycle air-source heat pump (also referred to as a reverse-cycle air conditioner). Like the air-source heat pump water heater described above, this type of space heater is particularly effective[4] in NSW's relatively warm winter climate[5]. These devices also provide the homeowner with space-cooling during periods of hot weather [8]. The NSW state government indicates that a heat pump is less costly to operate than a gas heater with the same star rating [15].

The deployment of air-source heat pumps is rapidly growing in NSW. Over the last ten years their market penetration has significantly surpassed that of gas space heating systems [9].

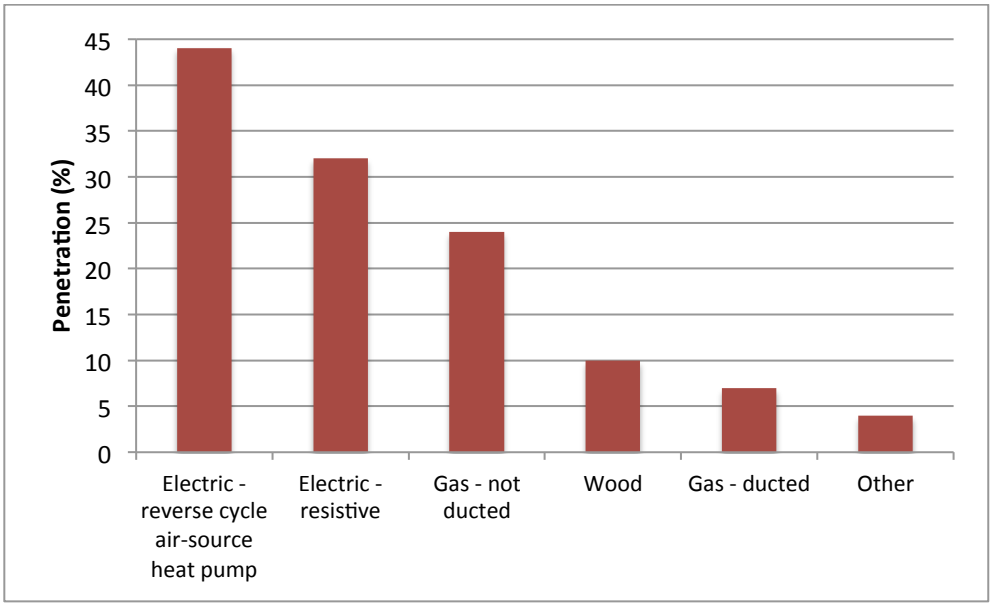

Figure 7: Penetration of different types of space heating systems in NSW

[4] The most efficient (seven star) air-source heat pump space heater on the Australian market is able to capture approximately five units of free renewable/ambient heat for every one unit of electricity used. See www.energyrating.gov.au In other words, heat pumps can be five times as efficient as electric-resistive or gas heating. In Australia, heat pump hot water heaters are eligible for renewable energy credits whereas heat pump space heaters are not eligible.

[5] July (winter) temperatures in Sydney (Observatory Hill) range from 8 °C (average July low) to 16 °C (average July high).

3. Historical gas supply to NSW

As shown in green on Figure 8, NSW is situated in the middle of the interconnected eastern Australian domestic gas market[6] [2].

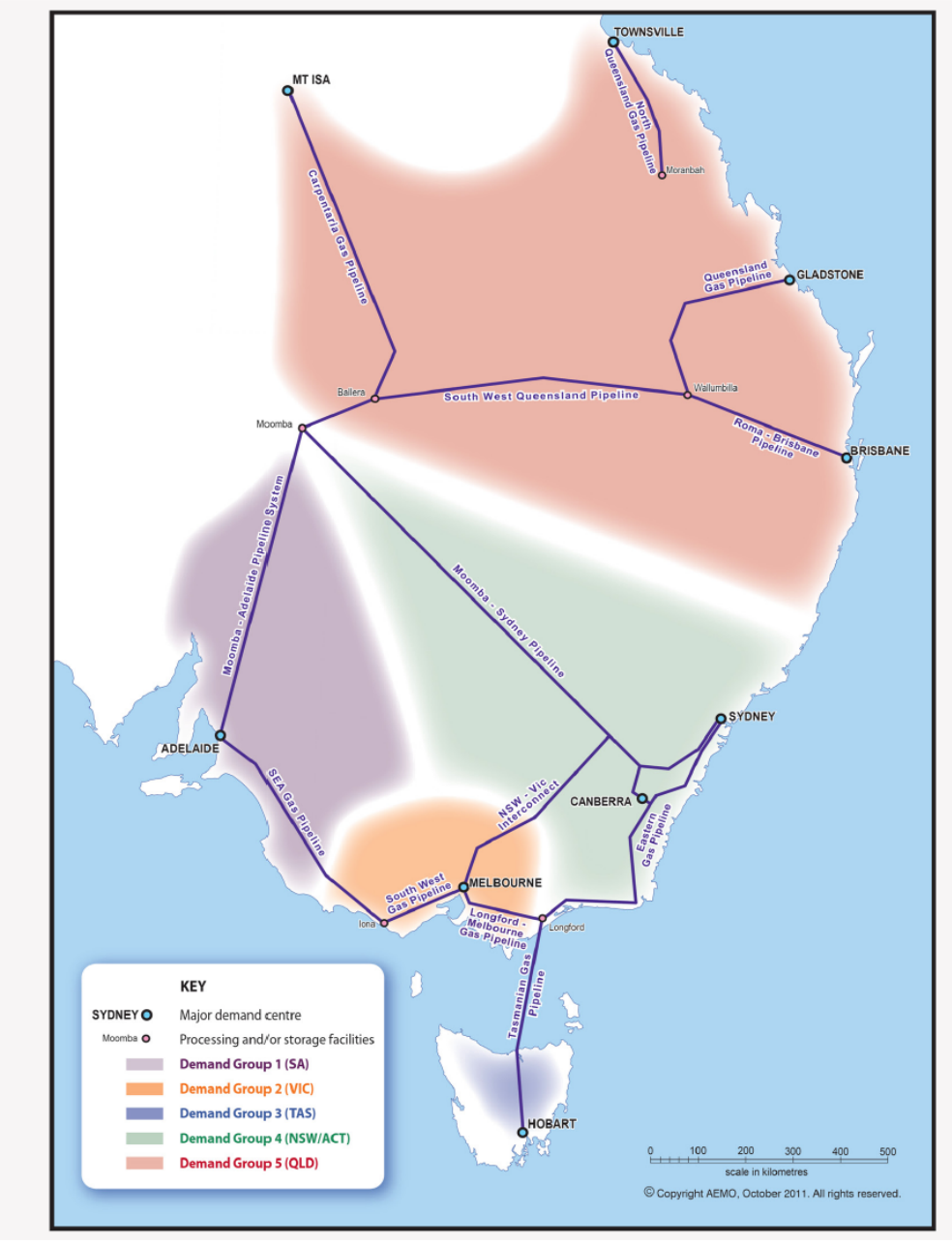

Figure 8: The interconnected eastern Australian gas market (from AEMO 2011 Gas Statement)

[6] References to NSW can be assumed to include the Australian Capital Territory, abbreviated as ACT.

Since the mid 1970's, gas for NSW has largely been supplied via pipeline from the neighbouring states of South Australia and Victoria.[7] In those neighbouring states, fossil gas and oil extraction using conventional methods was centred in the Bass Strait (offshore of eastern Victoria) and at Moomba in South Australia.

4. Gas exports will greatly exceed domestic use

Starting in about 2007, the eastern Australian gas market began to change. Identified reserves of coal seam gas (CSG) in NSW's neighbouring state of Queensland[8] grew to the point where developers could see that gas could be produced at volumes many times greater than the entire eastern Australian domestic market [2]. The focus of gas developers therefore turned to exporting liquefied natural gas (LNG) to customers in Asia.

Today, six LNG facilities (known as "trains") are under construction in Gladstone, Queensland. The first started exporting LNG in late 2014 [16]. Figure 9 compares a view of NSW gas demand in 2017 with the amount of gas that is contracted for export from Queensland that same year. The amount of gas used for export may exceed the amount of gas used in NSW by fourteen times.

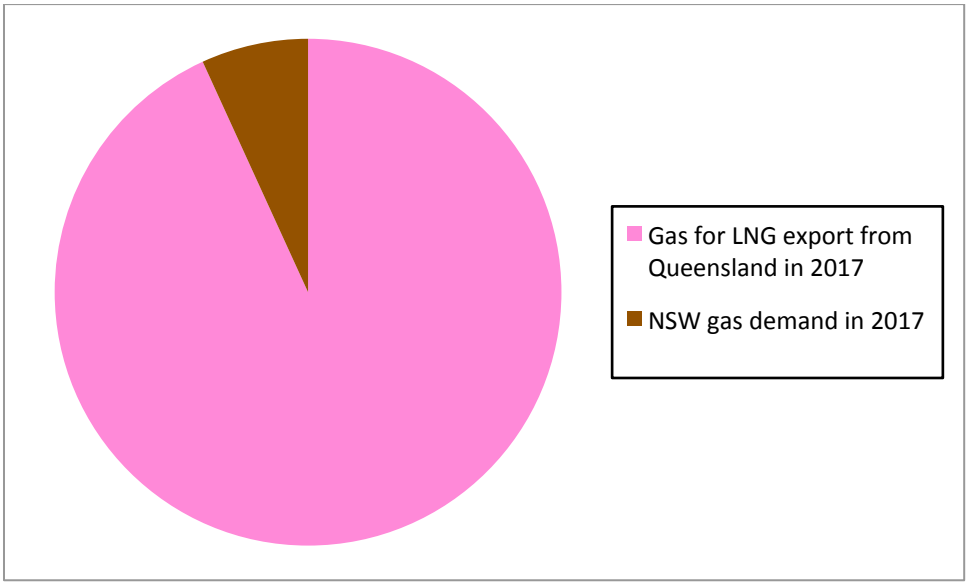

Figure 9: Queensland gas export volumes compared with NSW gas demand (MEI)

[7] Minor gas production commenced at Camden NSW in 2001. Capacity at that facility is now 26 terajoules per day.
[8] Coal seam gas (CSG) has been commercially produced in Queensland since 1999.

5. Higher domestic prices and consumer concerns

As has been thoroughly reported elsewhere [5,17,18,19,20,21], one consequence of the creation of this eastern Australia LNG export industry is that wholesale gas prices are increasing. As described in Section 2, for many years eastern Australian consumers have been able to purchase some of the lowest-cost fossil gas available anywhere in the developed world [2]. Now however, wholesale gas prices are on a path to double and possibly triple as they rise toward global parity. Industrial gas consumers have expressed their concerns about these price rises and also about their inability to contract for secure gas supply [22].

Retail gas prices have also increased in NSW due to rising distribution costs [23,24].

Building on the Queensland CSG experience, significant quantities of recoverable CSG have now been identified in NSW. Gas developers have slated some of this gas for export but have also said that it could be supplied to the NSW market. Based on experience overseas, in Queensland, and in NSW, some farming and community groups are concerned about the impacts and risks posed by unconventional methods of gas extraction. The NSW state government has responded by revising CSG production regulations [25].

Given the changes occurring in the eastern Australian gas market, the NSW state government and parliament are investigating the impacts of rising gas prices on consumers [26,27].

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6. A scenario of declining NSW fossil gas demand

This section describes a scenario in which, over the next ten years, annual fossil gas demand in NSW declines to approximately half of the level seen over the last few years. (Figure 1)

Our view is that it is important to consider all reasonable scenarios in planning Australia's energy future. Experience in the electricity industry over the last ten years teaches that the failure of planning scenarios to consider declining demand contributed to the unnecessary and costly expansion of electricity infrastructure [28,29,30].

A primary motivation for exploring reduced gas usage scenarios is the expected significant increase in wholesale and retail gas prices (described in Section 5) that will drive gas demand down in concert with other factors such as:

- the carbon price repeal
- ongoing energy efficiency schemes
- technological improvements of gas and electric appliances, and falling costs for these devices
- environmental concerns driving energy conservation efforts
- improving building standards
- the availability of efficient air-source heat pumps
- progressing bioenergy and other renewable energy technologies
- stabilising or falling electricity prices (wholesale, retail)
- self-generation of electricity (aided by the falling cost of solar photovoltaic technology)
- warmer winter temperatures.

Our scenario contrasts with forecasts derived[9] from those published by the Australian Energy Market Operator (AEMO). Its 2013 National Gas Forecasts show no decline trend in NSW [31]. (Figure 1)

The following sections discuss future NSW gas demand in each sector.

[9] We adjusted AEMO forecasts to account for the use of financial years versus calendar years and other bases differences that exist between AEMO and BREE data and information.

Future NSW gas use for electricity generation

In our scenario, NSW fossil gas demand decline occurs most significantly in the electricity-generation sector. (Figure 1)

Gas used in this sector is expected to have peaked in FY 2013-14 at approximately 43 petajoules/yr. In our scenario, demand then quickly declines to just 3 petajoules/yr by 2018-19. This small remainder is equal to what has been used in recent years only by the open-cycle gas turbine (OCGT) plants in NSW. OCGT plants generate electricity only intermittently, for example at times of high market prices.

In contrast, our scenario assumes that combined-cycle gas turbine plants (CCGTs, designed to run most of the time, i.e. "base-loaded") are uneconomic to operate versus coal-fired and renewable generators. The reasons that the amount of gas used by NSW CCGT's declines include:

- rising gas prices
- ongoing declining demand for grid-supplied electricity because of ongoing energy efficiency efforts and the deployment of low-cost solar photovoltaic (PV) systems
- the continuing "overhang" of excess coal-fired electricity generation capacity
- the ongoing deployment of wind-powered electricity generators
- the lack of environmental-economic drivers, such as a carbon price, that if present would deter the continuing use of coal for electricity generation.

Modelling done by the Australian Energy Market Operator for its National Transmission Network Development Plan supports the view that minimal amounts of gas will be used for NSW electricity generation in future [32].

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Future NSW gas use in manufacturing

Over the next ten years in our scenario, fossil gas used in the NSW manufacturing sector (for energy and feedstock[10]) declines by approximately 15 petajoules/yr (declining from 65 PJ/yr to 50 PJ/yr) or 23%. This is an average decline of 1.5 PJ/yr or approximately 2%/yr. (Figure 10)

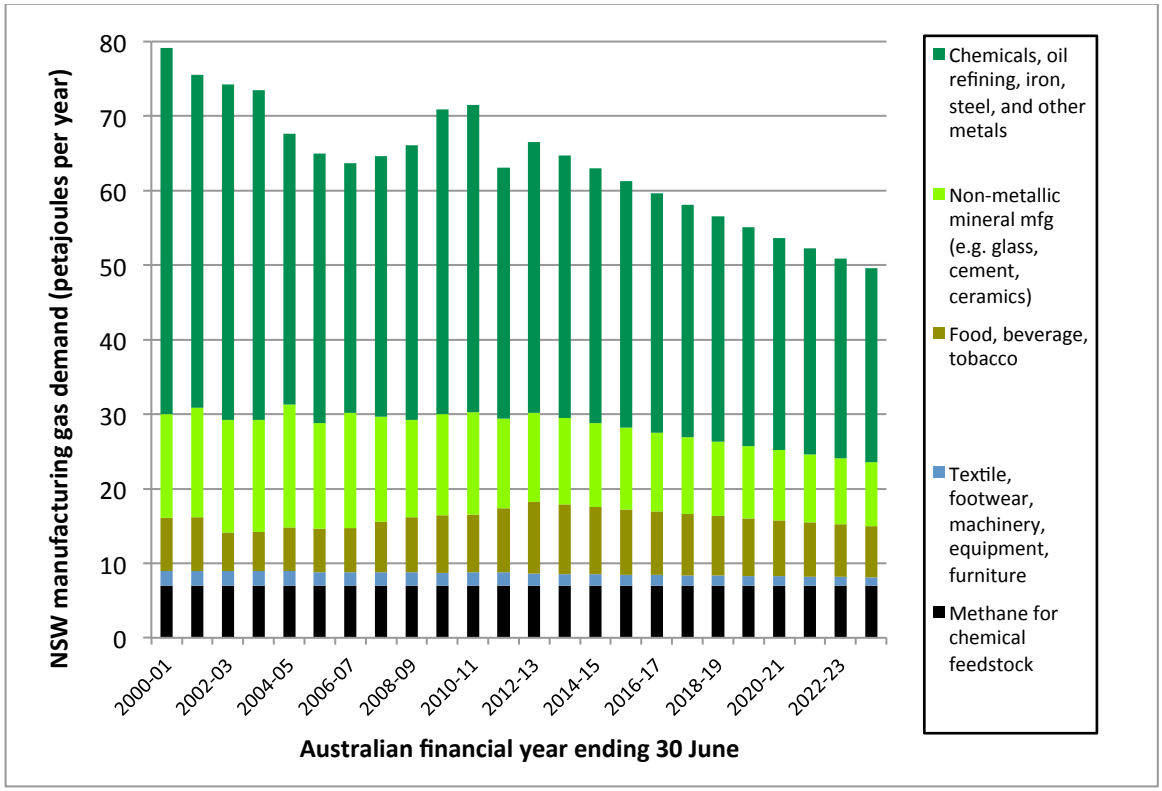

Figure 10: NSW fossil gas demand in the manufacturing sector (historical and future MEI scenario)

Reasons for this decline include the following three responses to rising gas prices and other economic and business-environment factors:

1. reduced manufacturing output (business cutbacks and closures)
2. fuel-switching to energy sources such as coal, bioenergy, solar energy, geothermal, energy from waste, and self-generated or grid electricity
3. energy efficiency measures.

[10] Chemical feedstock (methane) used for ammonia manufacture by Orica a Kooragang Island, NSW is included in these figures and assumed to be unchanged at 7 PJ/yr. Total fuel and feedstock consumption at the site is around 17 PJ/yr.

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The following discusses references that point to future declining gas use in the manufacturing sector.

Reduced manufacturing output

In a report for the Australian Industry Group, Deloitte Access Economics projected that manufacturing output could decline by up to $4 billion per year in NSW, with a potential negative impact on gas demand of 16 PJ/yr by the year 2021 [5]. This impact, due to declining output alone, is greater than the full decline in manufacturing gas demand assumed in our scenario.

Fuel-switching in manufacturing

As a source of energy for manufacturing, fossil gas is used provide process heat at various temperature levels. Lower-temperature process heat can potentially be economically provided by energy sources other than fossil gas. Where fossil gas is used to provide higher-temperature process heat, it can be more challenging to find economic alternatives.

In a draft study for the Australian Renewable Energy Agency (ARENA), IT Power identified the amount of gas-derived energy used at various temperature levels and identified potential renewable energy alternatives [33]. (Table 1) Electricity-based technologies (e.g. heat pumps, induction heating, resistive heating, electric arc heating) can be powered by renewable or non-renewable energy sources and used to achieve high process temperatures.

Table 1: Process heat supplied by fossil gas in manufacturing and renewable energy alternatives

Process heat level used in manufacturing	**Less than 250°C**	**250°C to 1300°C**	**Greater than 1300°C**
Share of total process heat requirement [33]	9%	45%	47%
Derived 2013-14 NSW fossil gas demand by process heat level (PJ/yr)	6	28	29
Applicable renewable energy technologies for process heat generation			
Electric heat pump – air source	yes		
Electric heat pump – ground source (geothermal)	yes		
Geothermal - direct	yes		
Biomass combustion	yes	yes	
Biogas combustion	yes	yes	yes
Solar thermal - direct	yes	yes	yes

Based on the breakdown given in Table 1, manufacturing fossil gas demand in NSW could be reduced by 10 PJ/yr if 50% of the < 250°C process heat and 25% of the 250°C-to-1300°C process heat were switched from fossil gas to other renewable energy sources. Fuel-switching from fossil gas back to coal may also occur [5].

Energy efficiency measures in manufacturing

ClimateWorks described typical historical Australian industrial energy efficiency improvements of 1%/yr [6]. Energy efficiency improvements at that rate could reduce gas demand in the manufacturing sector by approximately 6 PJ/yr (10%) by 2024. Rapidly rising gas prices could increase the uptake of energy efficiency measures above the pace historically experienced in the manufacturing sector.

In its 2013 work for the Industrial Energy Efficiency Data Analysis (IEEDA) project commissioned by the Australian and state governments through the National Strategy on Energy Efficiency [34], ClimateWorks summarised potential energy savings that were identified by the manufacturing industry across Australia as follows:

Manufacturing sub-sector	**Potential energy savings**
	(% of total energy used)
Metals manufacturing	6.6 %
Chemicals and energy manufacturing	16 %
Other manufacturing, construction and services	13.8 %
Average across all industries	11 %

Of the energy efficiency opportunities identified by industry, some will have been implemented already (many with a payback period of less than two years), implementation may be under way for others, but some were classified as not being economically attractive at the time. The onset of rising gas prices might mean that the economics for gas-saving projects has improved sufficiently so that more projects can go ahead.

Overall

In their work for the gas transmission and distribution company Jemena, Core Energy projected that gas demand in the manufacturing sector would decline by approximately 10 PJ/yr by 2020 (when compared with 2014), a decline rate of more that 3%/yr [9]. This decline rate is greater than that assumed in our scenario.

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Future NSW gas use in residential and commercial buildings

In our scenario over the next ten years, NSW fossil gas demand in the commercial and residential buildings sectors declines by approximately 50% (33 PJ/yr to 18 PJ/yr), or a decline of 15 PJ/yr. This is an average decline of 1.5 PJ/yr or approximately 5%/yr. (Figure 11)

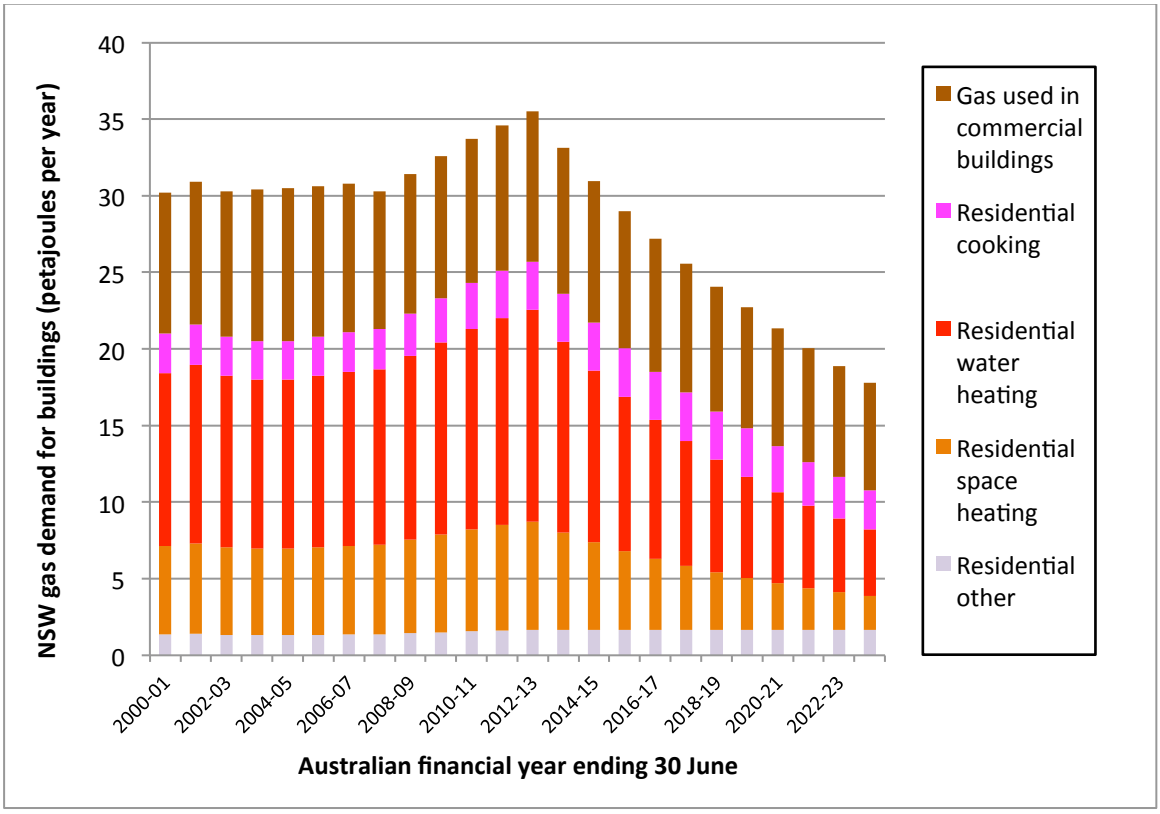

Figure 11: NSW fossil gas demand in buildings (historical and future MEI scenario)

Reasons for this decline are discussed below and include:

- rising gas prices – which drive gas demand decline via:
    - fuel-switching to efficient electric heat pumps (for space and water heating) and induction cooktops
    - energy efficiency measures
    - consumer behavioural responses
- warmer winter weather due to climate change and urban heat island effects
- the possibility of a "death spiral" emerging in the gas industry where falling gas sales require gas suppliers and distributors to further increase prices in order to maintain sales revenue, which then further accelerates demand decline
- electricity-only retailers actively promoting fuel-switching from gas.

The following discusses references that point to future decline in amount of gas used in buildings.

Core Energy noted that fuel-switching and energy efficiency in buildings will have a "material impact on gas consumption" over the review period of that study (2016 – 2020) [9].

Beyond Zero Emissions described how all Australian commercial and residential buildings can operate without using gas and what costs are involved [35].

Fuel-switching in buildings

A recent study by the Alternative Technology Association (ATA) [8], funded by the Consumer Advocacy Panel, identified the economic benefits of homes in NSW continuing to switch from gas to efficient electric appliances for space heating, water heating, and cooking as old gas appliances near the end of their lives. For example, the Sydney-area owner of a "large home" presently heated by gas, can save $1,284 (net present value) by switching to an electric heat pump (reverse-cycle air conditioner).

The Grattan Institute reports that a Sydney household that uses gas for cooking and hot water could save $600/yr by disconnecting from the gas network and instead using electricity to supply these services. (The Grattan analysis ignores the up-front costs of switching) [17].

The use of gas in homes in NSW is no longer the best economic option because of the continuing improvement in the efficiency and utility of electric appliances and more recently because of increasing retail gas prices.

The ATA also identify that there is no economic need for any **new homes or suburbs *anywhere in eastern Australia*** to connect to gas. Similar to recommendations made by the Grattan Institute [17], the ATA calls for an end to government subsidies for expanding gas supply networks, specifically recommending that

> "an urgent review of policy and programs that subsidise/support the expansion of gas networks is required."

The ATA study calls in to question the need for homes to be connected to both the electricity grid and the gas grid. Infrastructure costs would be reduced were the gas grid to be rationalised. The existing electricity grid would then be more productively used.

Residential fuel-switching from gas to electric can start immediately in cases where homeowners have in place efficient reverse-cycle air-source heat pumps that to date they use primarily as air conditioners for space cooling. As described by the ATA, homeowners may lack the knowledge that using the heat pump in winter for heating may be a better economic choice than using a gas heater. Gas appliance marketing can often mislead the consumer and the ATA recommends that it is necessary to:

> "strengthen the regulatory oversight of the marketing of gas as cheaper and more efficient than electricity."

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Assuming that gas-heating appliances last for 15 years, they are therefore replaced at the rate of 7%/yr and 70% are replaced over ten years. This rate of replacement exceeds the rate assumed in our scenario.

Efficient electric heat-pump space and water heating and induction cooking technologies can also be applied in commercial buildings.

Energy efficiency in buildings

In buildings where fuel switching is not employed, old gas appliances are likely to be replaced at the end of their lives with new gas appliances that are more efficient than older technologies. Comparing new appliance choices, a four-to-five-star rated gas appliance may use only 80% or less of the gas used by a one-to-two-star rated device. Six-star rated gas heaters are now available in Australia that use “condensing” technology (the European standard).

The largest demand sub-category shown on Figure 11 is gas used to heat water use in residential buildings. Continuing deployment of efficient showerheads can reduce gas consumption by over 40% compared with inefficient showerheads [9].

Building envelope energy efficiency measures (e.g. insulation, window treatments) can also reduce gas use. According to the Australian Bureau of Statistics, 30% of Australian homes still have no form of insulation [36]. The Insulation Council of Australia and New Zealand (ICANZ) cited five-year economic payback for insulation upgrades [37].

From work done by Pitt and Sherry, by 2030 an approximate 1 PJ/yr (10%) reduction in the amount of gas used in NSW commercial buildings may result from a range of Commonwealth building energy efficiency measures in place in 2013 [38].

Consumer behavioural responses

With increasing wholesale gas prices, the Grattan Institute reports that the average household gas bill in Sydney will rise by $100/yr [17]. Larger-than-average gas users will, of course, see even greater cost rises, which may drive demand down. Saddler [39] describes how consumers responded to rising electricity prices being often in the news and a topic of political debate by reducing their demand for electricity. If rising gas prices become a widespread news topic, gas consumers could respond in a similar way to that seen with electricity.

Warmer winter temperatures

In their August 2014 earnings report, AGL cited a “record mild winter” as a reason that gas sales were down 9.3% for the full financial year ending 30 June 2014 [40]. Likewise, Energy Quest [41] reported that NSW’s warmest early-winter period on record contributed to non-electricity-generation related gas demand across eastern Australia being down 10% in the quarter ending 30 June 2014.

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Core Energy describes the impact of warmer winter temperatures, caused by climate change and the urban-heat-island effect, on reducing gas demand [9]. NIEIR quantifies this at 0.095 PJ/yr, year-on-year as winter temperatures rise each year [9]. Over ten years, this amounts to a 1 PJ/yr reduction in gas demand in the NSW buildings sector.

The possibility that a gas death spiral shrinks the customer base in NSW

A utility market "death spiral" may occur when falling sales (due to factors such as customers switching fuels, implementing energy efficiency measures, making behavioural changes, etc.) require suppliers and distributors to further increase prices in order to maintain revenue. These ever-higher prices then further accelerate demand decline and result in a shrinking customer base. This has been described at length in Australia's electricity industry [42].

With declining volumes, energy distributors and retailers have incentives to increase the fixed-cost connection charges relative to volumes. With connection costs for both gas and electricity services likely to rise, there will be particular incentive to rationalise domestic energy services. Given that electricity offers a broader range of services than gas and that all domestic gas services can be provided by electric alternatives, the domestic gas network is at particular risk of facing a death spiral scenario. This is especially true in NSW where fuel-switching options are already economically attractive [43].

Electricity-only retailers actively promoting fuel-switching from gas

Some NSW energy retailers sell mostly electricity and little or no gas. Especially while electricity demand continues to fall [30], these retailers have an incentive to actively promote fuel-switching from gas to electricity. In Japan, this strategy allowed electricity retailers to nearly double revenues gained from individual households [44].

7. Biogas and gas-from-waste

As fossil gas prices rise, biogas (gas derived from biomass sources) and gas produced from municipal waste may emerge as another gas source for the market. In 2013, the Sydney of City identified that up to 50 PJ/yr of gas[11] could be produced from sources located around Sydney [45,46]. As an example, Sydney Water [47] reports that up to 5 PJ/yr of gas could be created available from their own waste sources.

Bioenergy and gas from waste [48] is proving to be a significant resource in countries such as Denmark and Germany [49]. In NSW, biogas and gas from waste may economically supply an important part of NSW' gas requirements as gas prices rise.

[11] Note that the City of Sydney study does not utilise timber plantations or native forest timber. The study sourced ~ 0.4 PJ/yr from pine wood processing residues.

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8. Existing gas supply capacity is adequate to meet peak demand

Traditionally, the periods of greatest gas use in NSW occur in the winter months of June, July, and August because of space-heating needs. In order to reliably supply customers, gas system pressure must be maintained above a certain lower-limit at all times. Figure 2 illustrates that in NSW the difference between the amount of gas used on a low-demand day outside of winter and a peak winter day can be more that a factor of two.

However, supplying gas is not as challenging as, for example, electricity where which must be supplied instantaneously throughout the entire network at all times in order to avoid electrical blackouts. Gas supply is less challenging because gas volumes equivalent to hours or even days of peak demand are commonly stored in pipelines (e.g. the 1,200 km Moomba (South Australia) to Sydney pipeline or the 800 km Victoria to Sydney Eastern Gas Pipeline) and purpose-built gas storage facilities, which range in scale as shown below [50].

Facility	Type	Gas storage capacity (petajoules)
Newcastle (NSW) Gas Storage Facility	above-ground liquefied gas	1.5
Moomba (South Australia) Underground Gas Storage Facility	underground compressed gas	85

In 2013, the Australian Energy Market Operator (AEMO) identified that winter daily supply capacity shortfalls could potentially occur starting in 2018 in NSW if:

- daily winter gas demand rises above 0.41 petajoules per day
- certain gas suppliers opt to divert South Australian gas to Queensland for export LNG production
- no other gas suppliers opt to supply the required gas at the required time
- no new gas supply infrastructure (e.g. storage or pipelines) is built and used to supply gas as required [51].

In MEI's declining gas demand scenario, peak-daily winter gas demand can be supplied from existing Victoria and NSW gas sources and transported via existing pipelines. (Figure 2) In our scenario, there is no need to develop new gas fields or to build new infrastructure in order to supply gas in mid-winter to NSW.

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Our scenario plotted in Figure 2 has been created by prorating-down AEMO's 2018 annual demand (143 PJ) and daily demand profile to the MEI scenario annual demand figure of 90 PJ. This simple approach is conservative because many of the gas-demand-reduction strategies highlighted by MEI (e.g. energy efficiency, fuel switching) will have the greatest effect in reducing gas demand exactly during the winter periods when gas demand has traditionally peaked. Further quantifying this seasonal impact was beyond the scope of our present research. Nevertheless, Figure 2 partly illustrates how employing energy efficiency and fuel-switching strategies that reduce winter peak gas demand can flatten the gas demand profile across the year. Over time, as gas demand becomes less seasonally "peaky", gas supply infrastructure can be rationalised and better utilised throughout the year.

The above analysis (by AEMO and MEI) ignores contractual mechanisms that can be employed to avoid capacity shortfalls. On the other hand, AGL has indicated that:

> "to the extent that any residual shortfall may exist in NSW, we would expect LNG producers, gas-fired power stations, gas shippers and large industrial consumers to initiate a series of transactional swaps and options so that NSW demand and supply clears without the need for emergency intervention by the NSW Minister for Energy." [52]

9. Policies to ease the transition to higher gas prices

The Australian federal government, NSW state government, and NSW local councils can pursue policies to ease the transition to higher gas prices, such as:

- acting on recommendations such as those documented by the Alternative Technology Association [8] with respect to residential fuel-switching from gas to electricity
- removing subsidies that encourage uneconomic use of gas, where other options exist such as using efficient electrically-powered appliances
- removing subsidies that encourage uneconomic expansion of the gas grid
- informing gas consumers of the potential advantages of switching to other fuel sources and of applying energy efficiency measures
- strengthening the regulatory oversight of the marketing of gas and gas appliances which are often claimed to be cheaper, more efficient, and more environmentally benign than all electrically-powered appliances
- facilitating the identification and financing of economic fuel-switching and energy efficiency projects
- reducing infrastructure costs by rationalising the gas grid where economically advisable.

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