TURNING DOWN THE GAS

SUPPORTING OUR MANUFACTURING SECTOR TO CUT GAS COSTS, SECURE JOBS AND BUILD A THRIVING ZERO-EMISSIONS FUTURE

NOVEMBER 2024 Image: Pixabay

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Supporting our manufacturing sector to cut gas costs, secure jobs and build a thriving zero-emissions future

This document is intended for general informational purposes only. The analysis in this report was commissioned by the Australian Manufacturing Workers Union and Lock the Gate Alliance and was prepared by Springmount Advisory.

Springmount Advisory is a specialist policy and research company that specialises in the economic opportunities for Australia from building a clean and just economy. Our research provides insight reports to drive policy change that are underpinned by strong analysis of financial, job and community benefits of driving rapid shifts to a more sustainable future.

Analysis and recommendations expressed in this report are prepared in good faith and based on Springmount Advisory's expertise in industrial transition pathways.

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Introduction and Recommendations

Accelerating the phase-out of fossil gas use in industrial settings is critical to providing energy independence to Australian industry and manufacturers, providing job security for the nation's 900,000 manufacturing workers, and reducing industry exposure to predatory gas pricing.

Many industries within Australia's manufacturing sector today utilise gas as either a direct input or energy source during production. However, the opening of the East Coast LNG export industry and the resultant surge in gas prices in recent years is threatening the future of the local manufacturing sector. This risk is now being compounded as the export-focused gas industry is creating a risk of domestic shortages.

There is an urgent need to support the manufacturing sector to decouple its future from a gas industry which is threatening the sector's viability. Australia needs to strategically utilise the gas it produces and deploy decarbonisation technology at speed and scale to keep our manufacturing sector viable as we navigate the energy transformation of the coming decade.

This report shows that the majority of industrial gas use (90%) on the East Coast can be replaced with proven and available technology today, freeing local manufacturing facilities from the high input costs and volatile contract availability of gas. A supportive policy environment that enables the mass deployment and cost reductions of these commercially available technologies will also ensure the availability of gas for the 10% of industrial use which is genuinely harder, but not impossible, to abate, and requires a longer runway for technology advancements.

The analysis groups industries into three broad categories based on whether gas using processes can be electrified or regassed with hydrogen using commercially available technology, or whether more technology research and innovation is needed to reduce the dependence of the manufacturing sector on expensive gas supplies. The three categories are:

1. **Electrify Now:** Industries where gas processes can be electrified now including the LNG export sector. On the East Coast, 60% (244 PJ) of manufacturing gas use is in processes that can be electrified with commercially available technology today. Rapid deployment of electric alternatives will enable businesses to reduce costs, reduce emissions and secure the future of thousands of jobs in these industries.
2. **Regas industry:** Industries where fossil gas use can be replaced with hydrogen. Approximately 30% (123 PJ) of industrial gas use on the East Coast for processes like steel making and ammonia production. These are keystone industries for Australia's broader economic security as they support much wider economic activity. A key challenge will be accessing sufficient renewable energy to produce hydrogen to support these industries.
3. **Harder to abate:** Industries where fossil gas use can be reduced but will require longer to completely phase out. The truly "hard-to-abate" segment, comprising glass, ceramics and cement, uses just under 10% (38 PJ) and requires more research investment support now.

The key barrier to industry electrification and fuel switching is that Australia lacks a comprehensive program and policy settings aimed at supporting manufacturers to make the shift.

This report focuses on gas use by industry on the East Coast of Australia and the potential to achieve significant reductions in gas use by 2035 which will avoid shortages, cut costs, save jobs and reduce emissions.

Overall, industrial gas consumption could be reduced by 216 PJ by 2035 through an ambitious program of industrial fuel switching. A priority must be to reduce the consumption by the LNG sector itself to provide the manufacturing sector time to transition. Restricting the sale of uncontracted gas for export would address short term shortage concerns, while the electrification or phase down of two of the three East Coast LNG facilities by 2035 could reduce domestic gas demand by 79 PJ.

The large-scale electrification of industrial subsectors, like food and beverage manufacturing, with commercially proven technologies could further reduce gas consumption by 67 PJ by 2035. Fuel switching from gas to green hydrogen could help regas industry which requires very high heat levels of heat or uses gas a feedstock could deliver a 62 PJ reduction by 2035.

Finally, in genuinely hard to abate like glass, cement and ceramics production, support for efficiency measures could deliver a gas use saving of 8 PJ by 2035. These measures would significantly reduce the exposure of the manufacturing sector to gas price inflation and unpredictable price spikes, reduce emissions, help eliminate the risk of gas shortages, while protecting existing jobs and creating new roles in industry regassing and electrification.

We recommend that the Federal Government undertake the following to address the policy gap, support industry to transition and enable a strong, jobs-rich and low-carbon future for manufacturing in Australia.

1. Cease the export of uncontracted gas by LNG exporters without Ministerial approval and require Ministerial consent for all new gas export contracts based on a national self-sufficiency test.
2. Establish an obligation for the LNG sector to reduce gas consumption by at least 79 PJ by 2035 to ensure gas availability for other sectors. This could be achieved through efficiency improvements, electrification of operations with renewable energy, or through a staged wind-down of exports. The reduction target should be incorporated within the Resources Sector Plan and National Net Zero Plan and be communicated in Australia's next Nationally Determined Contribution to the Paris Agreement.
3. Boost funding for state and territory household electrification initiatives to provide a longer runway for industry gas substitution, and accelerate renewable energy and battery storage deployment to remove the need for future increases in gas-powered electricity generation.
4. Establish a high-ambition industrial gas substitution, electrification and efficiency target as part of the Industry Sector Plan and Net Zero Plan with a key goal of reducing industrial gas use by 216 PJ by 2035. A clear timeline for hydrogen switching of selected industries should be established to enable efficient planning and provide certainty for co-location and demand projections/offtakes by green hydrogen producers and users.
5. Establish a dedicated Industrial Electrification and Fuel Switching Fund priority investment area within the National Reconstruction Fund, with support from the Clean Energy Finance Corporation, to support equipment upgrade costs of switching from fossil gas to electric and green hydrogen alternatives. The fund should prioritise achieving mass deployment of electrification equipment, a reduction in unit costs and increased availability for key industries like food and beverage manufacturing.
6. Where appropriate, link financial support with recoupment of investment from gas cost savings made from increasing energy efficiency and productivity.

Summary

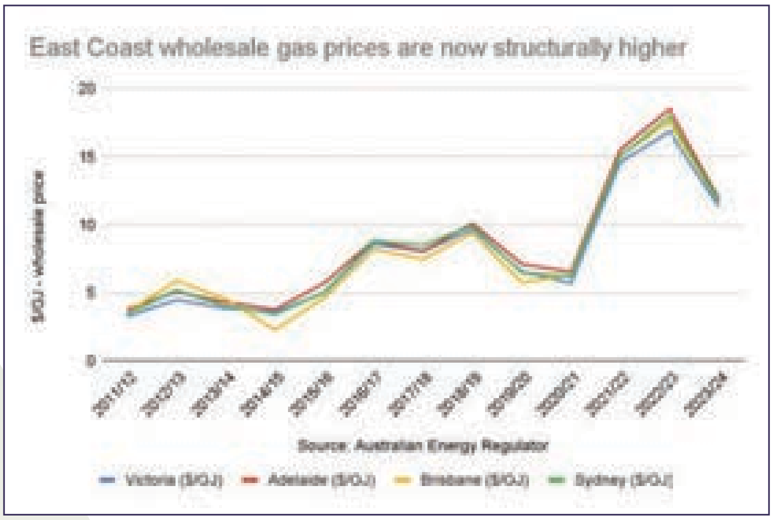
The short-term future competitiveness of Australia's manufacturing sector on the East Coast is intrinsically linked to the domestic availability and cost of gas supply and the speed and scale at which industry is supported to switch to alternative sources of energy to meet manufacturing requirements.

This report shows how Australia can support the transition of our existing manufacturing sector from gas to alternative fuel sources and in doing so:

- **Reduce wholesale gas expenses by the East Coast manufacturing sector by at least $2.5 bn**
- **Lower gas demand in 2035 by 216 PJ:**
    - Manufacturing by 112 PJ
    - Commercial buildings by 25 PJ
    - LNG onshore gas use by 79 PJ
- **Mitigate risk of future domestic gas shortfalls**
- **Reduce emissions by 11.1 MTCO2-e per annum by 2035**
- **Safeguard hundreds of thousands of manufacturing jobs during the transition from gas**
- **Support manufacturers to reduce exposure to recurrent gas price hikes which impact competitiveness and increase costs to end consumers**

The establishment of the Queensland LNG export industry has created and exposed critical structural challenges in the East Coast gas market.

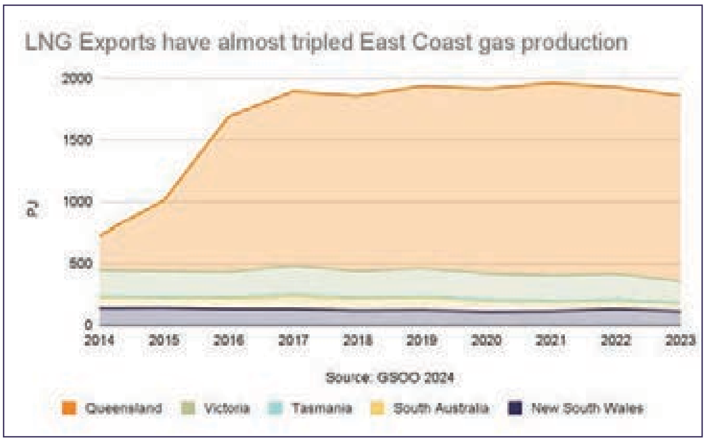
Since exports commenced gas prices and extraction levels on the East Coast have increased rapidly with average wholesale prices increasing from $3.28/GJ in 2014-15 to $11.65/GJ in 2023-24[1,2]. The rapid increase in gas prices was a key contributor to cost inflation during the spike in 2022[3] and continue to drive inflation.[4] Reducing industry dependence on gas will improve economic security and stability.[5]



East Coast gas production has almost tripled since 2013, but the domestic market is now beset by impending 'supply shortages' due to gas producers prioritising exports.

1 https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/consumer-price-index-australia/sep-quarter-2022
2 https://www.aer.gov.au/industry/registers/charts/gas-market-prices
3 https://www.afr.com/policy/economy/gas-price-spike-to-stoke-inflation-crimp-growth-20220605-p5ar6w
4 https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/consumer-price-index-australia/sep-quarter-2024
5 https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220317_2~dbb3582f0a.en.html

Australia's east coast manufacturing sector has borne the brunt of these impacts and it has already resulted in a number of companies having to shut down due to the price of gas[6], resulting in the loss of thousands of jobs – and many more are at significant risk.

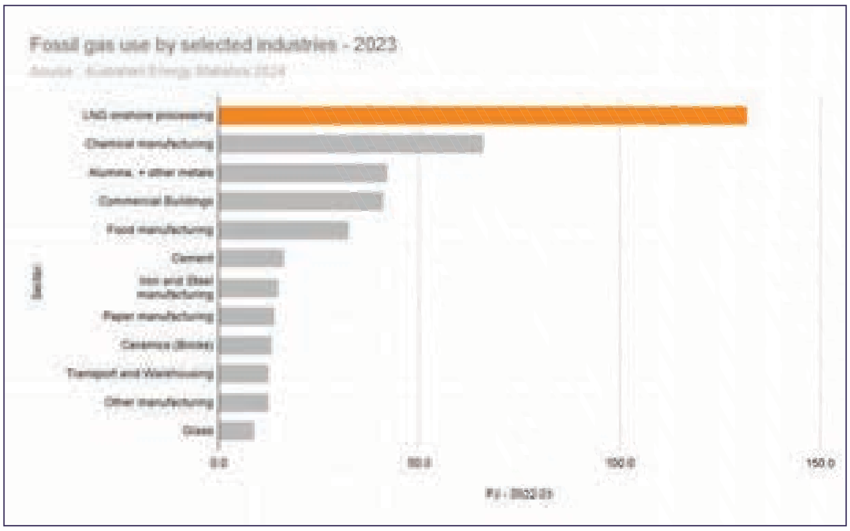


Despite the major impacts on domestic manufacturing, the gas industry continues to export almost two-thirds of East Coast gas under long-term contracts as well as selling large volumes of uncontracted gas for export on the spot market.

This is gas that could be made available at reasonable prices to Australian manufacturing during the current transition to renewables, but is instead being exported. The Australian Competition and Consumer Commission's authoritative quarterly gas inquiry reports[7] regularly identify future uncontracted gas volumes of between 20-30 PJ being available in future quarters – for example in Q1 2025 it forecasts a surplus of 27 PJ gas[8] despite talk of domestic shortages – however domestic availability is threatened by gas overproduction and its subsequent sale into the international market.

The LNG sector is also often making a net negative contribution to the domestic supply – i.e. LNG exporters purchase more gas from the domestic market to sell overseas than they sell into the domestic market, for example in 2023, LNG net contribution to the domestic market was -6.3 PJ.[9].

Protecting local manufacturers from exposure to LNG driven gas shortages and price hikes will require a broad and ambitious agenda for industrial gas substitution and climate change action.



Capital, political will and a supportive regulatory and economic environment are the primary enablers that will unlock a secure fossil gas-free future for Australia's manufacturing sector.

The initial heavy lifting should be done by the LNG industry as it is the largest domestic user of gas and the root cause of domestic price rises. Electrification of LNG terminals

6 https://www.abc.net.au/news/rural/2021-11-13/incitec-pivot-shut-brisbane-plant-amidst-fertiliser-price-boom/100610750 + https://www.aigroup.com.au/news/media-centre/2024/imminent-qenos-closure-has-massive-implications-for-industry/

7 https://www.accc.gov.au/about-us/publications/serial-publications/gas-inquiry-2017-30-reports

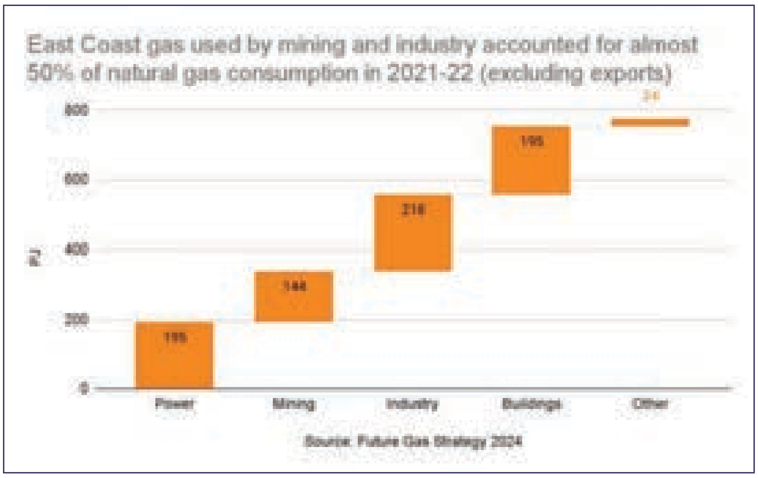
8 https://www.accc.gov.au/media-release/gas-supply-for-q1-2025-tightens-as-risk-of-shortfall-in-short-term-remains

9 https://www.accc.gov.au/system/files/gas-inquiry-june-interim-gas-inquiry-report_1.pdf

or a phase down in exports could save at least 79PJ of gas in 2035, equating to 4.1 Mtc2O-e. The LNG sector's super profits in recent years, puts the industry in a strong position to finance electrification.

GAS PRODUCTION AND USE ON THE EAST COAST

Since 2017, almost 2000 PJ of gas has been extracted on the East Coast per year on average. In 2022, 2108 PJ of gas was extracted on the east coast[10] with 1358 PJ used by the LNG export industry for both exports and onsite gas consumption.[11]



Excluding LNG exports, domestically gas is utilised within the power, mining, industry and building sectors.

In 2021-22, the industry sector (218 PJ) was the largest end-user of gas on the East Coast, followed by buildings and power generation (195 PJ each), mining (144 PJ) and other uses (24 PJ).[12]

For the purpose of this report, LNG gas plant usage as well as commercial building gas demand has been incorporated into a broader industrial consumption analysis.

On a state-by-state basis, Queensland is the largest domestic consumer of gas, due to the volume consumed by the LNG facilities and the power sector, followed by Victoria which has the most expansive domestic gas network and very high use in the residential sector. [13]

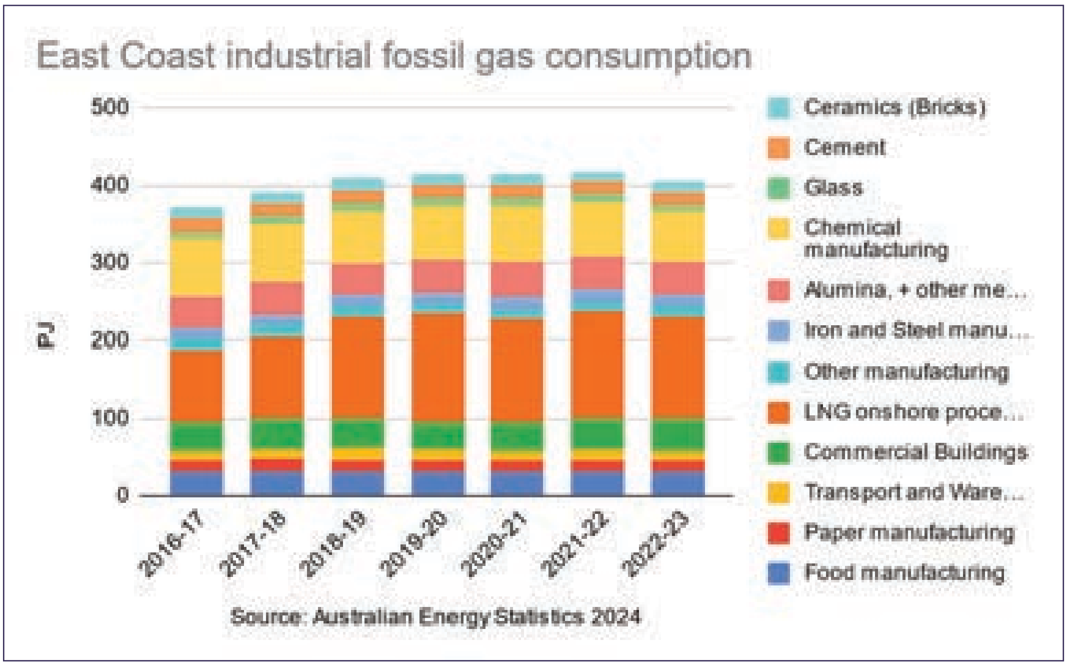
Gas use in all states is trending down, with a peak in East Coast gas consumption in 2021. The growth of Queensland's LNG industry masks the underlying gas trends occurring on the East Coast.

Excluding the LNG industry, gas consumption on the East Coast dropped by a third between 2014 and 2023.

The reduction has been driven by a rapid decline in gas use in the power sector, where consumption has halved in a decade.

In contrast, gas use has been largely flat in the industrial sector and has grown considerably in the mining sector since the establishment of the LNG export industry which is a major onsite gas user.

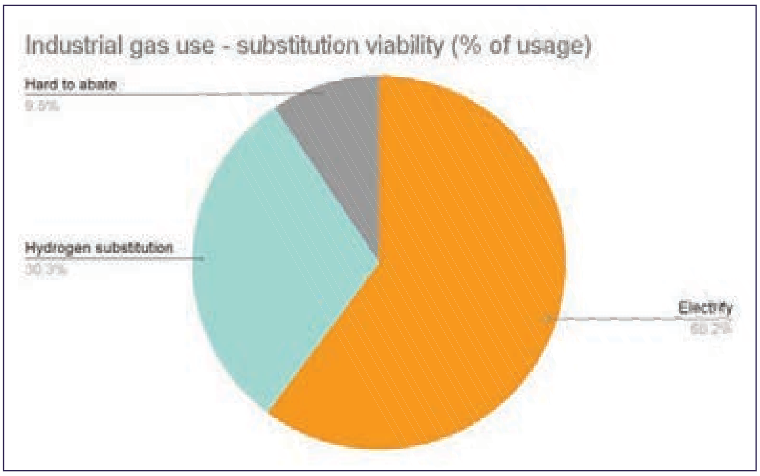
10 https://www.ga.gov.au/aecr2024/gas
11 https://aemo.com.au/energy-systems/gas/gas-forecasting-and-planning/gas-forecasting-data-portal
12 https://www.industry.gov.au/publications/future-gas-strategy
13 The Future Gas Strategy categorises Gas power generation for LNG under Power, and gas for liquefaction under Mining



The lack of support for industry to invest in renewable energy and heat solutions is leaving Australia's manufacturing sector increasingly exposed to exploitative gas pricing and the risk of future supply shortages as gas fields are depleted in the Gippsland basin[14] and gas supplies are preferentially exported by gas producers. The instability of gas prices and supply is jeopardising the future of the manufacturing sector and policy – financial support to free keystone industries from dependence on gas will reduce costs, increase certainty and reduce greenhouse gas emissions.

INDUSTRIAL GAS USES

Gas is used by industry for three primary functions, low heat processes (<120C) like food processing and space heating, high heat processes (>120C) like alumina, glass and cement making, and as a feedstock for chemical production.



Additionally, a huge volume of gas (132PJ equivalent to 30% of industrial gas use) is consumed by LNG export facilities in Queensland to run onsite gas turbines that provide electricity to chill the gas to -162°C for liquefaction.

Despite industrial gas use generally being characterised as 'hard to abate', the reality is that for the majority of industrial gas use, technology now exists and is being installed at industrial sites globally to cut demand for fossil gas.

14 https://www.smh.com.au/business/companies/bass-strait-gas-can-t-keep-the-lights-on-if-coal-plants-fail-next-year-20230321-p5cu0o.html

Industrial heat pumps for instance can completely meet the needs for low-heat processes that many of Australia's manufacturing industries and the commercial building and warehousing sub sectors require. These have been deployed in sites including 3 Ravens brewery and Hardwicks meat processing[15] through a recent ARENA trial – but a large-scale deployment plan is required to support industry-wide uptake.

Similarly, the active development of the domestic green hydrogen industry through initiatives such as Hydrogen Headstart[16] and the soon-to-be-introduced Hydrogen Production Tax Incentive (HPTI)[17] will see the supply of competitively priced hydrogen become available for use in the industrial sector. This new national focus on delivering green hydrogen at a sustainable price will enable industrial decarbonisation and must remain a key national priority.

Meanwhile, the use of gas for electricity generation at LNG export facilities can be supplied by renewable energy sources and substantially reduce domestic gas demand[18] – as fossil fuel use is phased out globally, the renewable energy infrastructure can be used to power clean industry.

This research shows that ambitious **industrial gas substitution can be delivered at speed and scale if we provide clear and well-designed support for our manufacturing sector.**

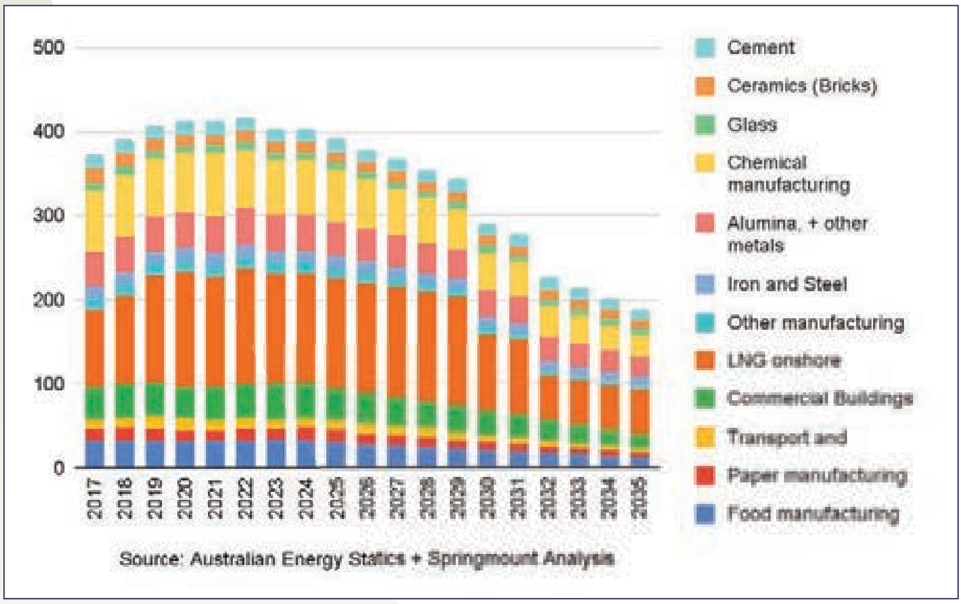
DIFFERENT PATHWAYS FOR DIFFERENT INDUSTRIES

This research has analysed gas use in 12 industrial sub-sectors (including LNG and commercial building gas use) using data from Australian Energy Statistics 2024, the Future Gas Strategy and AEMO's Gas Statement of Opportunity 2024.

The research has sorted each industrial sub sector into one of the following categories based on the viability of reducing gas use with existing technologies.

1. **LNG electrification or export phase down**
2. **Industries where gas use can be electrified**
3. **Industries where gas use can be replaced with hydrogen**
4. **Industries where fossil gas use can be reduced but will require longer to completely phase out.**

Overall, industrial gas on the East Coast could be reduced by 216 PJ by 2035 through the establishment of a high-ambition industrial gas substitution, electrification and

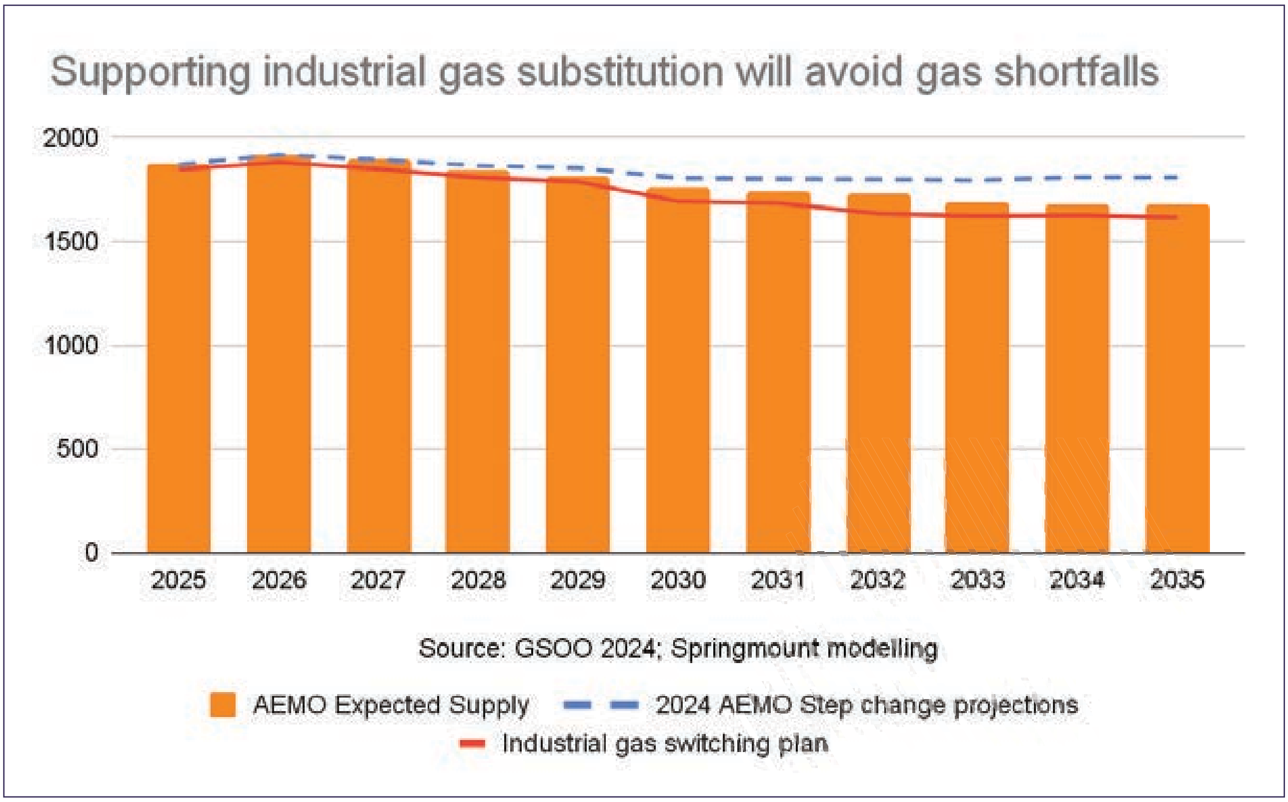


15 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/
16 https://www.dcceew.gov.au/energy/hydrogen/hydrogen-headstart-program
17 https://treasury.gov.au/sites/default/files/2024-06/c2024-541265-cp.pdf
18 https://www.cdu.edu.au/news/research-reveals-integrating-solar-energy-lng-industry-cuts-australia%E2%80%99s-carbon-footprint

efficiency plan. This would cut east coast industrial gas demand from 405 PJ in 2023, down to 189 PJ in 2035.

This would protect industry from ongoing gas supply risks and protect manufacturing and industry from sustained gas price inflation and future gas price shocks. At current wholesale prices, this would reduce the cost of gas used by industry from at least $4.7 billion per year today, to less than $2.2bn in 2035.

INDUSTRIAL ELECTRIFICATION AND SUBSTITUTION WILL HELP AVOID GAS SHORTFALLS

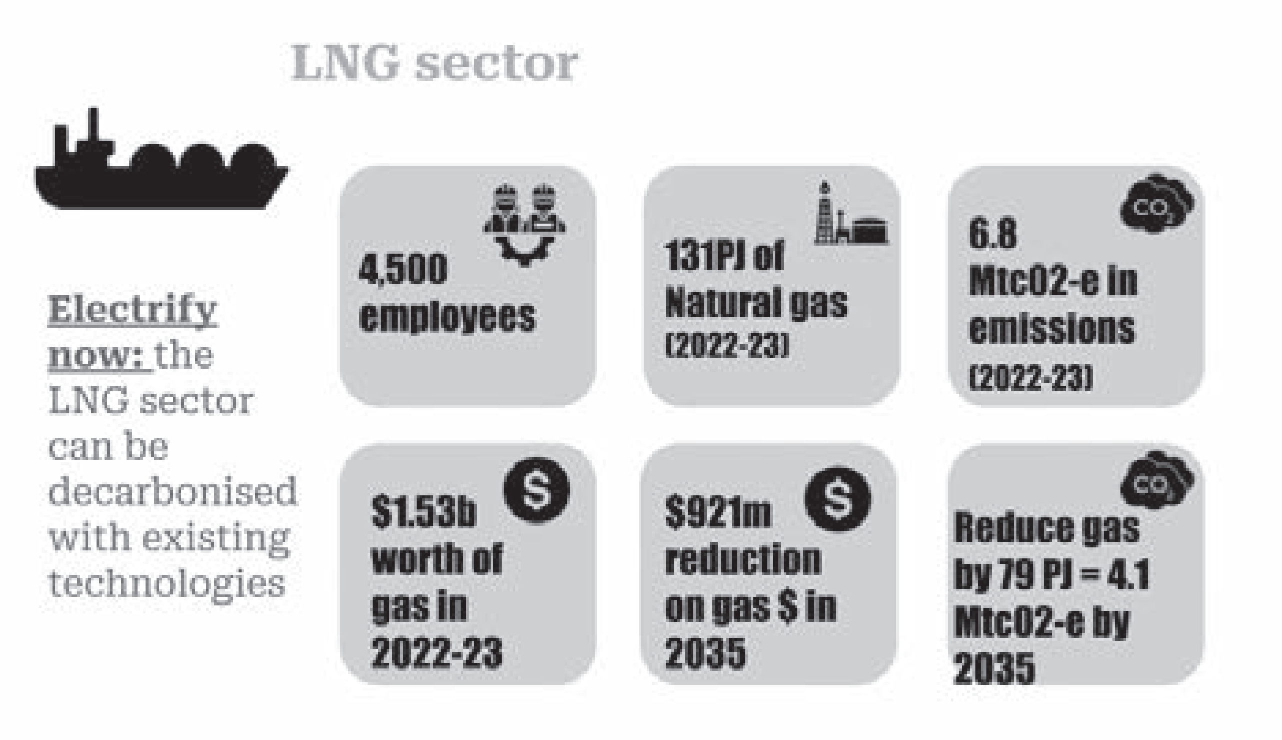


This report shows that an ambitious program to support industry to electrify and fuel switch can help ensure that East Coast gas demand stays below forecast gas supply.

The modelling however underscores the need for concurrent programs that will drive deeper reductions in gas use by the residential sector and for power generation as well as further measures to ensure the export of uncontracted gas is restricted to provide even greater confidence that domestic shortfalls can be avoided.

Summary of gas reduction opportunity by industrial category

Electrifying LNG – reducing gas from the largest gas user



Just over 30% of industrial gas use analysed in this report occurs in LNG onshore processing, which currently consumes an estimated 132 PJ (2023)[19], valued at $1.5 billion in wholesale gas prices.

A program to support LNG electrification with a goal of reducing gas use in these sectors by 60% by 2035 would reduce gas demand by 79 PJ, lower emissions by 4.1 million tonnes of CO2 per annum and reduce wholesale gas expenses by $921 million in today's prices. This reduction will be the electrification of at least 2 of the 3 LNG export facilities in Queensland.

HARD TALK: PATHWAYS AND CONSEQUENCES OF ELECTRIFYING INDUSTRY

The LNG industry is the largest industrial user of gas in the country – the sector needs to significantly reduce gas use to reduce the pressure on other manufacturers. If the LNG sector does not reduce consumption – gas shortages may occur which would impact thousands of manufacturing workers.

LNG export facilities are also among the largest emitters of greenhouse pollution in the country and threaten the ability of Australia to meet national emissions reduction targets.

Hard decisions are required about how to reduce LNG sector gas usage.

One option is to electrify onsite LNG processing and improve onsite gas efficiency. This would substantially reduce gas use, but doing so will require significant investment in new renewable energy (11GW) plus onsite upgrades. The scale of investment may increase pressure for ongoing gas

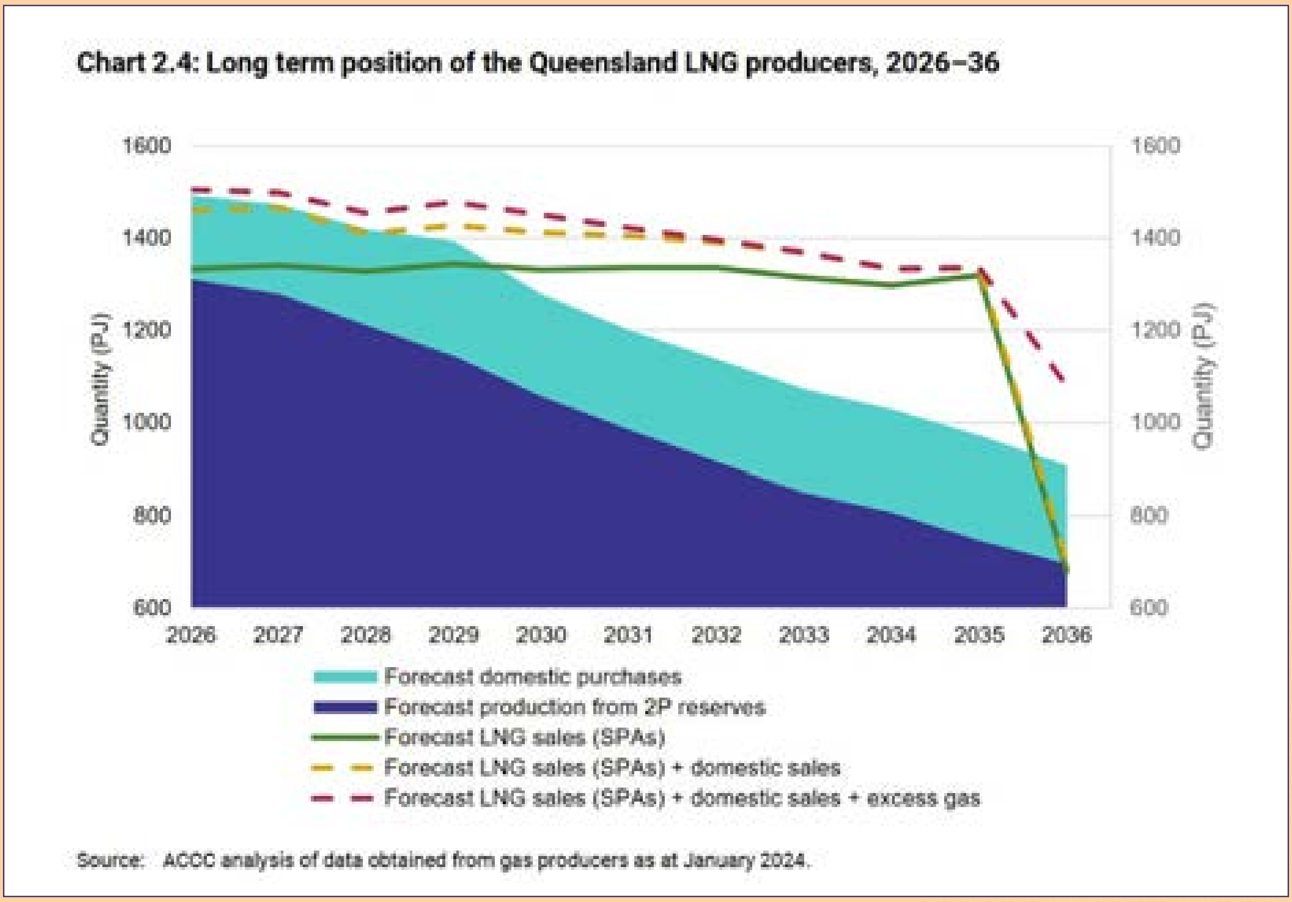
19 https://www.energy.gov.au/publications/australian-energy-update-2024

exports and the opening of new gas fields to supply the plants, which would further erode domestic gas security and would be at odds with IEA's advice about gas production under its Net Zero Emissions scenario.[20]

Alternatively, a staged phase-out of LNG processing in Queensland would reduce pressure on domestic gas stocks.

Long term contracted volumes are forecast to drop sharply in 2035.[21] If one of the three Queensland LNG export facilities closes in 2034/45 year this would reduce total gas demand by 44 PJ per annum on the East Coast. Not to mention the PJs of upstream gas used to supply the LNG terminals. The NZEA is focused on transition pathways for the Gladstone workforce[22] – however, in the absence of a phase-out plan, there is likely to be significant pressure from the gas industry and foreign governments like Japan for production to continue.

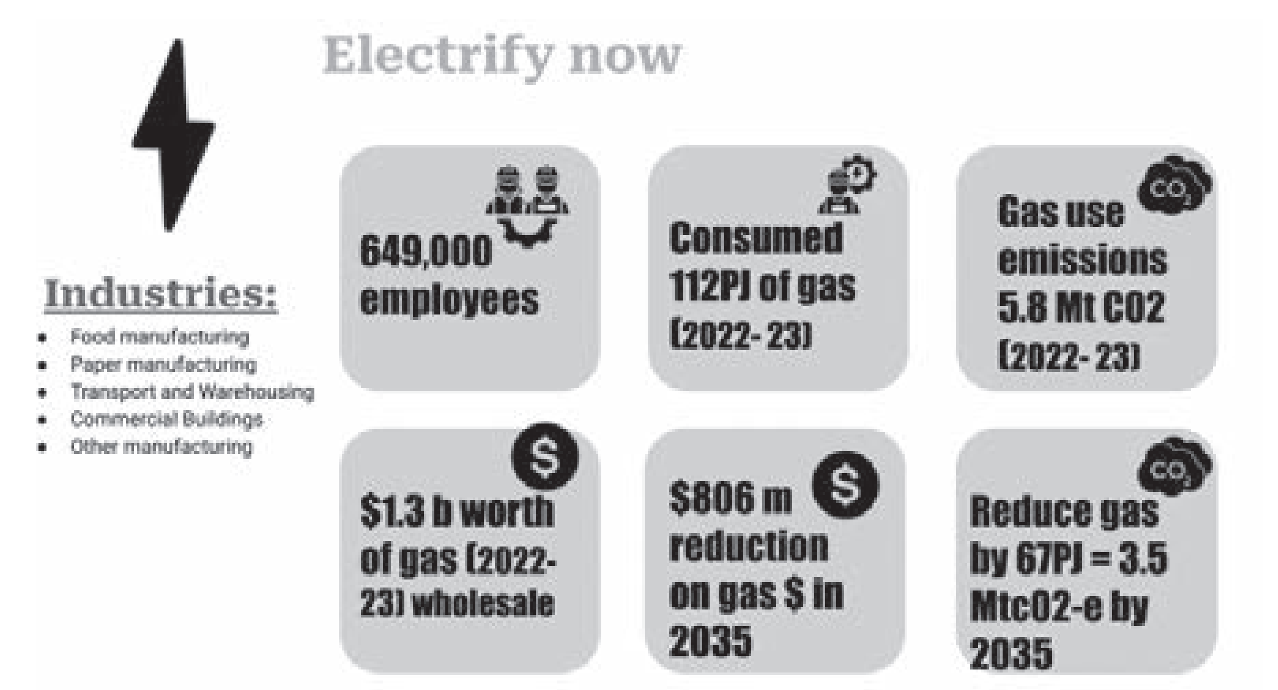
Queensland LNG export cliff



Source: ACCC, Interim Gas Inquiry Report, June 2024

20 https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze
21 Chart 2.4 – https://www.accc.gov.au/system/files/gas-inquiry-june-interim-gas-inquiry-report_1.pdf
22 https://www.actu.org.au/media-release/net-zero-economy-authority-historic-breakthrough-for-australian-energy-workers/

Electrifying manufacturing processes and commercial buildings



Approximately 30% (112PJ) of industrial gas use occurs in five sub sectors (F*ood and beverage manufacturing, paper manufacturing, transport and warehousing, commercial buildings and other manufacturing)* where gas is primarily used for low-temperature heat processes. These industries are also major job creators and employ 79% of the total manufacturing workforce.

In 2023, $1.3 billion wholesale worth of gas was consumed in these sectors, with the retail price charged significantly higher. The rapid increase in gas prices is impacting the viability of many manufacturers, putting jobs at risk and exacerbating the cost of living crisis as costs are passed through to consumers. Structural reliance on gas in the manufacturing sector obstructs the resilience and long-term economic security at the heart of the Future Made in Australia agenda.

Established and deployable technology solutions exist which can electrify gas processes in all these industries, and can be deployed at scale with adequate government support. Industrial and commercial heat pumps of different capacities can drive electrification and substantially reduce the cost of business and greenhouse gas emissions. An ambitious program to support businesses to switch to electric solutions with a goal of reducing gas use in these sectors by 60% by 2035 would reduce gas demand by 67 PJ, lower emissions by 3.5million tonnes of CO2-e per annum and cut wholesale gas expenses by $800 million at today's prices.

HARD TALK: CONSTRAINTS ON RENEWABLE ENERGY SPEED AND SCALE

Electrifying and fuel switching in the industrial sector will drive down fossil gas use but will require a faster rate of renewable energy construction to meet increased electricity demand.

Reducing industrial gas use by 216 PJ by 2035 – while maintaining existing industries – will require **an estimated 35 GW of additional renewable energy generation to be installed over the next 11 years**. This is equivalent to an additional 3.2 GW of renewable energy per year.

For context, Australia installed 5.9 GW of new renewables in 2023[23], and likely 7 GW in 2024.[24] The AEMO ISP Step Change scenario has an average of 7.2 GW per year for the next 11 years. However, Step Change does not factor in a rapid shift from gas in the industrial sector, so the additional capacity required to support industrial electrification should be seen as additional to the ISP.

Renewable energy for electrifying industry:

We have calculated that a maximum of 22 GW of renewable energy (7 GW of wind and 15 GW of solar) is required to electrify 146PJ of fossil gas by industry. However, electric processes are more efficient than gas – so less renewables could deliver an equivalent amount of useful energy. Electrification efficiencies of 20% on average are expected for the industrial sector.[25]

Renewable energy for green hydrogen production:

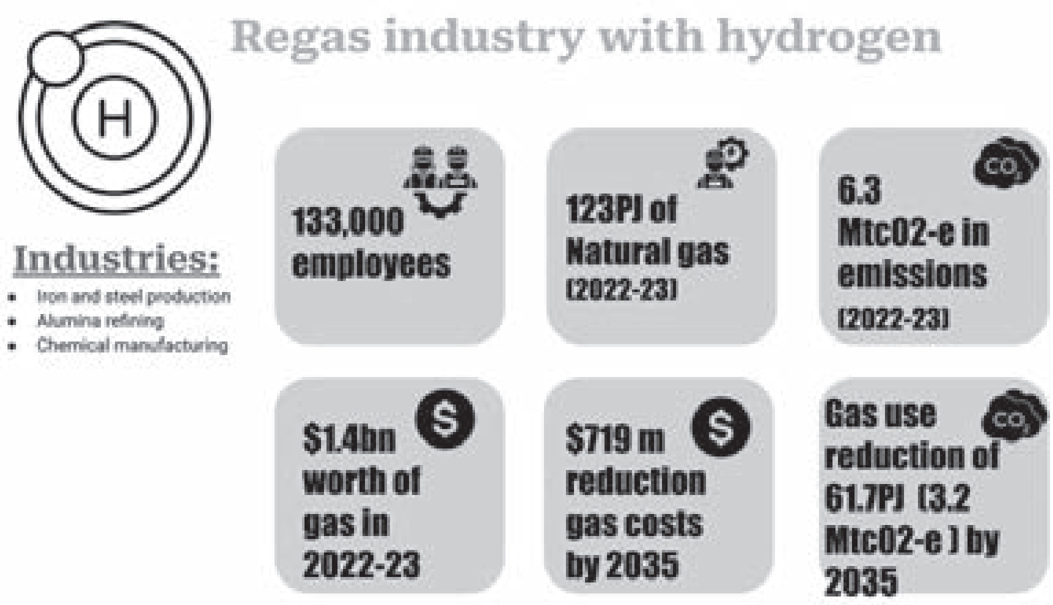
Regassing and substituting industries with hydrogen will require replacing 70 PJ of fossil gas with 70 PJ of green hydrogen* – equivalent to 577 Kilotonnes of hydrogen.[26] This would require about 19,200 GWh of electricity[27] or 13.7 GW of renewables, equating to 4.4 GW of Wind and 9.3 GW of solar by 2035.

Alongside a faster rate of renewable energy construction, new or expanded policy mechanisms will be required to underpin renewable energy projects. The Capacity Investment Scheme in its current form will deliver 23 GW of new capacity – far short of the 37 GW required to support the industrial transition away from gas.

**The hydrogen substitution requirements of each sub sector have not been calculated and a level of variation is expected depending on the end use of hydrogen depending on its end use as a heat source or as a manufacturing input.*

23 https://cleanenergycouncil.org.au/getmedia/0cb12425-37ab-479e-9a4b-529622cc9c02/clean-energy-australia-report-2024.pdf
24 https://www.pv-magazine-australia.com/2024/09/25/new-added-renewables-capacity-tipped-to-exceed-7-gw-in-2024/
25 https://link.springer.com/article/10.1007/s12053-021-09982-9
26 https://www.idealhy.eu/index.php?page=lh2_outline#:~:text=Hydrogen%20is%20an%20excellent%20energy,www.h2data.de).
27 https://www.aemc.gov.au/hydrogen-new-australian-manufacturing-export-industry-and-implications-national-electricity-market

Regassing industry – shifting from fossil gas to green hydrogen



Approximately 30% (123PJ) of industrial gas use occurs in three sub-sectors where green hydrogen can be substituted for fossil gas use. This includes iron and steel manufacturing; non-ferrous metal production (alumina, aluminium, copper, silver, lead and zinc production); and chemical production.

In 2023, these sectors consumed $1.4 billion wholesale worth of gas and have been particularly impacted by the rapid rise in gas prices. Incitec Pivot for example made the decision to cease operations at its Gibson Island fertiliser plant in 2022 due to the price of gas.[28] The firm has since partnered with CSIRO and Fortescue Future Industries to establish a green hydrogen and ammonia project on-site[29], demonstrating that fuel switching to hydrogen is an increasingly viable pathway for chemical manufacturers.

Similarly, the high heat requirements of the metals industry can be met by a combination of renewable energy and green hydrogen combustion technologies.

An ambitious program to support industrial users to fuel switch from gas to green hydrogen could lower gas demand by 50% (62 PJ) by 2035. This would reduce emissions by 3.2 million tonnes of CO2-e per annum and cut wholesale gas costs by $719 million at today's prices.

28 https://www.incitecpivot.com.au/news/media/gibson-island-manufacturing-operations-to-cease-at-end-of-2022/
29 https://research.csiro.au/hyresource/gibson-island-green-hydrogen-and-ammonia-project/

HARD TALK: THE NEED FOR METAL PROCESSES TO LEAPFROG GAS AND GO DIRECT TO GREEN HYDROGEN

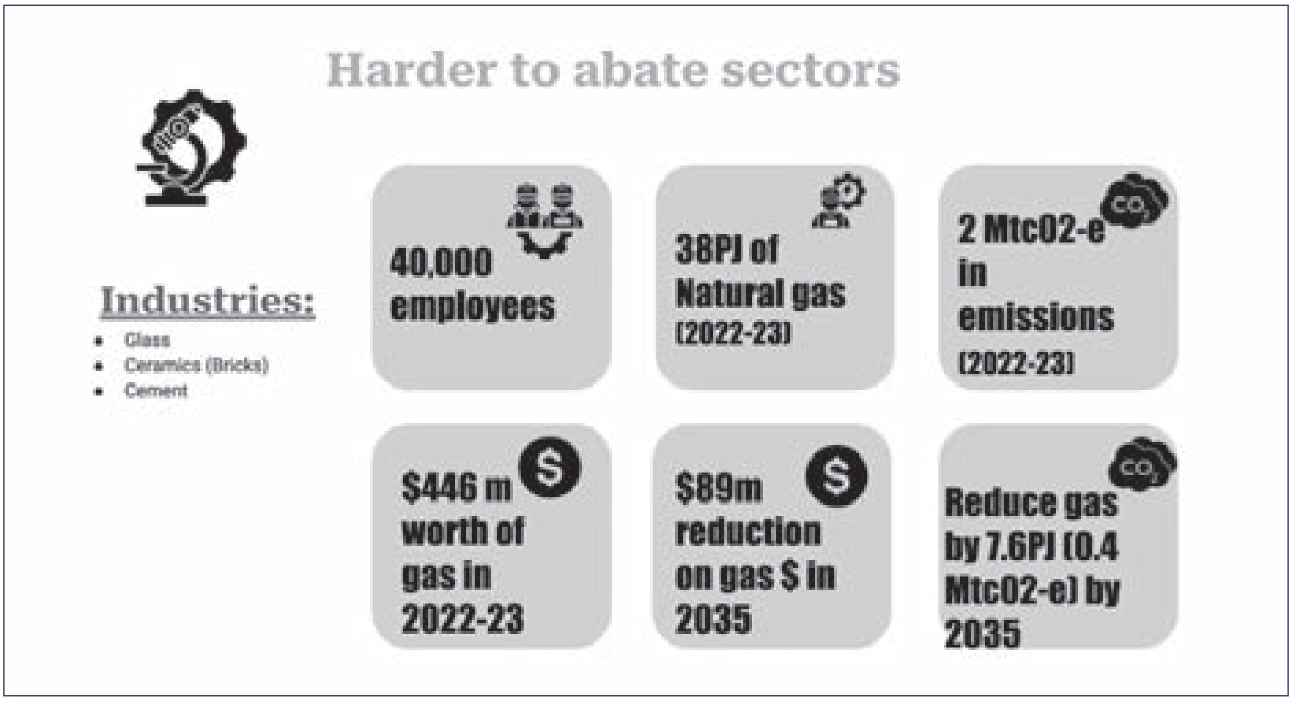
The analysis in this report has only examined existing gas usage by industry. However, many industrial facilities like the Port Kembla Steelworks are planning on shifting from coal to gas as part of the production process. A facility like Port Kembla shifting from coal to gas could increase East Coast gas demand by an additional 40 PJ per annum, place even greater strain on domestic gas security and further expose the steel industry to the international gas price volatility.

Australia needs to plan and support major industrial users to leapfrog gas and go directly to green hydrogen. If it doesn't, domestic gas shortages will become more likely and emissions will not reduce as fast as required to be consistent with stabilising global average temperatures at 1.5C above the pre-industrial average.

In New Zealand, the government has worked and co-invested with Bluescope to establish an Electric Arc Furnace at the site of New Zealand Steel's Glenbrook steel mill.[30] Serious investment needs to be committed that will enable the transition of Australia's existing metal industries to bypass gas and transition to a zero-emissions future.

30 https://www.bluescope.com/news/NZ-Steel-partners-with-Government-in--300M-co-investment

Genuinely hard to abate industries



Around 10% (38PJ) of industrial gas use occurs in sectors that are genuinely hard to abate including glass production, ceramics (brick making), and cement production.

Despite being characterised as hard to abate, technology solutions exist and are being deployed by local and international leaders that can help reduce or even eliminate gas use in these sectors. While large-scale gas use reductions are unlikely to be delivered before 2035, gas use could be reduced by 20% by 2035 with the establishment of targeted government support. This would reduce the annual wholesale gas bill by $89 million per annum, down from $446 million today, and cut greenhouse gas emissions by 400 thousand tonnes CO2-e per annum.

Industrial sub-sector analysis

Over the last seven years, there have been very marginal reductions in industrial fossil gas consumption (2.3% decrease) with sectors aside from LNG largely flat.

While AEMO's Gas Statement of Opportunities 2024 report projects future industrial gas use will decrease under all modelled scenarios – the actual and potential rate of change differs widely within and between the primary gas-consuming sectors of the economy.

The lack of a comprehensive program and policy settings aimed at supporting industry to decarbonise and shift away from gas to make the shift also means that AEMO's industrial gas use forecast is inherently conservative and significantly underplays the reductions that could be achieved.

This analysis demonstrates a more complex picture. Some industrial sub-sectors have a clear, 100% decarbonisation pathway and these sectors account for the bulk of gas demand for industry and the largest cohort of the industrial workforce. Other sub sectors will be assisted by technologies still in the prototype/testing phase making it crucial that secure and cost-effective gas supplies are available during the period of transition.

When viewed in aggregate, the industrial sector is described as hard to abate, with minimal or no carbon-neutral technologies. However, the real world is moving fast with case studies highlighted in each of the following sectors demonstrating a commercially available zero-carbon option for all sectors. Common knowledge needs to keep up with the fast evolving technology development.

The following section provides a sector by sector analysis to demonstrate the scale of electrification and gas substitution that could be achieved by industry with an ambitious and targeted plan.

Image: Gas flare / Johanna Evans

Image: Curtis Island LNG Export plant / Shutterstock

The LNG industry on the East Coast is centred in Queensland, with the LNG processing near Gladstone (Curtis island). The industry employs an estimated 4,200 employees[31] at the 3 main plants operated by Queensland Gas Company (Shell, China National Offshore Oil Corporation and Tokyo Gas), Australia Pacific LNG (ConocoPhillips, Origin and Sinopec) and Santos GLNG (a joint venture of Santos, Petronas, Total, and Kogas).[32]

In general, an LNG plant's onsite gas usage is equivalent to ~10% of the gas export volume.[33] Most of that gas is used to run onsite power generation which power the chillers to cool the gas until it liquifies at -162°C.[34]

Renewable energy with storage can be used as the power source for liquefaction rather than onsite gas generators. Electrification can also increase processing efficiency[35] and would significantly free up fossil gas for domestic use in hard-to-abate sectors (if appropriate measures are put in place to require it be made available domestically). This would cut emissions and create jobs through electrification installation and renewable job installation and maintenance.

31 https://www.shell.com.au/about-us/projects-and-locations/qgc/about-qgc/_jcr_content/root/main/section/call_to_action_594071590/links/item0.stream/1693927526176/57386794bdcdbb5083b2a0fc166cbfd2719fa8fe/about-us.pdf
32 https://www.bechtel.com/projects/curtis-island-lng/
33 Australian Energy Statistics data
34 https://www.sciencedirect.com/science/article/abs/pii/S1364032118306828
35 https://www.gevernova.com/power-conversion/case-study/full-electric-solution-for-LNG-liquefaction-trains

CASE STUDY: FREEPORT LNG'S ALL-ELECTRIC LIQUEFACTION PLANT

Freeport LNG, established in 2002 and based in Houston, Texas, has developed the world's largest all-electric liquefaction facility on Quintana Island. This facility was constructed in 2014 and is capable of exporting 15.3 million tons of LNG annually.

Freeport LNG partnered with GE Power Conversion to install all-electric drivers for the facility's refrigeration compressors. Each of the three liquefaction trains features two electrically driven refrigeration cycles, powered by three 75 MW electric systems. This setup included the largest electric motor ever supplied for an LNG facility, alongside a range of electrical infrastructure such as transformers and variable speed drives. The project helped eliminate the need for gas or steam turbines, allowing the facility to draw electric power directly from the local grid.

Freeport LNG reduced onsite combustion emissions by 90% while production has increased 6.5% due to more efficient onsite gas use.[36]

Australian LNG Electrification study

The Energy and Resource Institute of Charles Darwin University has produced a blueprint for the electrification of LNG plants. The study found that by electrifying Australia's LNG plants and powering them with solar, gas use could be reduced by up to 97PJ per annum.[37]

36 https://www.gevernova.com/power-conversion/case-study/full-electric-solution-for-LNG-liquefaction-trains
37 https://www.cdu.edu.au/files/2024-05/Wider-Benefits-and-Industry-Blueprint-for-the-Integration-of-Solar-Power-into-LNG-Plants.pdf

Electrifying of LNG Plants

This report estimates that the three LNG plants in Queensland use on average 131 PJ (2022-23)[38] a year in processing to convert around 1400 PJ of fossil gas into LNG, equating to 6.8 MtC2O-e emissions per annum.

A target of electrifying two of the plants or combining electrification of one with the phase down of another as long term export contracts expire by 2035 would result in a 79 PJ reduction of onshore fossil gas consumption.

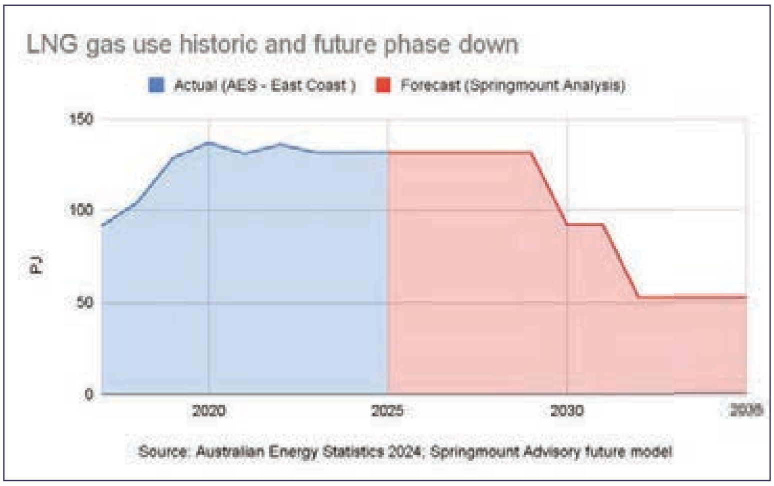


Image: Ruby Jo Field Compression Station / Johanna Evans

38 https://www.energy.gov.au/publications/australian-energy-update-2024

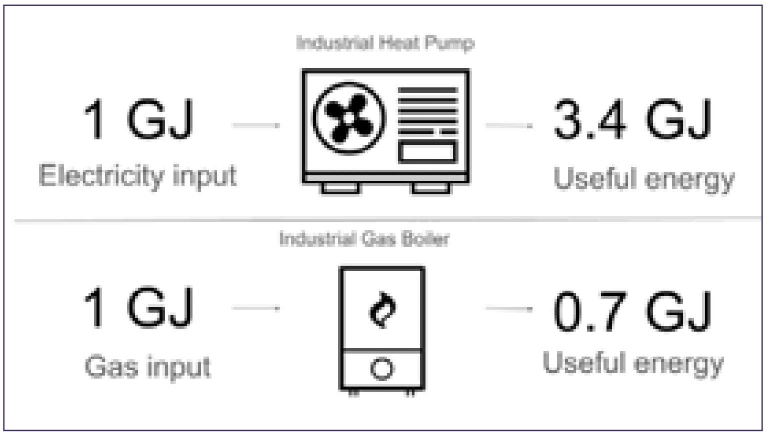
B. Electrifying manufacturing and commercial buildings

Image: Milk bottling facility

"Process heating currently accounts for the largest share of fossil fuel use in Australian manufacturing" – ARENA[39]

There are five industrial sub sectors that have an immediate opportunity to electrify their operations and eliminate fossil gas consumption, food and beverage manufacturing, paper manufacturing, other manufacturing as well as commercial buildings, and transport and warehousing. These sectors have small to moderate fossil gas consumption, ranging from 13-41 PJ, but combined, they represent a significant portion of industrial fossil gas consumption (112PJ out of 380PJ) and nearly 80% of the roughly 900,000 people employed in manufacturing in Australia. The sector is characterised by large economic value in manufacturing as well as tight business margins with gas price rises hitting hard.

Electrification of these sub sectors not only reduces fossil gas consumption from 112 PJ to 45 PJ by 2035, equating to a $800 million reduction in wholesale gas expenditure but will also deliver a significant reduction in greenhouse gas emissions.



Heat pumps are the stand-out technology in these sectors and are commercially proven and highly efficient. A heat pump will provide up to six times the thermal energy output relative to a gas boiler based on equivalent energy inputs (see infographic). This efficiency, combined with decreasing electricity costs and a greening grid, makes heat pumps a cost-effective solution for reducing greenhouse gas emissions.

39 https://arena.gov.au/projects/renewable-energy-for-process-heat-opportunity-study-phase-2/

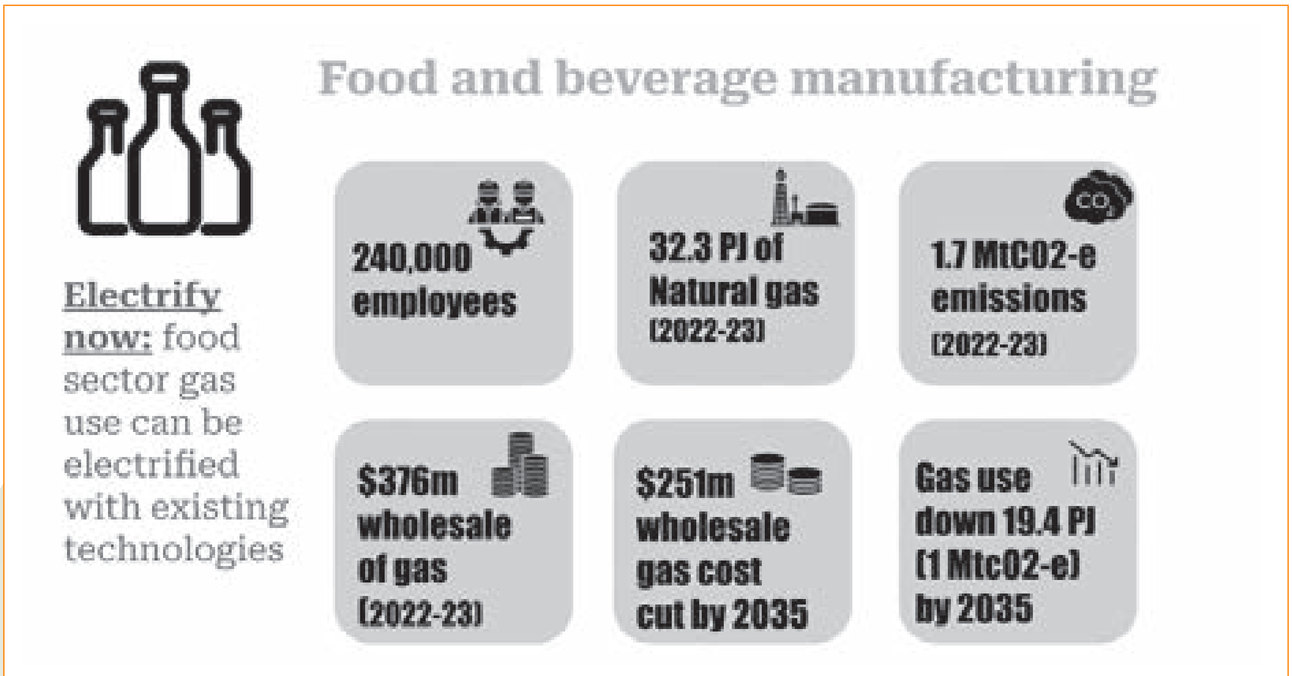
Manufacturers will benefit from support and programs that can bring down the cost of heat pumps, through financing, and or bulk ordering for various industries.

The benefits of electrifying these sub sectors include greater energy productivity, increasing the output of Australian manufacturing, increased marketability of products, reduced energy risk with rising gas prices, and opportunity for a larger portion of energy to be produced onsite or nearby.

Key barriers to overcome:

- Electrical equipment costs, mainly heat pumps;
- Labour costs to install equipment;
- potential network upgrade costs;
- plant shutdown timing.

FOOD AND BEVERAGE INDUSTRY



The food and beverage manufacturing sector employs approximately 240,000 people in around 16,000 businesses.[40] The number of people working directly in factories is estimated to be 30,000.[41]

The sector uses 32.4 PJ of fossil gas per annum[42] – the majority for ‘process heat’ where gas is used to generate hot water and lower-temperature steam – this generates around 1.7Mt CO2-e per annum.[43]

Gas use has been very moderately trending down over the past decade. The industry is growing in size, at least in Victoria[44] and sites range from large-scale food and beverage manufacturing to smaller facilities like microbreweries. Gas use is typically for hot water and lower-temperature steam with energy use accounting for at least 15% of the total operational costs in food and beverage

40 https://www.afgc.org.au/news-and-media/2021/11/new-funding-highlights-food-and-beverage-manufacturings-vital-role-in-australias-economic-future
41 https://www.jobsandskills.gov.au/data/labour-market-insights/occupations/8311-food-and-drink-factory-workers
42 https://www.energy.gov.au/publications/australian-energy-update-2024
43 https://www.vic.gov.au/sites/default/files/2020-02/Appendix_6_Electrification_Industrial.pdf
44 https://www.vic.gov.au/sites/default/files/2020-02/Appendix_6_Electrification_Industrial.pdf

manufacturing businesses. **Electrifying the food and beverage sector will reduce the cost of business and help provide input cost certainty to local manufacturers.**

Heat pumps are a key technology for decarbonising Australia's food and beverage industry. They offer an efficient way to generate industrial-grade heat using renewable energy, crucial for processes like cleaning and sterilisation. By leveraging renewable electricity from solar PV and transferring waste heat, heat pumps can significantly reduce or eliminate reliance on fossil gas boilers.[45]

Process heating in the food and beverage industry generally requires temperatures of between 70C to 160C[46] (the entire range is between 20C and 250C – see Appendix 1). This degree of heating can easily be achieved through electrical processes, like industrial heat pumps, and trials have been successfully run by ARENA and Australian Alliance for Energy Productivity to replace gas boilers with heat pumps in breweries, hot water units at meat processes facilities (see Case Study – Beer and Beef).[47] According to a recent ARENA study on process heat (Appendix 2), heat pumps are the most widely available technology for replacing various food processing processes and equipment. Sixteen out of the 18 applications have a heat pump as the available replacement technology for fossil gas burners or steam boilers. Other technologies include solar thermal, and anaerobic digestion.[48]

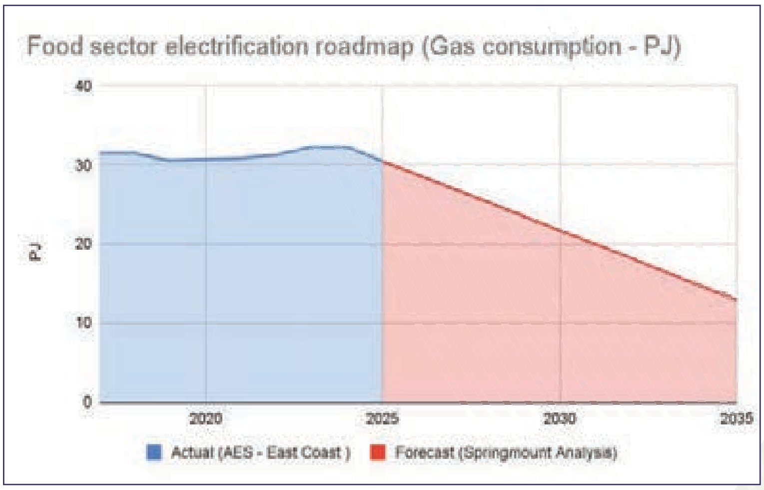
CASE STUDY: BEER AND BEEF ARE SLASHING GAS USAGE WITH HEAT PUMPS

Hardwick Meatworks in Kyneton, Victoria, plans to cut gas consumption by 75% and reduce CO2 emissions by 450 tonnes annually by adopting heat pump technology. This shift will significantly lower their carbon footprint and enhance sustainability by using renewable energy more efficiently in their meat processing operations.

Similarly, 3 Ravens Brewery in Melbourne aims to use heat pumps, powered by solar arrays and waste heat, to improve energy efficiency and reduce reliance on gas. This transition will help the brewery lower its emissions and advance its commitment to sustainability, demonstrating how heat pumps can benefit both food and beverage production.[49]

Electrifying the food and beverage sector

Gas use in the food and beverage sector has remained flat due to a lack of comprehensive government support to help businesses with the expense and risk of electrifying processes.



45 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/
46 https://static1.squarespace.com/static/5b514ee57e3c3a1fbf675baf/t/63f568c08cedcf707ae0e3d0/1677027541433/Harnessing+heat+pumps+for+net+zero.pdf
47 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/#:~:text=Beer%20and%20beef,for%20cleaning%2C%20sterilisation%20and%20packaging.
48 https://arena.gov.au/assets/2022/03/renewable-energy-for-process-heat-opportunity-study-final-report.pdf
49 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/#:~:text=Beer%20and%20beef,for%20cleaning%2C%20sterilisation%20and%20packaging

A clear program to support 60% of food and beverage producers to install high-quality electric heating solutions by 2035 could reduce gas usage in the sector by 19.4 PJ per annum and reduce gas use expenditure by at least $225 million.

Electrifying the food and beverage sector will reduce ongoing costs to business and insulate Australian manufacturers from the risk of future gas shortages while also helping drive down emissions as fast as possible.

PAPER, PULP AND PRINTING MANUFACTURING

Paper, pulp and printing manufacturing produces 3.25 million tonnes of paper and paperboard per annum.[50] The sector employs around 18,000 workers, mostly in regional Australia, across 117 businesses in the Pulp, Paper and Paperboard Manufacturing industry in Australia.[51]

Gas use in the sector is around 14 PJ, producing 0.7 Mt CO2-e emissions per annum. Paper production is heat-intensive, primarily because of the significant water evaporation required during pulp and paper drying. Innovations aimed at reducing water evaporation, and enhancing on-site waste heat recovery can boost energy efficiency and lower emissions.

Gas requirements are typically for process heat requirements, drying, boiling, bleaching and de-inking with temperature requirements from 40 to 240°C.[52] Heat pumps and electric boilers are a key technology for decarbonising the paper manufacturing sector (see Case Study: UPM Paper Mills). The use of heat pumps in paper production is highly efficient and can be used to capture latent heat from drying paper to generate steam for further drying processes.[53] By leveraging renewable electricity

50 https://ausfpa.com.au/wp-content/uploads/2018/12/2018-National-Pulp-and-Paper-Sustainability-Report.pdf
51 https://www.ibisworld.com/au/industry/pulp-paper-paperboard-manufacturing/158/#:~:text=There%20are%20117%20businesses%20in,4.1%20%25%20between%202019%20and%202024.
52 https://static1.squarespace.com/static/5b514ee57e3c3a1fbf675baf/t/63f568c08cedcf707ae0e3d0/1677027541433/Harnessing+heat+pumps+for+net+zero.pdf
53 https://www.iea.org/energy-system/industry/paper

from solar PV and transferring waste heat, heat pumps can significantly reduce or eliminate reliance on fossil gas boilers.[54]

Heat pumps can also produce heat for de-inking and bleaching processes and can reach some of the temperature requirements for boiling and drying but the upper limits are still in laboratory research (160C plus). Mechanical vapour recompression is a heat pump variant technology that assists with the evaporation process and provides a temperature lift up to 250C. This can specifically assist with wood pulping processes.

This sector has a clear, deployable pathway to cut gas use with electrification.

CASE STUDY: UPM PAPER MILLS

UPM is a major Finnish paper company with production facilities in 11 nations.

In 2023, the company announced it would replace the use of fossil gas with electric boilers in heat and steam production at its mills in Finland and Germany. A total of eight boilers will be installed, which will produce steam and heat for the mills as well as district heating.

Heat generation by electrical energy is highly efficient compared to fossil fuel boilers, which tend to lose a significant amount of energy during combustion.[55]

Once operational, they will replace a significant amount of various fossil fuels, thereby reducing emissions at the mills and at UPM. At the Finnish plants, CO_2 emissions will be cut by 50,000 tonnes per year, and even greater reductions are forecast for the mills based in Germany. An additional benefit the electric boilers offer is the ability to provide rapid demand response and quickly ramp output between 0 and 40 MW which will enable greater grid stability.

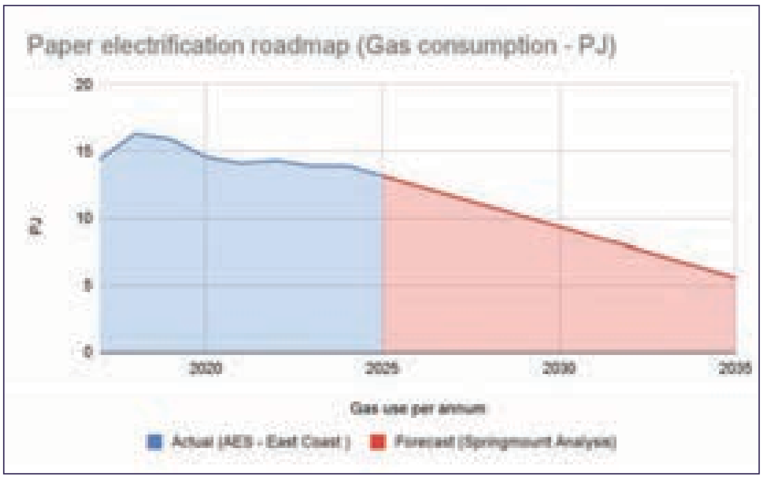
"In addition to improved security of supply and emission reduction, electric boilers will significantly increase the mills' ability to provide demand side flexibility to the electricity system and markets," – Petri Hyyryläinen, Energy Director at UPM Communication Papers.[56]

Electrifying the paper, pulp and printing manufacturing

Gas use in the paper, pulp and printing industry has been recently declining due to the closure of certain paper manufacturing processes. This is due to decreases in consumption and changes to forestry practices that have reduced the supply of 'virgin' or white paper products.[57] It's expected that operations will be adjusted to focus on paperboard using recycled paper products.

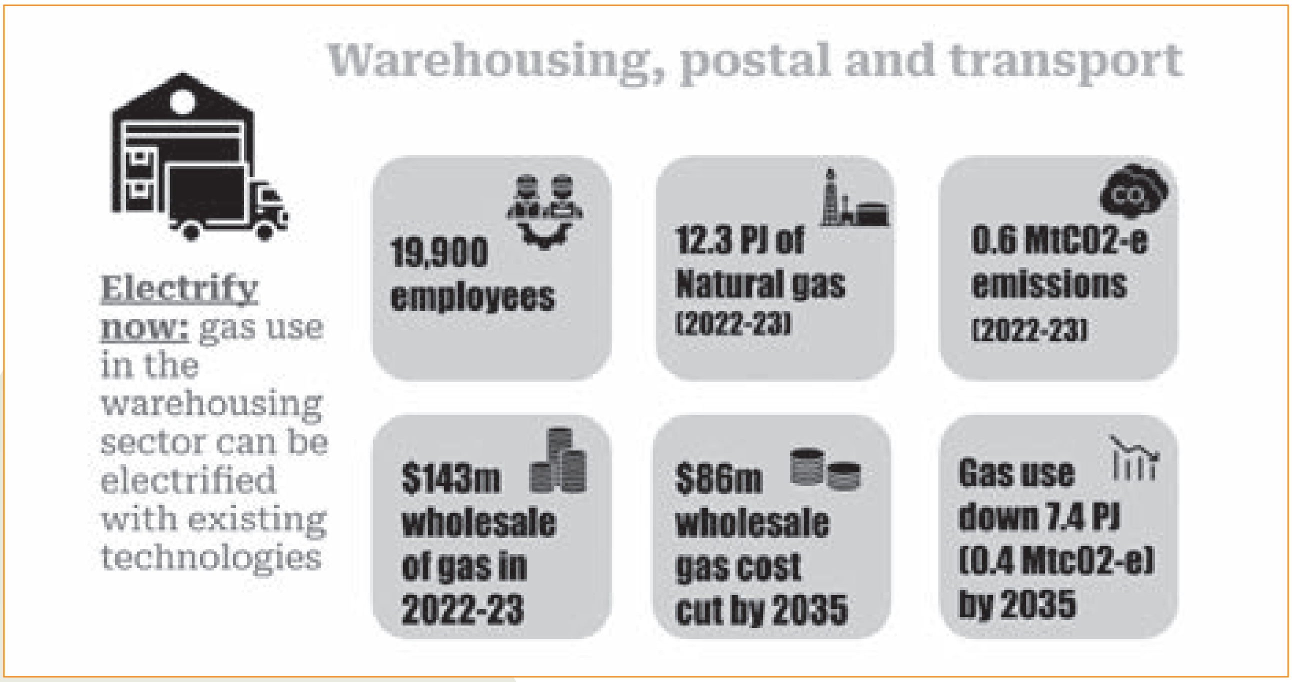
54 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/
55 https://www.upmpaper.com/articles/communication-papers/23/powering-the-future-of-paper-how-the-new-electric-boilers-at-upm-mills-will-benefit-sustainable-and-efficient-production/
56 https://www.upm.com/about-us/for-media/releases/2023/04/upm-electrifies-heat-and-steam-production-at-its-mills-in-finland-and-germany/
57 https://www.theguardian.com/australia-news/2023/feb/16/australias-white-paper-industry-is-dead-leaving-rural-communities-to-pick-through-the-pulp

There is an opportunity as paper manufacturers adjust operations to more paperboard and recycled paper production. Purchasing new electric equipment or upgrading existing equipment as lines are adjusted can avoid some of the typical electrification challenges.



A clear program that supports the 117 businesses to upgrade to high-quality electric heating solutions for the paper industry could reduce gas usage in the sector by 8.3 PJ per annum by 2035 and reduce gas use expenditure by at least $96 million.

TRANSPORT, WAREHOUSING



The transport and warehousing sector used 12.3 PJ in 2022-23 of fossil gas. The majority of gas used in this sector is likely used for heating water and heating air for the thermal comfort of workers. There are 19,900 warehouse administrators employed in Australia.[58]

This sector, similar to the commercial building sector, has a clear, deployable decarbonisation pathway through electrification. Heat pumps are a key technology for decarbonising the warehousing sector. They offer an efficient way to generate building hot water or space heating using

58 https://www.jobsandskills.gov.au/data/occupation-and-industry-profiles/occupations/591116-warehouse-administrators

renewable energy. By leveraging renewable electricity from solar PV and transferring waste heat, heat pumps can significantly reduce or eliminate reliance on fossil gas boilers.[59]

CASE STUDY: WAREHOUSE ELECTRIFICATION:

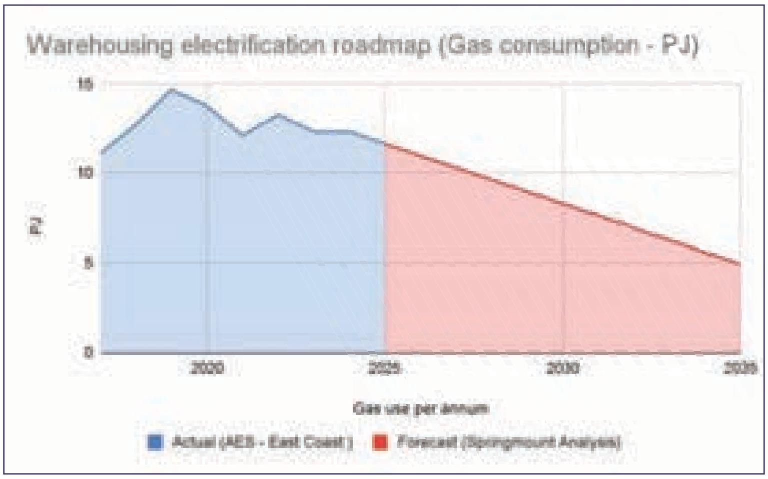
DHL UK has opened a multi-user facility in Coventry that is entirely powered by renewable electricity and has achieved BREEAM 'Outstanding' certification. Key features include an air source heat pump that reduces CO2 emissions by approximately 135 tonnes annually, alongside 3,000 solar panels and an innovative battery storage system, which collectively enhances energy self-sufficiency. Additionally, it includes infrastructure for electric vehicles and all-electric material handling equipment, ensuring a modern and efficient operational environment.[60]

Electrifying the transport, postal and warehousing sector

The roof capacity and space availability in the warehouse sector makes it well positioned to rapidly electrify gas equipment and reduce exposure to future gas price spikes. Gas use in the transport postal and warehousing sector peaked at 15 PJ in 2019, with a notable decline during the COVID-19 period. Without government support to help businesses install electrification equipment, the use of fossil gas will likely persist.

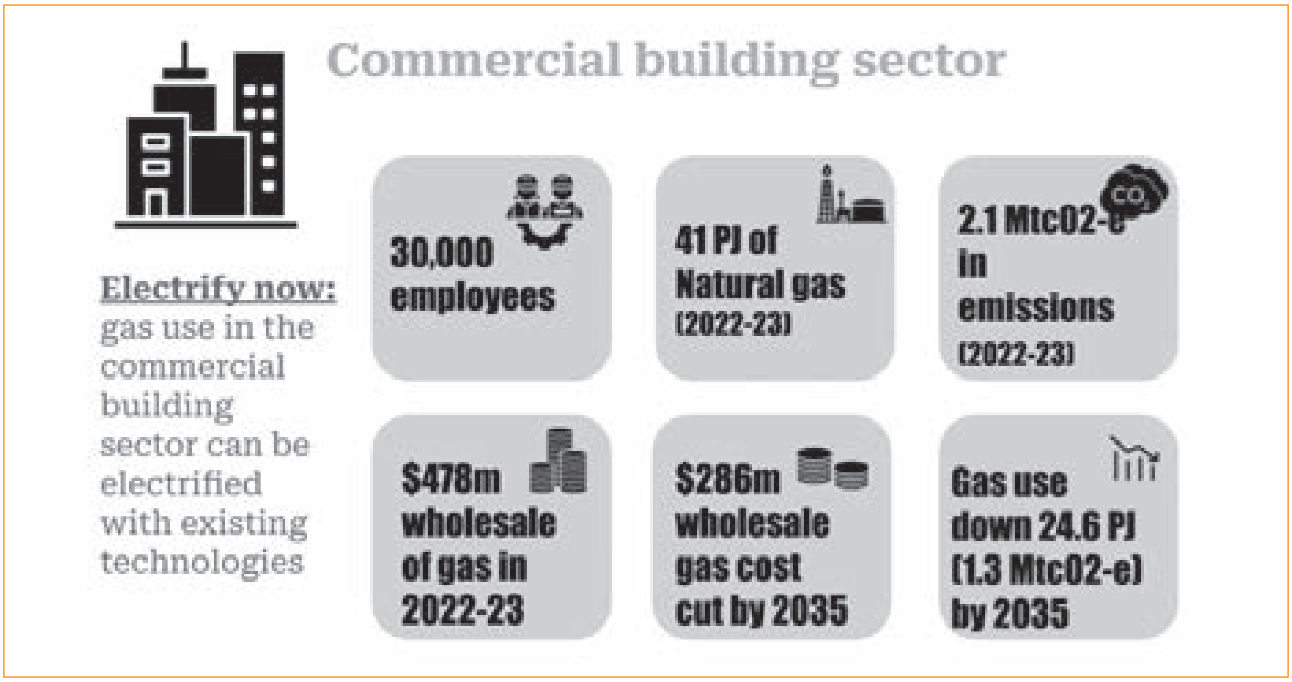
A clear program to support businesses to upgrade to high-quality electric solutions for the transport postal and warehousing sector could reduce gas usage by 7.4 PJ per annum by 2035, equaling 0.4 Mtc2O-e of carbon emissions and reducing gas expenditure by at least $86 million.

Electrifying the transport and warehousing space will reduce ongoing costs to businesses and insulate local manufacturers from the risk of future gas shortages while also helping drive down emissions as fast as possible.



59 https://arena.gov.au/blog/heat-pumps-electrifying-industrial-processes/
60 https://www.logisticsbusiness.com/materials-handling-warehousing/distribution-centre-property/operationally-carbon-neutral-warehouse/

COMMERCIAL BUILDING SECTOR



There are 190,000 commercial buildings in Australia[61] with the majority of gas use occurring in Victoria and NSW. Gas use peaked in 2010-11 at 45.9 PJ and is now roughly 40 PJ a year equivalent to 2.5 mt CO2-e of emissions per annum.

Gas is used in commercial buildings for space and water heating and in commercial kitchens. There is a significant opportunity to drive down commercial building gas usage through the replacement of gas units with heat pumps and induction cooktops. The GBCA has developed a practical guide to reducing emissions for existing commercial buildings.[62]

Heat pumps are a key technology for decarbonising commercial buildings. They offer an efficient way to generate both hot water and space heating, additionally, when coupled with heat recovery, heat pumps can further increase efficiency. Heat pumps are highly efficient, providing up to six times the thermal energy compared to the electrical energy input, which greatly surpasses the efficiency of traditional steam systems. This efficiency, combined with decreasing electricity costs and a greening grid, makes heat pumps a cost-effective solution for reducing greenhouse gas emissions.

Additionally, induction stove cooktops compared to gas cooktops have several benefits over gas burners/ovens/fryers/grills. Their cooking efficiency is up to 90%, compared to 53% for gas cooktops, for example boiling water in 3 mins 35 sec compared to 5 mins 49 seconds. They are also easier to clean, have a lower fire risk and need less ventilation. These benefits make it safer and more pleasant for staff as well as increasing efficiency and lowering operational costs for businesses.[63]

61 https://www.afr.com/property/commercial/time-to-do-away-with-gas-in-buildings-gbca-says-20220920-p5bjin
62 https://gbca-web.s3.amazonaws.com/media/documents/electrification-guide---existing-buildings-final.pdf
63 See page 26, https://gbca-web.s3.amazonaws.com/media/documents/electrification-guide---existing-buildings-final.pdf

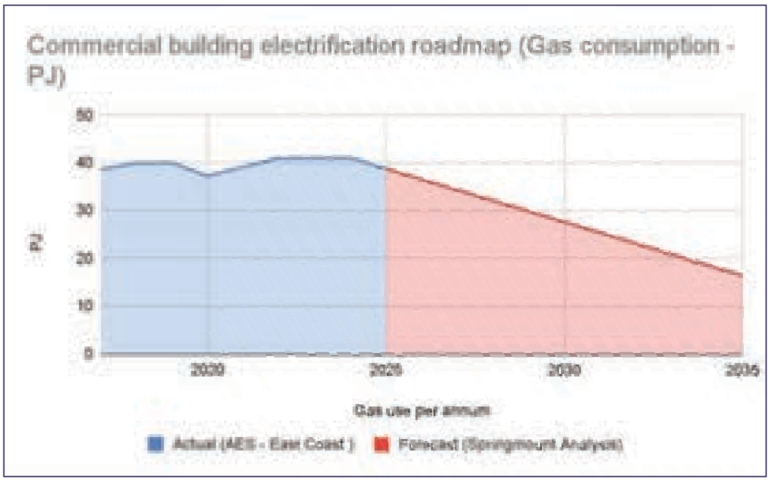
CASE STUDY: CHEFS AND RESTAURANTS RECOGNISE THE VALUE OF INDUCTION COOKING

The majority of gas use in commercial buildings is for heating air and water, however commercial kitchens located in each building will normally have a gas supply too. Many leading restaurants are leading the charge to an electric future and removing a barrier that prevents some commercial buildings from fully electrifying. Stokehouse chef, Jason Staudt, welcomes the shift saying “As much as I love gas, induction has advanced in so many ways. It’s more powerful, the cleaning is easier, and the cooking is more accurate.”[64]

While Neil Perry has driven a shift to electrification by installing induction cooktops in the kitchens at Rockpool Bar & Grill, Spice Temple and Rosetta. “They’re far easier to clean down after use, which is one of the main reasons we chose induction over gas. With induction, you’re no longer a slave to an incredibly dirty gas stove top with multiple fittings that have to cool down and be dismantled ahead of cleaning.”[65]

Electrifying the commercial buildings sector

A clear program is required to support commercial building electrification. A priority is to ensure no new commercial buildings are connected to the gas network to prevent deepening dependence on expensive fossil gas.



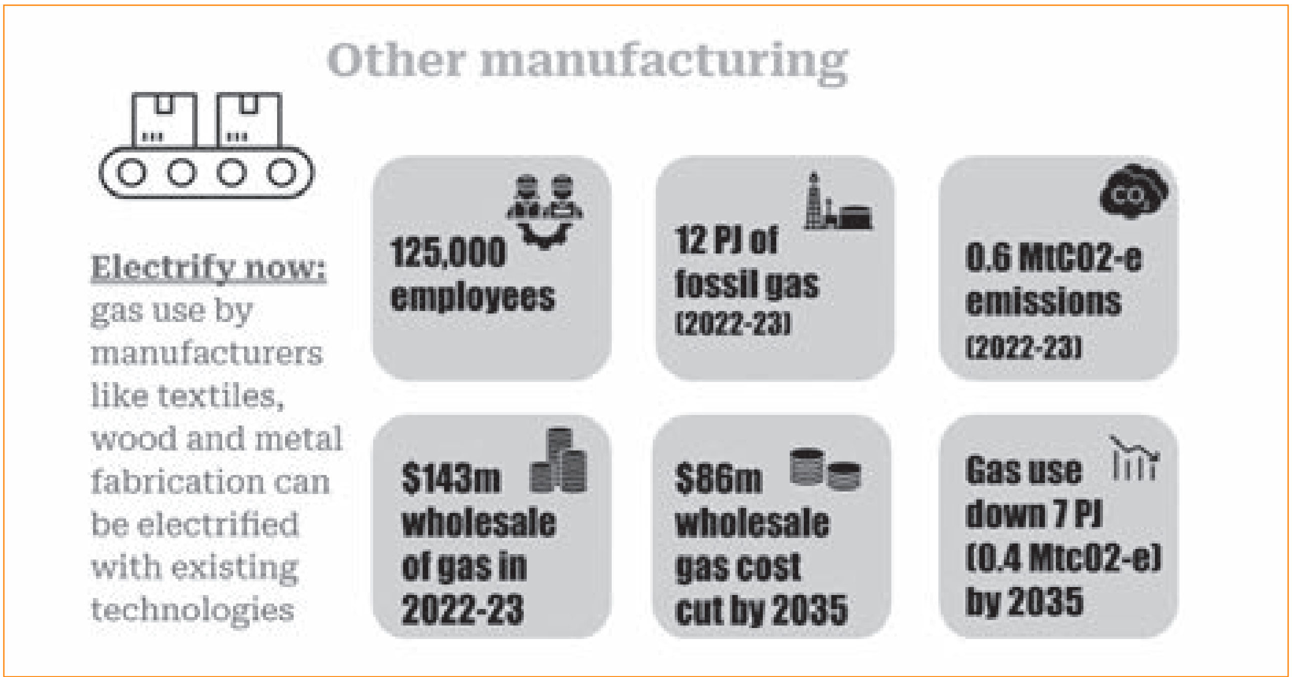
There are physical and economic constraints to switching commercial buildings to all-electric, with some buildings requiring more space for an electric unit (as it must store water instead of instantly heating it). Additionally, there will be engineering challenges where plants are located on the roof of buildings (as opposed to basements) and therefore load limits can be an issue as well as space.

A focus on buildings with minimal constraints and older plant equipment ready for replacement could result in a steady electrification of commercial building stock. This could reduce gas use in the sector by 24.6 PJ per annum by 2035 and reduce gas use expenditure by at least $286 million.

64 https://www.goodfood.com.au/eat-out/news/no-longer-cooking-with-gas-how-a-shift-to-induction-cooking-could-affect-victorian-homes-and-restaurants-20210507-h1vocw

65 https://www.goodfood.com.au/good-living/gas-v-induction-cooktops-what-is-your-pick-20170428-gvv914

OTHER MANUFACTURING



A wide range of manufacturers are captured within "other manufacturing" – this includes textiles; wood products; fabricated metal; machinery equipment; furniture; and non-metal mineral products.

These industries used 12.3 PJ of fossil gas in 2022-23, down from around 15 PJ in 2017 and 2018. The bulk of these industries likely use gas for process heat, kilns for wood drying, and heating for treating and shaping fabricated metal. Together they employ around 125,000 people.

Most gas use requirements in the sectors can be electrified as outlined in the *Harnessing heat pumps for net zero* report[66]. Textiles require heat between 40- 160 C which can mostly be served by commercially available heat pumps. Wood products require temperatures between 40-180C some of which can be provided by heat pumps, while higher heat can be provided by solar thermal technology and thermal bricks. Fabricated metal and non metal mineral products require temperatures between 20- 200C and can likely be met via a mix of electric technology solutions. The exact role of gas in furniture making and machinery equipment is unclear but is small and can likely be met via electric technology solutions like heat pumps.

Electrifying manufacturing

The six manufacturing sub-sectors use 12.3 PJ of fossil gas in 2022-23. It's estimated that this could be reduced through electrification by 60% in 10 years. Reducing fossil gas consumption by 7.38 PJ and gas expenditure by $86 million in 2035.

66 https://static1.squarespace.com/static/5b514ee57e3c3a1fbf675baf/t/63f568c08cedcf707ae0e3d0/1677027541433/Harnessing+heat+pumps+for+net+zero.pdf

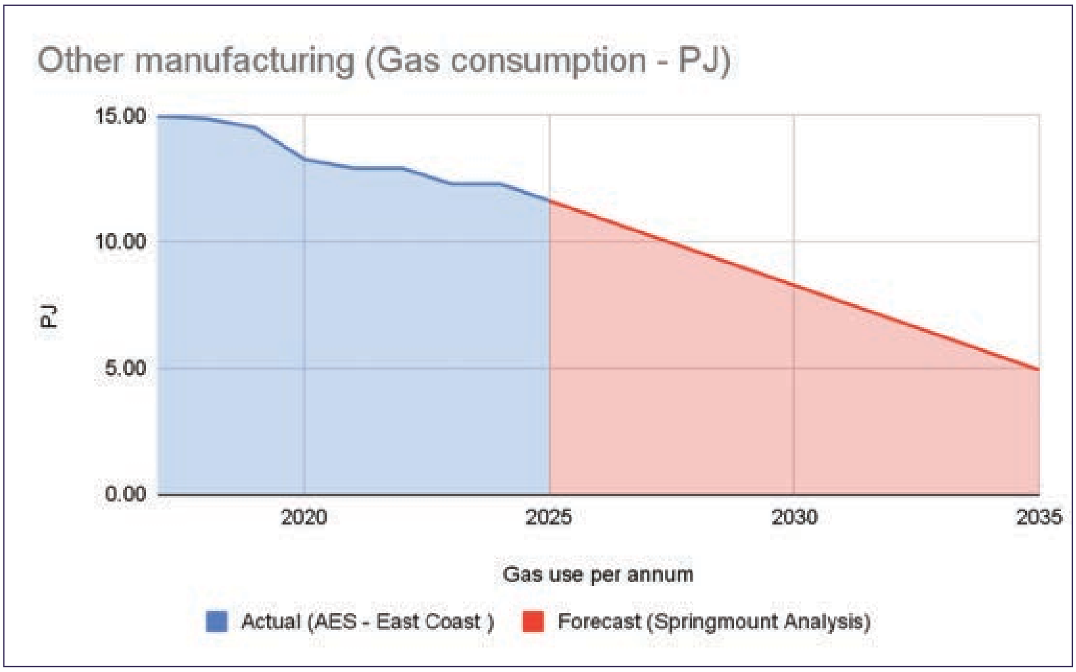


Image: Induction heaters in a restaurant kitchen / Shutterstock

Image: Yarwun alumina refinery; Rio Tinto

The Regassing industry cluster covers metals smelting and refining, iron and steel manufacturing, and chemical manufacturing,

These 3 sectors have had a considerable focus on decarbonisation pathway development, for example, ARENA has produced a *Roadmap for Decarbonising Australian Alumina Refining*.[67] They have been classed as hard to abate due to the high heat requirements for steel and alumina and the energy requirements for ammonia. However, accelerating investment in hydrogen production means a clearer pathway now exists. Additionally, in alumina refining electrification options such as mechanical vapour compression can also play a role in reducing onsite gas use.

These sectors are highly valuable to the Australian economy, contributing significantly to exports and employing 134,500 people nationally. In addition, the sector provides critical inputs to the broader manufacturing ecosystem. There is an opportunity for Australia to lead investment in regassing these industries and demonstrating our capability for low-carbon industries.

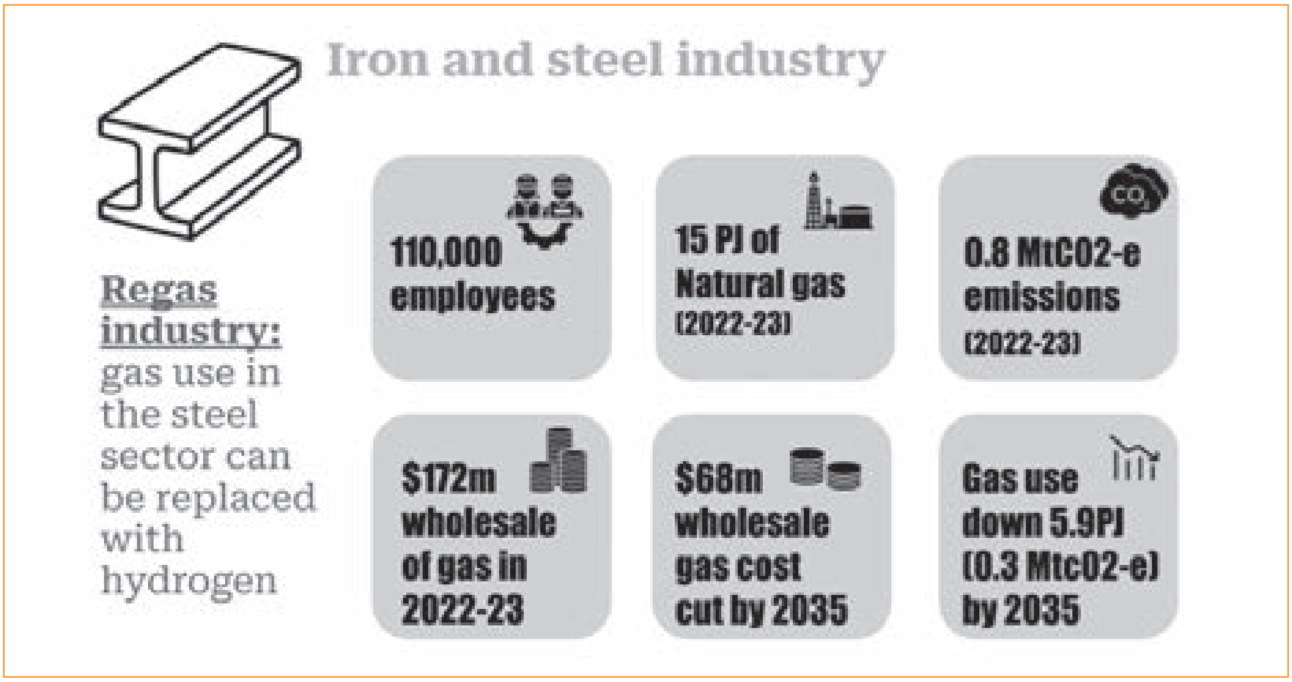
An ambitious program to regas industry could cut fossil gas consumption on the East Coast by these three sub sectors from 123 PJ to 61PJ by 2035. This would reduce the exposure of these critical industries to gas price volatility and supply constraints and ultimately help reduce energy costs and increase energy productivity.

Regassing will also ensure Australian steel, aluminium and chemicals have access to global markets as global supply chains increasingly decarbonise.

Making this a reality will require overcoming key barriers including ensuring they have access to a sufficient amount of hydrogen, sufficient renewable energy to produce the hydrogen, and support with the investment costs for installing hydrogen compatible equipment and facility upgrades.

67 https://arena.gov.au/knowledge-bank/a-roadmap-for-decarbonising-australian-alumina-refining/

IRON AND STEEL INDUSTRY



The iron and steel industry in Australia employs around 110,000 people. The Australian steel industry consists of four primary steel producers, supported by over 300 steel distribution and processing sites throughout the country and hundreds of manufacturing, fabrication and engineering companies.

The industry uses a small amount of fossil gas relative to the rest of its emission-intense production, around 15 PJ equating to 0.8 Mtc2O-e in emissions per annum. A significant proportion of the steel gas use is for industrial process heating applications like hot rolling, heat treatment, and curing.[68]

Hot rolling requires high-temperature heat (1000-1200 degrees) and is typically done with a gas-fired furnace as the steel must be deformed and shaped quickly. Heat treatment is done to improve the properties of the steel such as hardness, wear resistance and strength, typically involving temperatures between 500- 800 degrees.[69] Hot rolling and heat treatment have two decarbonisation options with hydrogen furnace technology the most likely while electrical induction is another option.

Pre-heating, drying and curing are used to add surface coating for aesthetics and corrosion resistance such as galvanising or painting. Typically fossil gas is used in an oven or furnace as part of the curing or removal of water with temperatures normally operating between 100-200 degrees.[70] Drying and curing can be performed with hydrogen, but given the low-temperatures, a heat pump-based oven may be better suited both economically and from an equipment availability perspective.

68 https://www.steel.org.au/Membership/media/Australian-Steel-Institute/Submission%20documents/Submission-to-the-Future-Gas-Strategy-consultation-paper-091123.pdf

69 https://www.steel.org.au/Membership/media/Australian-Steel-Institute/Submission%20documents/Submission-to-the-Future-Gas-Strategy-consultation-paper-091123.pdf

70 https://www.steel.org.au/Membership/media/Australian-Steel-Institute/Submission%20documents/Submission-to-the-Future-Gas-Strategy-consultation-paper-091123.pdf

Additionally, there are several waste heat recovery solutions that are available, especially if parts of the production process are closely located.[71]

CASE STUDY: REDUCING GAS CONSUMPTION FOR STEEL ROLLING

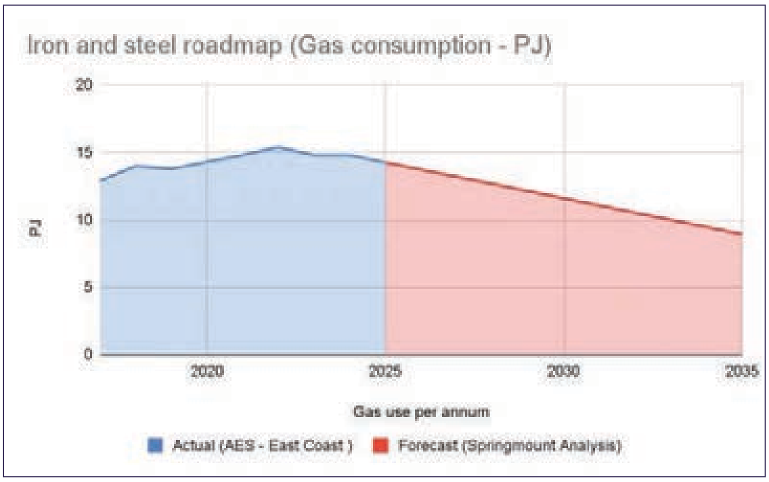
On September 5, 2023, Ovako launched the world's first plant that produces fossil-free hydrogen for heating steel, marking a significant milestone in Swedish steelmaking. The facility can generate 3,880 cubic metres of hydrogen per hour using a 20 MW electrolysis plant. Ovako aims to cut emissions from its heating processes to nearly zero and help reduce overall emissions by 80% by 2030.[72]

By replacing fossil fuels with hydrogen in high-temperature processes such as rolling and forging, Ovako is taking a big step towards sustainable steel production. The initiative is supported by the Swedish Energy Agency and the European Union and underscores the key role of ambitious policy and investment to reduce the environmental impact of steel manufacturing.

Regassing and electrifying the iron and steel industry

Decarbonising the steel processing industry will require significant capital investment, especially for both rolling and heat treatment given their high-temperature requirements. Electrification of drying and curing processes should be an immediate focus due to the low heat requirements and available electrification options.

As local steel makers transition away from coal use there needs to be caution around the fuel type and infrastructure build-out when decisions are being made to replace Australia's current BF-BOF steel-making industry or any build of new industry. Supporting industry to leapfrog gas and go direct to green hydrogen production methods should be a priority given the tightness of the East Coast gas market and our climate commitments.

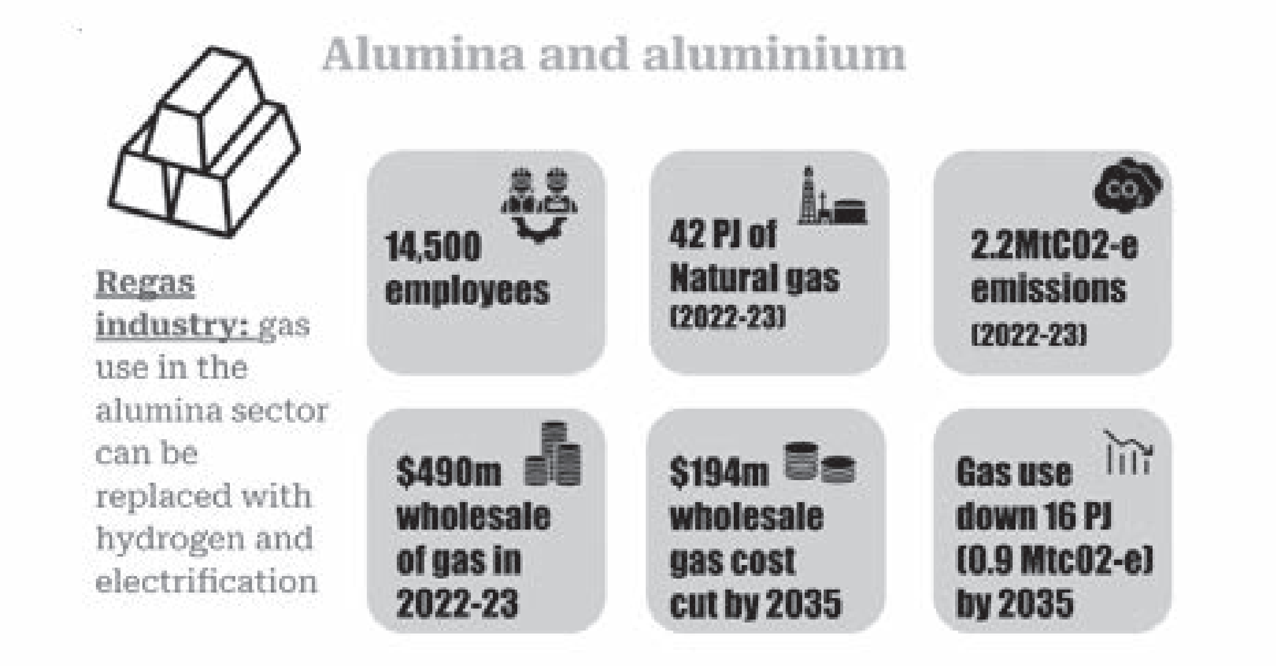


With the right support this is completely feasible. For example, Bluescope is building an electric arc furnace – in New Zealand – that was made possible, in part, by support from the New Zealand government[73]. It's likely Australia could achieve the same result here if governments provide a clear direction in Australia's Net Zero Plan.

Replacing some equipment could reduce gas usage in the sector by 3.9 PJ per annum by 2035 and reduce gas use expenditure by at least $68 million in today's dollars.

71 https://www.allianceforindustrydecarbonization.org/-/media/Alliance/Files/Publications/AFID_Solutions_decarbonise_steel_industry_2024.pdf
72 https://www.steeltimesint.com/news/ovako-makes-climate-history-at-hofors-sweden
73 https://www.bluescope.com/content/dam/bluescope/corporate/bluescope-com/investor/documents/2023_BlueScope_NZ-steel-EAF-announcement.pdf

ALUMINA AND ALUMINIUM (NON-FERROUS METALS INDUSTRY)



This sector covers the refining of non-ferrous metals, i.e. metals other than iron. The majority of gas used in this sub sector is used by the alumina refining industry. Australia is the world's second largest alumina producer – refining 19 m t in 2022-2023.[74] Two of the nation's 5 alumina refineries are located in Queensland with the remainder in WA.

Aluminium smelting, the process after alumina production is a high energy user, but of electricity rather than onsite fossil fuels.[75] Other metals refining, including Copper, Silver, Lead and Zinc refining and smelting also use a small portion of gas.

Non-ferrous metals manufacturing on the East Coast uses a large amount of manufacturing gas, around 42 PJ,[76] equating to 2.2 Mtc2O-e in emissions per annum. The Australian aluminium industry overall employs around 14,500 people.[77]

The main use is for process heating requirements in refineries. The two alumina refineries in Queensland use higher-temperature digestion, the temperature of digestion is determined by the type of bauxite that is refined in each region and it is a key consideration when determining which abatement pathways should be pursued by different refineries.

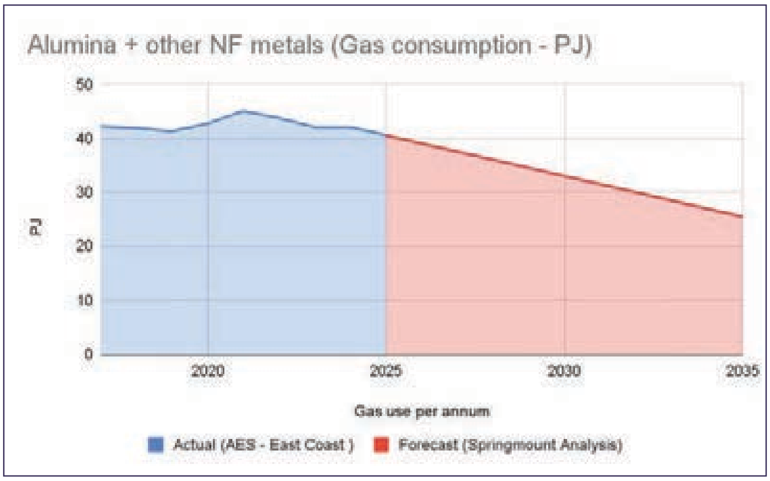
Rio Tinto has recently entered a major 2.2GW renewable energy PPA for its Gladstone operations (Boyne aluminium smelter, Yarwun alumina refinery and Queensland Alumina refinery).[78] The majority of the electricity is likely to be consumed at the Boyne aluminium smelter, but will also provide a pathway to start reducing gas use at the two alumina refineries too.

74 https://www.industry.gov.au/publications/resources-and-energy-quarterly-march-2024
75 https://arena.gov.au/assets/2022/11/roadmap-for-decarbonising-australian-alumina-refining-report.pdf
76 https://arena.gov.au/assets/2022/11/roadmap-for-decarbonising-australian-alumina-refining-report.pdf
77 https://awu.net.au/news/2020/03/10840/email-aluminium-council-statement/#:~:text=The%20Australian%20aluminium%20industry%20directly,near%20regional%20operations%20around%20Australia.
78 https://www.riotinto.com/en/news/releases/2024/rio-tinto-signs-australias-biggest-renewable-power-deal-as-it-works-to-repower-its-gladstone-operations

Regassing and electrifying the Alumina and Aluminium industries

Gas use in the non-ferrous metal manufacturing industry has been consistent over the last decade without much reduction, (peak in 2013-14 at 149.1 PJ for Australia).

A program that supports the two QLD alumina refineries to switch to decarbonised technologies will require significant capitalist investment and sufficient renewable build-out. A gradual reduction in gas use of 16 PJ by 2035 will reduce gas expenditure by almost $194 million.



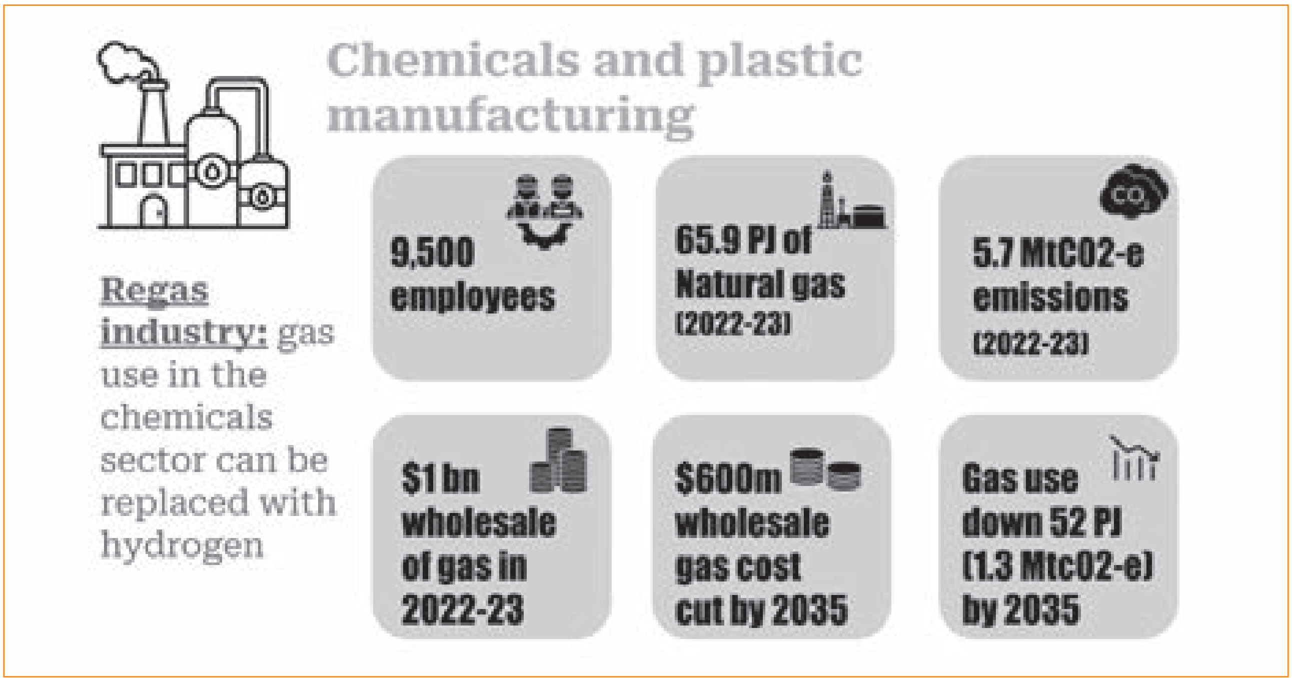
CASE STUDY: ALPHA HPA'S GLADSTONE HPA FIRST PROJECT

Alpha HPA secured $400 million in financing from the Australian Government to develop its Gladstone-based HPA First Project, which aims to become one of the largest ultra-high-purity alumina refineries globally. The investment will enable Alpha HPA to achieve full-scale production of over 10,000 tonnes of high-purity alumina annually, creating 120 permanent local jobs alongside 300 construction jobs.

Alpha HPA's proprietary technology allows for the cost-effective and low-carbon extraction and purification of aluminium from industrial feedstock, targeting high-tech sectors such as semiconductors, lithium-ion batteries, and LED lighting. The 10-hectare facility will be nearly zero waste, recycle nearly 100% of its reagents, operate on 100% renewable energy, and utilise processes that are 70% lower in carbon emissions compared to traditional HPA refining methods. This initiative represents a major step toward establishing Australia's first large-scale commercial capability for high-purity alumina production, aligning with the global energy transition.[79]

79 https://alphahpa.com.au/news/400m-australian-government-support-to-establish-australias-first-commercial-scale-high-purity-alumina-products-facility/

CHEMICALS AND PLASTIC MANUFACTURING INDUSTRY



The chemical industry on the East Coast uses an estimated 66 PJ of fossil gas each year, producing roughly 5.7 MtCO2-e of emissions per year, and employs approximately 9,500 workers.[80]

The primary use of fossil gas by the industry is its use as a feedstock[81] for the production of ammonia for the manufacture of fertilisers, explosives and other chemicals. Ammonia is currently produced using fossil fuels but green hydrogen production pathways are also viable. This involves generating hydrogen through water electrolysis and separating nitrogen from the air. These two components are then combined in the Haber-Bosch process to produce ammonia.[82]

CASE STUDY: YURI RENEWABLE HYDROGEN TO AMMONIA PROJECT

The Yuri Renewable Hydrogen to Ammonia Project will utilise a 10 MW electrolyser powered by 18 MW of solar PV and supported by an 8 MW battery energy storage system. This setup aims to generate renewable hydrogen for producing renewable ammonia at Yara Pilbara Fertilisers' nearby liquid ammonia plant in Karratha, Western Australia.[83]

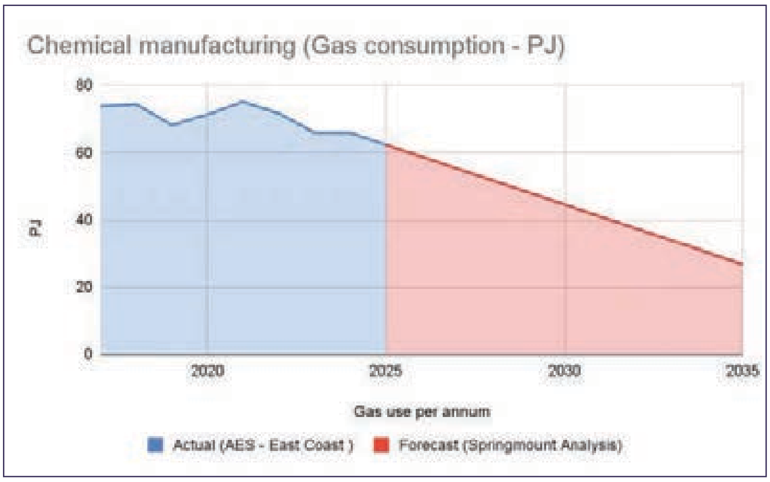
The Yuri Project will generate renewable hydrogen for ammonia production using off-grid, intermittent renewable power through electrolysis and will help validate the business case for renewable hydrogen and foster the growth of the renewable ammonia industry in Australia. Alongside other demonstration projects, this initiative is crucial for transitioning renewable hydrogen concepts into industrial applications. Once operational, it will rank among the largest renewable-powered electrolysers globally.

80 Calculated from Jobs and Skills Australia employment data, 60% of jobs assumed to be located in the East Coast – 9540
81 https://www.gasenergyaus.au/get/1872/acil-allen-chemistry-australia-report-july.pdf
82 https://royalsociety.org/news-resources/projects/low-carbon-energy-programme/green-ammonia/#:~:text=However%2C%20the%20process%20of%20making,is%20from%20the%20SMR%20process.
83 https://arena.gov.au/projects/yuri-renewable-hydrogen-to-ammonia-project/

Regassing the chemical industry

There are already several green hydrogen to ammonia projects in development in Australia (like the Yara Yuri case study) although they are small compared to the 410,000 tonnes of hydrogen produced each year from fossil gas for ammonia.[84] Decarbonising hydrogen for ammonia will require significant build costs, for renewable energy for hydrogen production, as well as hydrogen electrolysers. Based on the Yara Yuri project, meeting all of Australia's current hydrogen requirements for ammonia would require 6.4 GW of electrolysers, 11 GW of solar energy, and 3.2 GW of battery storage.

Producing green ammonia for fertilisers and explosives will require significant capital investment in both infrastructure and renewable energy, however, exports stand to increase due to their green credentials and eventually lower-cost energy inputs. A plan over the next 10 years to reduce reliance on gas would reduce consumption by 52 PJ and reduce gas use expenditure by $600 million.



84 https://www.csiro.au/en/research/environmental-impacts/fuels/hydrogen/ammonia-and-reaching-net-zero

D. Harder to abate industries

Image: Railton cement; Cement Australia

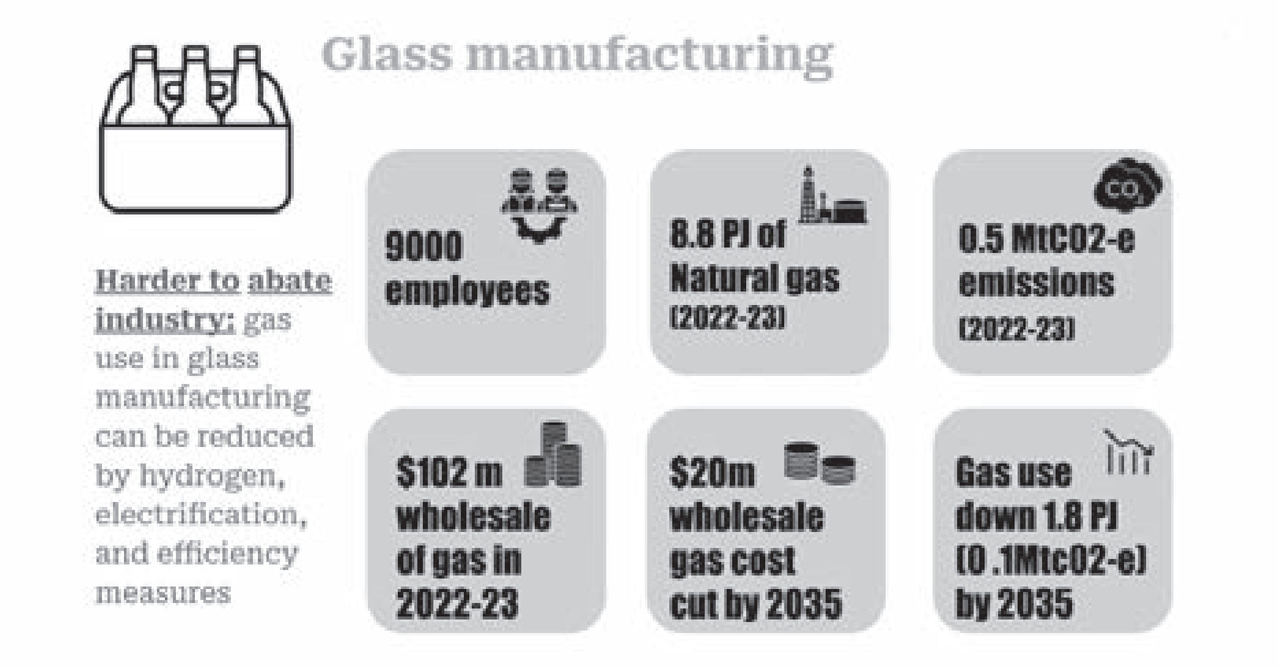
Cement, glass and ceramics (predominantly brick production) make up the final three gas using industries in Australia. While these sectors are hard to abate, abatement is not impossible as shown below by recent case studies, and deployable efficiency measures already exist.

Globally, new technology is now being deployed to reduce gas use in these sectors which Australia can learn from and start to deploy as the technology matures. The challenges to reducing gas use immediately however underscore the need to deploy at scale in the other sectors covered in this report first to reduce gas demand and ensure there is sufficient runway and affordable gas while decarbonisation technology develops for the harder to abate industries.

Despite the challenges, using a combination of hydrogen blending and efficiency measures, gas use in the harder to abate industries on the East Coast can be reduced 38 PJ to 30PJ by 2035, equivalent to $88 million reduction in wholesale gas expenditure per annum.

Upgrades are likely to lead to energy efficiency improvements, saving on energy costs and increasing energy productivity. However increased investment into research and development and pilot deployment is required in these industries over the next decade.

GLASS INDUSTRY



The glass industry in Australia employs 9000 people.[85] The industry uses around 9PJ of fossil gas each year, producing 0.5Mt CO2-e emissions per annum. The main requirement for gas is in-process heat during the forming of the molten glass phase.

For virgin glass, gas is used in a furnace with blended raw materials (silica sand, soda ash and limestone. Molten glass is formed at 1550 degrees celsius in 20-minute cycles. The current method relies on the carbon in fossil gas as it participates in the chemical reaction. There are constraints with getting to the temperature using different technologies (such as electric), especially after accounting for capital costs and current electricity prices.

For recycled glass, the glass is crushed, cleaned, sometimes incorporated with colours or raw materials, and then melted in the furnace.[86] Incorporating recycled glass with new glass or only using recycled glass requires slightly lower heat temperatures (1420 degrees).[87]

CASE STUDY: VERALLIA GLASS, COGNAC, FRANCE

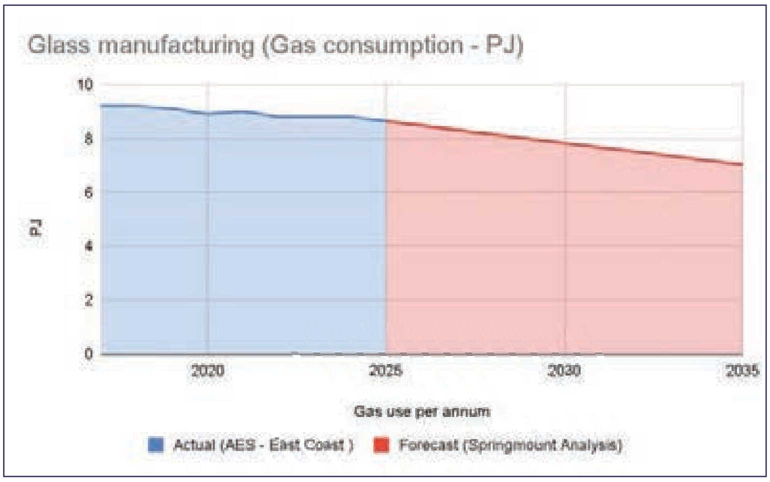
Verallia has inaugurated the world's first 100% electric furnace at its Cognac plant[88] The electric furnace, developed in collaboration with Fives, has a daily production capacity of 180 tons and reduces CO2 emissions by 60% compared to traditional gas-fired furnaces and represents a significant technological advancement in the hard to abate glass industry.

The project required a €57 million investment and aligns with Verallia's decarbonization strategy, which targets a 46% reduction in emissions by 2030 from 2019 levels.

85 https://www.ibisworld.com/au/industry/glass-and-glass-product-manufacturing/206/
86 https://www.recyclenow.com/how-to-recycle/glass-recycling
87 https://www.gpi.org/facts-about-glass-recycling
88 https://www.verallia.com/en/communique-de-presse/cognac-electric-furnace-inauguration/

The furnace's design leverages decarbonized energy available near the Cognac site, supported by the ADEME initiative under the 'France 2030' plan. It is specifically engineered for producing flint glass bottles, contributing to a more sustainable production process while maintaining high quality. This innovation underscores a shift in manufacturing practices within the glass industry, emphasising energy efficiency and lower environmental impact through the adoption of electric melting technologies.

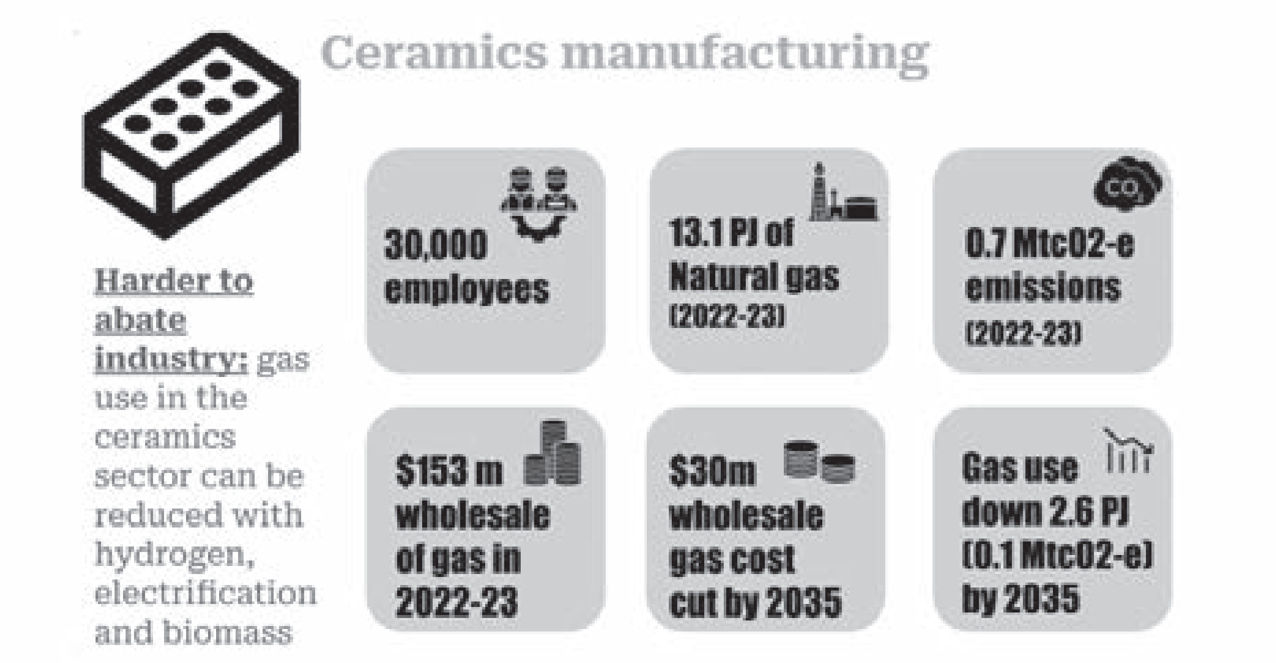
Electrifying the glass industry



As the technology for decarbonising glass manufacturing has only recently been commercially deployed (September 2024), it will take time for glass electric arc furnaces to be more widely deployed. The industry will likely need support with the infrastructure costs and the renewable energy build-out required to support the energy needs of electric arc furnaces.

In the longer term, the industry will benefit from more energy-efficient operations with electric arc furnaces as well as selling a green premium product. Switching some of the glass manufacturers over to electric arc furnaces will reduce gas demand, we estimate by 1.8 PJ, savings $20 million

CERAMICS INDUSTRY



The ceramics industry in Australia is made of two main categories, clay brick manufacturing and other ceramic products (other brick types, tiles, crockery, pots, pipes, roofing). It's difficult to ascertain the gas use split for bricks and other ceramic products however it's assumed that brick manufacturing is the main gas consumer. The brick industry employs 30,000 workers.[89]

Bricks are produced by mixing clay water and then moulding that into a rectangular shape, drying and then firing. The mixture must be fixed into stiff mud and then pressurised by a vacuum to remove air. It's then shaped and left for the water to evaporate (24-48 hours). Then bricks are fired in gas-fired kilns for between 10-40 hours[90] typically at temperatures ranging from 900-1200 degrees Celsius.[91]

One challenge in eliminating gas is the low cost of gas for heating at 900-1200 degrees. Hydrogen can provide heat at that temperature but would require a significant upgrade to equipment.[92] Hydrogen can currently be blended at rates between 5-20% but increases costs.[93] Two other pathways to reduce gas use are electrification and biomass substitution and are already in use in Tasmania.

Austral bricks have substituted waste sawdust (biomass) in place of fossil gas as fuel to fire their kilns in Tasmania. The approach is claimed to have reduced emissions by 97% compared with fossil gas – from 8,522 tCO2-e to 215 tC2O-e.[94]

89 https://www.thinkbrick.com.au/About
90 https://buildmart.com.au/2021/08/29/how-bricks-are-made/#:~:text=In%20short%2C%20bricks%20are%20produced,higher%20manufacturing%20efficiency%20and%20quality.
91 https://www.sciencedirect.com/science/article/pii/S2214157X21008352#:~:text=During%20cooking%2C%20the%20brick%20is,baking%3A%20intermittent%20and%20continuous%20kilns.
92 https://assets.publishing.service.gov.uk/media/649ac8f8f901090012818881/Michelmersh_Brick_Holdings_-_Deep_Decarbonisation_of_Brick_Manufacturing_-_IFS_Feasibility_Report.pdf
93 https://www.themanufacturer.com/articles/generating-a-cleaner-future-hydrogen-and-brick-production-trial/
94 https://www.brickworks.com.au/wp-content/uploads/2020/07/AB-Bricks-CarbonNeutralBrochure-NAT.pdf

CASE STUDY: SERATECH LOW HEATING (60°) BRICK

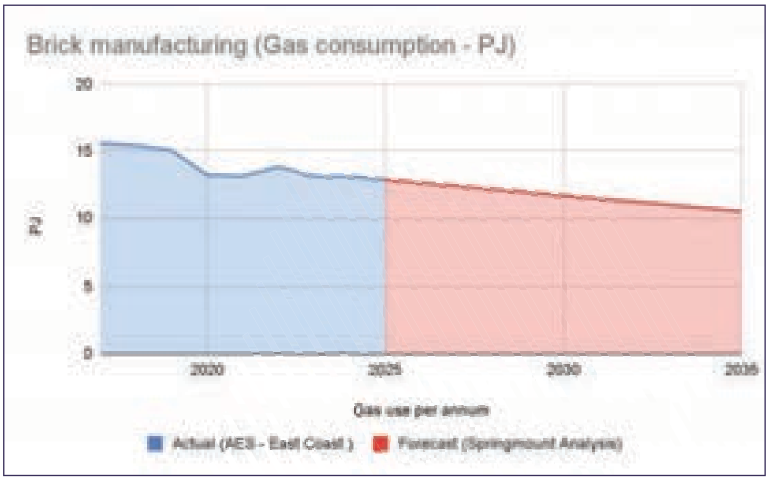
The high heat requirements for firing bricks is one of the key challenges to replacing gas use in the sector. Seratech, a UK based company aiming to create 100% carbon neutral cement, has developed its first low-carbon brick prototype. Unlike traditional clay bricks, which require firing at over 1,200°C and have nearly 1 kg of embodied CO2 per brick, Seratech's brick only needs to be baked at 60°C and cured at ambient temperature for up to two weeks to achieve full strength.[95]

Supporting local investment in promising new solutions like the Seratech low carbon brick will be essential for reducing the exposure of the ceramics sector to gas prices while reducing emissions.

The long-term approach to decarbonising the brick industry

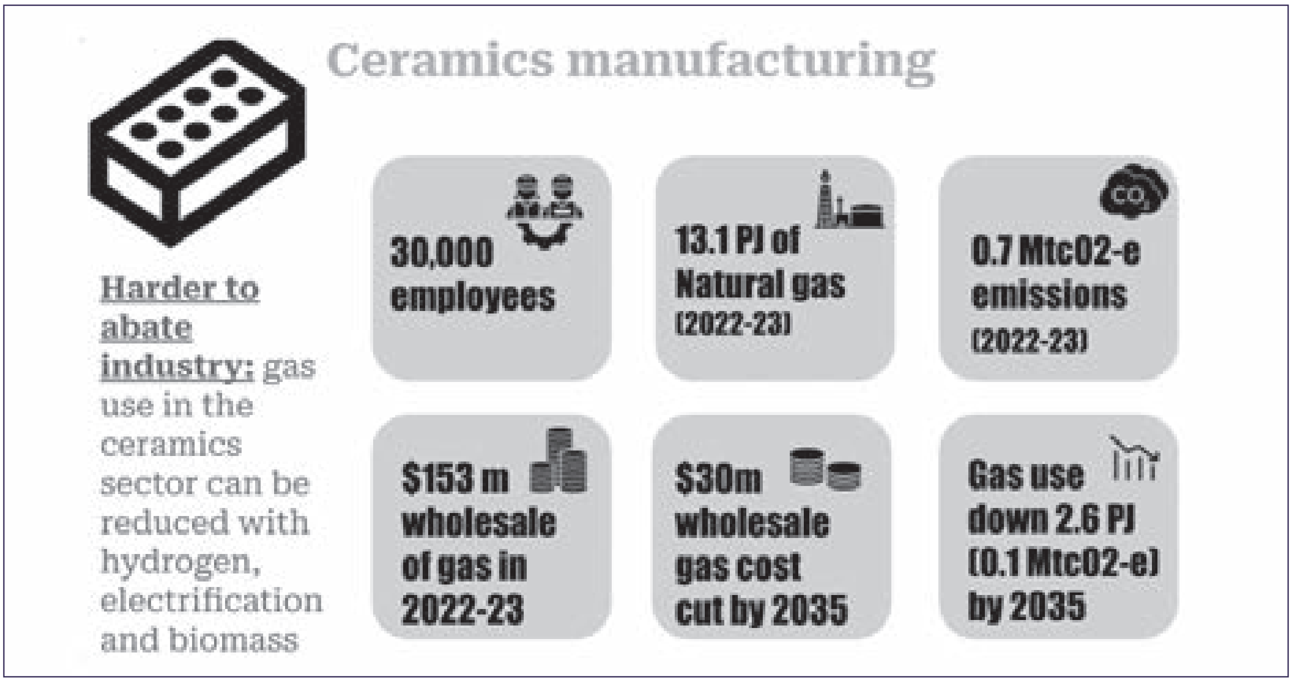
Supporting Australia's 10 major ceramics manufacturers will involve choosing technological solutions viable for different locations and production lines.

Sites that do not have access to waste biomass could begin in the short term using hydrogen blending of between 5%-20% to reduce fossil gas consumption and emissions. Biomass conversions and hydrogen blending over the short term could reduce gas consumption by 2.6 GJ, reducing fossil gas expenditure by $30 million.



95 https://constructionmanagement.co.uk/scientists-create-an-almost-carbon-neutral-brick/

CEMENT INDUSTRY



In Australia, the cement industry employs 1,300 people directly and supports 5,000 indirect jobs.[96] There are three major companies, Adbri, Cement Australia and Boral, operating 8 main manufacturing sites. Gas use is 16 PJ a year, generating around 0.8 CO2-e emissions per annum, accounting for 30% of overall emissions (14% from electricity) with the far greater percentage of emissions coming from carbon emitted during the processing – roughly 56% – the chemical transformation of limestone to clinker.

The majority of gas is used for process heat in the production of clinker. The industry uses the Portland cement process created in the early 1800's[97] with kilns heated to over 1,450 degrees Celsius to produce clinker. Cement and lime production generates 8% of global CO_2 emissions.[98]

Cement production is broken up into a few categories, quarrying, crushing, grinding/blending, preheating, firing to form clinker, and pulverising.[99] Crushing, grinding and blending (cement milling) account for greater energy consumption than clinker production, however, these processes use electricity as opposed to gas.[100]

CASE STUDY: CALIX LEADING GLOBAL LOW EMISSIONS CEMENT TECHNOLOGY

The LEILAC (Low Emissions Intensity Lime and Cement) initiative by Australian company Calix, aims to reduce the cement industry's CO_2 emissions.[101] Traditional methods of carbon capture have proven costly and inefficient, particularly because of the unavoidable emissions released during

96 https://www.climatechangeauthority.gov.au/sites/default/files/058%20-%20Cement%20Industry%20Federation%20Submission.pdf
97 https://www.cement.org/cement-concrete/how-cement-is-made/
98 https://www.pbl.nl/en/publications/trends-in-global-co2-emissions-2016-report
99 https://www.cement.org/cement-concrete/how-cement-is-made/
100 https://cement.org.au/energy-use/#:~:text=In%20total%20Australian%20cement%20producers,diesel%20oil%20and%20other%20fuels.
101 https://calix.global/cement-lime/

limestone processing. LEILAC proposes a novel solution by directly capturing CO_2 from precalciner processes, significantly reducing the industry's carbon footprint.

The LEILAC technology operates by indirectly heating limestone in a specialised reactor, allowing for efficient separation of CO_2 without the energy penalties associated with conventional methods. This project, backed by significant EU funding, focuses on optimising energy efficiency and reducing operational costs through innovative heat sources.

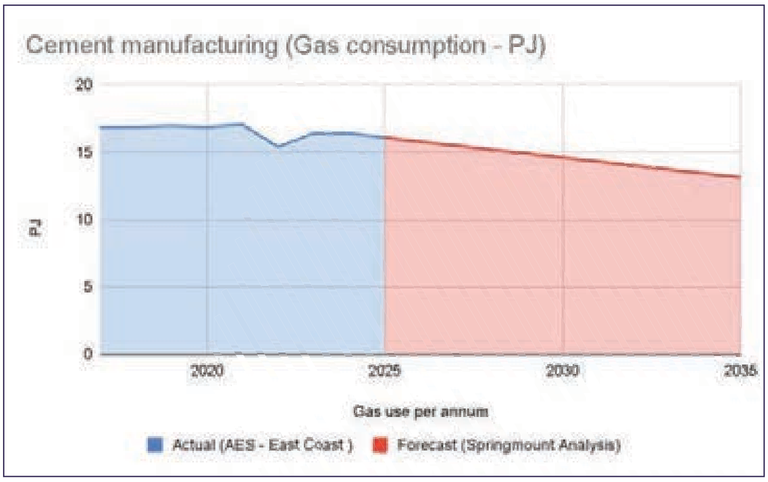
Separately, in August 2024, Calix has worked with Boral, UTS, and SmartCrete to successfully calcine the first batch of lower carbon concrete using Australian calcined clay using Calix's unique renewably powered electric calcination technology.[102]

Increasing investment in local innovators will help reduce the cement industry's exposure to gas.

Setting cement on the right trajectory

Further assistance, like the support provided from the Repowering the Regions Fund to Cement Australia and Adbri to reduce cement production emissions[103], is encouraged to help improve efficiency, reduce gas use and emissions at all eight primary cement production facilities in Australia.

Furthermore, substituting clinker with other cementitious materials (such as fly ash[104]) can reduce the requirement for new sources of clinker (reducing the gas requirements). A range of technological solutions, planning and support can decarbonise the cement industry over the next 25 years, with some significant (10 year) reductions in gas through technology changes and clinker substitutions.



This could reduce gas usage by 3 PJ by 2035, reducing gas expenditure by $38 million.

102 https://concreteinstitute.com.au/first-batch-successfully-calcined/
103 https://minister.dcceew.gov.au/bowen/media-releases/330m-investment-australian-heavy-industry-future
104 https://www.abc.net.au/news/2019-03-10/coal-ash-has-become-one-of-australias-biggest-waste-problems/10886866&sa=D&source=docs&ust=1730330204148375&usg=AOvVaw0VNPUICc6zUmsTE4O5hj11

APPENDIX – Methodology and Summary Tables

All baseline fossil gas consumption used was taken from Australian Energy Statistics 2024, with various methods used to calculate the percentage allocated to East Coast industrial fossil gas consumption. The method for allocating is detailed in the right hand column below.

			All of Australia		East coast gas use				
Readiness level	**No.1**	**Industrial Sectors**	**PJ (2022-23)**	**CO2 (Mt c02e)**	**PJ (2022-23)**	**CO2 (Mt c02e)**	**% reduction by 2035**	**Reduction model**	East Coast % Assumptions
Electrify now	1	Food manufacturing	34.6	1.8	32.3	1.7	60%	5.45% per year for 11 years	AES East Coast minus West Coast
	2	Paper manufacturing	13.9	0.7	13.9	0.7	60%	5.45% per year for 11 years	AES East Coast minus West Coast
	3	Transport and Warehousing	19.2	1.0	12.3	0.6	60%	5.45% per year for 11 years	AES East Coast minus West Coast
	4	Commercial Buildings	49.1	2.5	41	2.1	60%	5.45% per year for 11 years	AES data, aggregate of state by state
	5	LNG onshore processing	96.9	5.0	131.7	6.8	60%	5.45% per year for 11 years	AES Data, only for QLD
	6	Other manufacturing (see row 84-92)	13.8	0.7	12.3	0.6	60%	5.45% per year for 11 years	Calculated based on population split, see AES 2 tab for breakdown
Regassing industry	7	Iron and Steel manufacturing	14.8	0.8	14.8	0.8	40%	3.6% per year for 11 years	Assumed 100% of steel rolling is done in EC
	8	Alumina, Aluminium + Copper, Silver, Lead and Zinc refining and smelting	125.6	6.5	42.1	2.2	40%	3.6% per year for 11 years	Assumes gas consumption by the alumina sector is split evenly between the 6 total alumina plants in Australia WA (4) & QLD(2).
	9	Chemical manufacturing	109.9	5.7	66	3.4	60%	5.45% per year for 11 years	Assumed 60% of chemical manufacturing is in EC
Hard to abate	10	Glass	8.8	0.5	8.8	0.5	20%	1.8% per year for 11 years	Informed by industry expert this all EC
	11	Ceramics (Bricks)	14.7	0.8	13.1	0.7	20%	1.8% per year for 11 years	Calculated based on population split, see AES 2 tab for breakdown
	12	Cement	18.4	0.9	16	0.8	20%	1.8% per year for 11 years	Informed by Calix LEILAC-2 technology potential to reduce cement emissions.

Electrifying industry summary

No.1	Industrial Sectors	PJ (2022-23)	PJ reduction in 2035	Emissions (Mt c02e) 2023	Emissions reduction (Mt c02e) 2035	economic savings	Employee count
1	LNG onshore processing	131.7	79.0	6.8	4.1	$921M	4,500
2	Food manufacturing	32.3	19.4	1.7	1.0	$251M	240,000
3	Paper manufacturing	13.9	8.3	0.7	0.4	$97M	18,000
4	Transport and Warehousing	12.3	7.4	0.6	0.4	$86M	236,000
5	Commercial Buildings	41	24.6	2.1	1.3	$286M	30,000
6	Other manufacturing)	12.3	7.37	0.6	0.4	$86M	125,000
Sub-total		243.5	146.1	12.5	7.5	$1,727M	649,000

Regassing industry summary

Industrial Sectors	PJ (2022-23)	PJ reduction in 2035	Emissions (Mt c02e) 2023	Emissions reduction (Mt c02e) 2035	economic savings	Employee count
Iron and Steel Manufacturing	14.8	5.9	0.8	0.3	$172M	110,000
Alumina, Aluminium + Copper, Silver, Lead and Zinc refining and smelting	42.1	16.7	2.2	0.9	$490M	14,500
Chemical manufacturing	65.9	39.2	3.4	2.0	$768M	9,232
Sub-total	122.8	61.7	6.3	3.2	$1,430M	133,732

Genuinely hard to abate industry summary

Industrial Sectors	PJ (2022-23)	reduction in 2035	Emissions (Mt c02e) 2023	Emissions reduction (Mt c02e) 2035	economic savings	Employee count
Glass	8.8	5.3	0.5	0.3	$61M	9000
Ceramics (Bricks)	13.1	7.9	0.8	0.4	$92M	30000
Cement	16	9.8	0.9	0.5	$115M	1300
subtotal	38.3	7.6	2.0	0.4	$446M	40300

Other industry manufacturing uses of fossil gas

Other manufacturing includes	PJ (2022-23)	Emissions (Mt c02e)	Employee Count
13 Textile, clothing, footwear and leather	3.7	0.19	9400
14 Wood and wood products	1.9	0.10	5200
22 Fabricated metal products	1.4	0.07	42,600
23-24 Machinery and equipment	0.4	0.02	23,500
25 Furniture and other manufacturing	0.1	0.00	42,300
209 Other non-metallic mineral products	4.7	0.24	unknown
total	12.3	0.63	123000

Table 6. Other manufacturing uses of fossil gas from 2022-23 on the East Coast of Australia, Australian Energy Statistics 2024

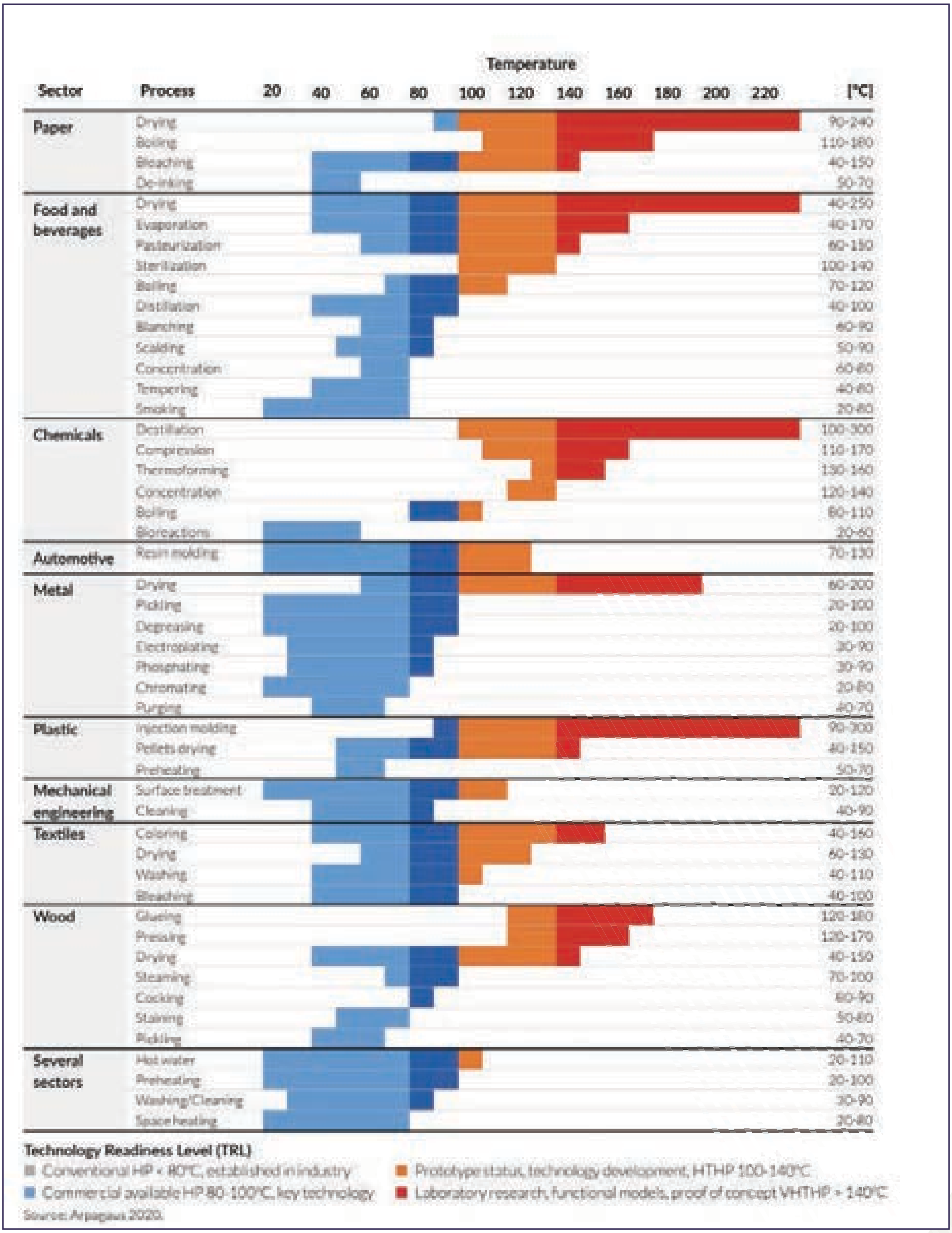
Emissions calculation method

National Greenhouse Account Workbook 2024 – **Natural Gas Combined KG CO2-e/GJ**
51.53

AES categories and correlated naming in this report

AES NAME	Springmount Description
Div. C other Manufacturing	No changes see other industry manufacturing table
11-12 Food, beverages and tobacco	Food manufacturing
15-16 Pulp, paper and printing	Paper manufacturing
1700 Refining oil and coal products	Oil and Coal refining
18-19 Basic Chemical and Chemical, Polymer and Rubber Product Manufacturing	Chemical manufacturing
20 Non-metallic mineral products	Glass, Bricks and Cement Manufacturing
211-212 Iron and steel	Iron and Steel manufacturing
213-214 Basic non-ferrous metals	Alumina, Aluminium + Copper, Silver, Lead and Zinc refining and smelting
Div. I Transport, postal & warehousing	Transport and Warehousing

Appendix 1 – Heat temperature range for manufacturing processes by sector [105]



105 https://static1.squarespace.com/static/5b514ee57e3c3a1fbf675baf/t/63f568c08cedcf707ae0e3d0/1677027541433/Harnessing+heat+pumps+for+net+zero.pdf

Appendix 2 – Food manufacturers and decarbonised technology availability [106]

Application & region	Existing heating technology	Selected technology for heating <90 °C				
		Anaerobic digestion + biogas	Bio-mass	Heat recovery	Solar thermal	Heat pump
Brewery - VIC	Electric Resistance					X
Brewery - NSW	Natural gas steam boiler					X
Beverage - NSW	Natural gas steam boiler					X
Malting - QLD	Natural gas burner					X
Meat processing - VIC	Natural gas steam boiler			X		X
Hops - TAS	Natural gas burner		X			X
Petfood - VIC	Natural gas steam boiler				X	
Confectionary - VIC	Natural gas steam boiler					X
Meat processing - NSW	Natural gas steam boiler			X		X
Malting - NSW	Natural gas burner				X	X
Food - TAS	Natural gas steam boiler					X
Brewery - SA	Natural gas steam boiler					X
Food - VIC	Natural gas steam boiler					X
Food - NSW	Natural gas steam boiler	X				
Beverage - NSW	Natural gas steam boiler					X
Confectionary - VIC	Natural gas steam boiler					X
Petfood - NSW	Natural gas steam boiler					X
Winery - NSW	Natural gas steam boiler					X
Food - NSW	Natural gas steam boiler					X
Steel - NSW	Cogen steam boiler			X		X

Table 1: Appropriate/selected technology for each pre-feasibility study

Appendix 3 – Levelised cost of heating for food manufacturers[107]

For equipment with a 1MW nameplate capacity

Fuel and cost	Equipment	COP	Cost to deliver 1GJ of heat
Natural gas @ $12 per GJ	Burner for heating air	0.95	$13.28
	Steam boiler	0.8	$15.65
	Steam system	0.65	$19.11
Hydrogen @ $2 per kg	Burner for heating air	0.95	$18.25
	Steam boiler	0.85	$20.30
	Steam system	0.7	$24.50
Electric resistive @ $120 per MWh	Heating element	0.95	$33.33
Heat pump @ $120 per MWh (for 70°C hot water)	Air sourced	3	$12.92
	Water sourced	5	$8.48
	Water sourced, integrated with a waste heat source	6	$7.37

Figure 2: Levelised Cost of Heating (LCOH) comparison for different fuels.

106 https://arena.gov.au/assets/2022/03/renewable-energy-for-process-heat-opportunity-study-final-report.pdf
107 https://arena.gov.au/assets/2022/03/renewable-energy-for-process-heat-opportunity-study-final-report.pdf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