ACIL ALLEN CONSULTING

REPORT TO
CHEMISTRY AUSTRALIA
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CHEMICAL INDUSTRY ECONOMIC CONTRIBUTION ANALYSIS

2017–2018

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GLOSSARY OF TERMS

ABS	Australian Bureau of Statistics
AEMO	Australian Energy Market Operator
ANZSIC	Australian and New Zealand Standard Industrial Classification
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortisation
Feedstock	In the context of this report, a feedstock is a chemical used to support a chemical reaction (e.g. natural gas used for creating ammonia). It is distinct to the use of an input (e.g. natural gas) for energy gained through combustion.
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GSP	Gross State Product
GHG	Green House Gases
GJ	Giga Joules
IOIG	Industry Output and Industry Group
LNG	Liquified Natural Gas
PJ	Peta Joules
SNA	System of National Accounts

EXECUTIVE SUMMARY

The chemical industry comprises the firms and businesses that produce industrial chemicals and plastics. The chemical industry converts raw materials such as oil, natural gas, air, water, metals and minerals into different products.

Natural gas is consumed in two ways in the chemical industry — as energy to drive processes; and as feedstock. Processing energy consumption in the chemical industry is similar to other industrial sectors — fuels are consumed to provide direct heat, steam and electricity to drive the industry's processes, equipment and facilities. The use of gas as feedstock is unique to the chemical industry.

Feedstock describes the use of various gas, fuels or other materials as a material input. Akin to iron ore inputs to the iron and steel industry or alumina inputs to the aluminium industry, chemical feedstock is the source of carbon and hydrogen used to constitute a range of intermediate and finished chemical products. Feedstock is quantified in energy units because, before use, it is indistinguishable from the same energy products used as fuels. However, once feedstock undergoes transformation in the chemical industry, it is easier to think of it as a material, with its carbon and hydrogen atoms rearranged physically to constitute the plastics and other chemical products manufactured within the industry.

Key aspects of gas feedstock demand are that it is non-switchable, non-substitutable, operates within a narrow band of operational tolerances and is energy intensive.

Since the reforming of gas to produce syngas (a mixture of hydrogen and carbon monoxide) was discovered, the importance of natural gas as a chemical industry feedstock has become a more cost-effective way of making chemical products.

Natural gas is an essential feedstock input for the chemicals and plastics sector. More importantly, it is vital for transformation into high-value chemicals such as advanced engineering plastics, ingredients for cleaning products, detergents and crop protection chemicals, explosives, pharmaceuticals and advanced textiles. Therefore, access to natural gas is a critical issue for the competitiveness of the Australian chemical industry.

In this context, **Chemistry Australia** commissioned **ACIL Allen Consulting** (ACIL Allen) to undertake a study to estimate:

- the direct and indirect economic value of gas used by the Australian chemical industry
- the comparative direct and indirect value of gas used by competing industries (such as power generation and Liquified Natural Gas (LNG))
- the gas price points where the domestic gas-based chemical sector is negatively affected, impacting its competitiveness and economic contribution.

The first two aspects of the study are provided in this report while the gas price analysis is provided in a separate report.

Economic contribution of the chemical industry

Table ES 1 and Figure ES 1 present the estimated economic contribution of the Australian chemical industry in 2017-18, including the contribution of the gas feedstock sector. The information presented includes:

— The **direct** contribution of the chemical industry to the Australian economy in GDP equivalent terms, estimated by industry gross value-add.

— **Indirect** effects, which are a broader notion of the economic contribution that includes the supply-side effects of other industries that supply inputs to the chemical industry and employees' expenditure in the economy. These estimates have been provided as lower and upper bounds, defined as follows:
  - Indirect **lower estimates** provide the value added and employment embodied within the supply chain of each input purchased by the chemical industry (*production induced effects*).
  - Indirect **upper estimates** include indirect lower estimates (*production induced effects*) plus *consumption induced effects* which represent the activity associated with households spending some or all of the wage income received for working in production on goods or services. This spend can create additional demand for goods and services by the industries of the economy.

The lower and upper bound estimates are generated through the use of Simple and Total multipliers, respectively.

The lower bound estimates of the chemical industry are additive with the lower bound estimates for other non-overlapping industries (such as iron ore, beverages, aluminium etc) and will never add to more than Australia's total GDP, household income or employment. While the lower bound estimates of the industry's footprint are useful for many contexts, they are a conservative estimate of the total economic activity or employment that could be affected by a change in the industry.

In light of this, the upper bound estimates provide a useful estimate of the total amount of economic activity or employment that is touched by the chemical industry in some manner (and therefore could be affected in some way if there was a shock to the industry).

It is estimated that in 2017-18, the chemical industry in Australia resulted in:

— a *lower bound* contribution of $27,781 million to Australian GDP, comprising $10,948 million directly from the industry (direct contribution) and $16,833 million indirectly from its input demand sources (indirect contribution). As a whole, the chemical industry contributed a minimum of 1.5 per cent to Australian GDP in 2017-18.

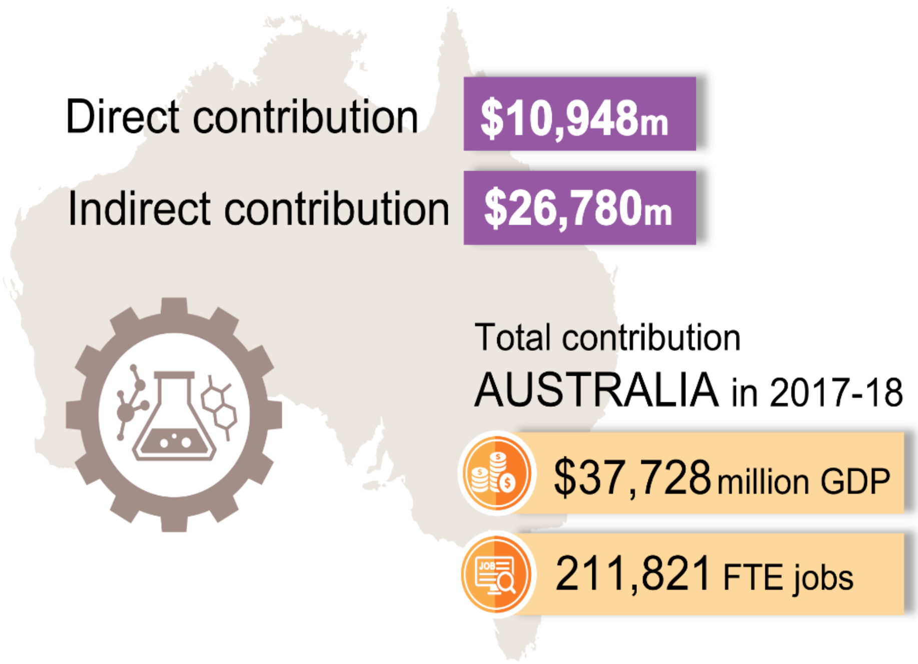
— an *upper bound* contribution of $37,728 million to Australian GDP, comprising $10,948 million directly from the industry (direct contribution) and $26,780 million indirectly from its input demand sources and an additional spend of employees of the chemical industry (indirect contribution). As a whole, the chemical industry contributed a maximum of 2.0 per cent to Australian GDP in 2017-18.

TABLE ES 1 TOTAL ECONOMIC (VALUE-ADD) CONTRIBUTIONS, 2017-18

Sector	Direct	Indirect		Total	
		Lower	*Upper*	*Lower*	*Upper*
	A$m	A$m	A$m	A$m	A$m
Total chemical industry	10,948	16,833	26,780	27,781	37,728
– *Gas feedstock chemical sector*	*3,252*	*4,725*	*7,349*	*7,977*	*10,601*
		Per cent of GDP			
Total chemical industry	0.59	0.91	1.45	1.50	2.04
– *Gas feedstock chemical sector*	*0.18*	*0.26*	*0.40*	*0.43*	*0.57*

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively. Totals may not add due to rounding.
SOURCE: ACIL ALLEN

FIGURE ES 1 ESTIMATED ECONOMIC CONTRIBUTION OF THE TOTAL CHEMICAL INDUSTRY TO AUSTRALIA, 2017-18



SOURCE: ACIL ALLEN

The estimated employment contribution of the chemical industry in Australia for 2017-18 is provided in Table ES 2 and summarised in Figure ES 1.

It is estimated that in 2017-18 the Australian chemical industry supported up to 211,821 full-time equivalent (FTE) jobs. To put this another way, for every, one million dollars of revenue received by the industry, there are up to 4 FTE jobs that are supported elsewhere in the Australian economy.

In understanding the estimated number of jobs supported by the industry, it should be noted that they are presented as FTE jobs for convenience. In reality they represent the summation of many shares of individual jobs or include part-time and casual jobs. Consequently, the number of people whose employment is supported (partially or wholly) by the activities of the chemical industry will actually be greater than the estimated number of FTE jobs.

TABLE ES 2 TOTAL EMPLOYMENT (FTE) CONTRIBUTIONS, 2017-18

Sector	Direct	Indirect lower	Indirect upper	Total lower	Total upper
Chemical industry	61,458	93,998	150,363	155,456	211,821
– *Gas feedstock chemical sector*	*9,232*	*24,396*	*39,269*	*33,628*	*48,500*

SOURCE: ACIL ALLEN

Economic contribution of the gas feedstock chemical sector

Within the chemical industry are a group of unique businesses which manufacture chemicals using natural gas as feedstock. These chemical processes convert the raw gas molecule into a range of significantly value-added intermediate and finished products which are used throughout the economy. The gas is used as a chemical feedstock in the same way that iron ore is used to make steel. Specific examples include:

— Methane, which is made into Ammonia, Ammonium Nitrate, Sodium Cyanide, Methanol and Peroxide. These in turn are manufactured into fertilisers, mining inputs, agricultural chemicals, water treatment chemicals, cleaners, disinfectants and biodiesel.

Ammonia (produced from Methane) is an important feedstock for several industries. The most commonly used fertiliser in the world, urea, is produced from ammonia. Australian industries use 1.6 million tonnes of urea each year, and each tonne of urea requires 21 GJ of natural gas.

Ammonia is also used in explosives, cleaning products, fermentation, brewing and wine making.

— Ethane, which is made into Ethylene, Polyethylene and Ethylene Oxide:
  – Ethylene is used as an industrial refrigerant in the LNG and other industries
  – Polyethylene is manufactured by companies to package fresh milk for domestic use and is becoming an increasingly higher value export for regional economies. It is also manufactured into poly pipe that supplies natural gas to homes and businesses.
  – Ethylene Oxide is used for a broad range of surfactants, glycols and other inputs to manufacturing and other sectors.

For this analysis, ACIL Allen has estimated the economic contribution of the businesses within the broader chemical industry which rely on gas as a major feedstock.

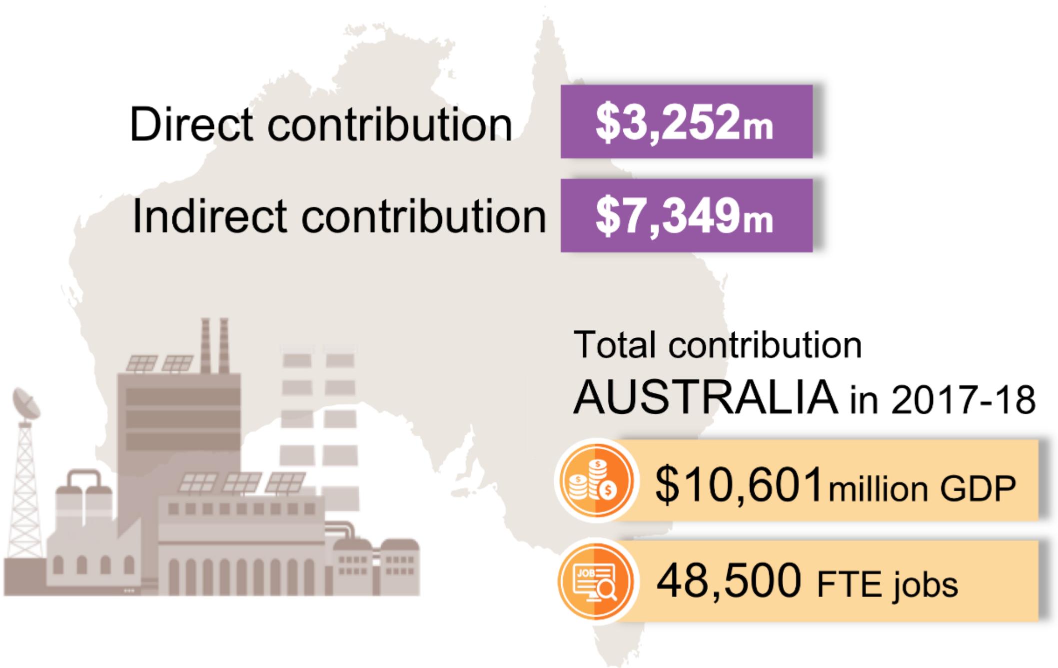
The total economic contribution of the Australian major gas feedstock chemical sector in 2017-18 is summarised in Figure ES 2.

It is estimated that in 2017-18, the gas feedstock chemical sector in Australia resulted in:

— a *lower bound* contribution of $7,977 million to Australian GDP, comprising $3,252 million directly from the sector (direct contribution) and $4,725 million indirectly from its input demand sources (indirect contribution). As a whole, it contributed a minimum of 0.43 per cent to Australian GDP in 2017-18.
— an *upper bound* contribution of $10,601 million to Australian GDP, comprising $3,252 million directly from the sector (direct contribution) and $7,349 million indirectly from its input demand sources and an additional spend of employees of this sector (indirect contribution). As a whole, it contributed a maximum of 0.57 per cent to Australian GDP in 2017-18.

It is estimated that this subset of the Australian chemical industry supported up to 48,500 FTE jobs in 2017-18. To put this another way, for every one million dollars of revenue received by the gas feedstock chemical sector, there are up to 4 FTE jobs that are supported elsewhere in the Australian economy.

FIGURE ES 2 ESTIMATED ECONOMIC CONTRIBUTION OF THE GAS FEEDSTOCK CHEMICAL SECTOR TO AUSTRALIA, 2017-18



SOURCE: ACIL ALLEN

Footprint of the chemical industry by state

The estimated total (direct and indirect) economic and employment contributions of the chemical industry in each Australian jurisdiction is summarised in Table ES 3 and Table ES 4, respectively. Australian states are economically interdependent; each state's economy depends on the inputs and services from other states and sells goods and services across the nation. Each state depends on chemical industry products to support their agriculture, manufacturing and services industries. Nearly all states have some chemical industry activity, however production mainly occurs in four states — New South Wales, Victoria, Western Australia and Queensland. Production is distributed mainly where the gas feedstock is available and where there is demand for chemical industry products.

TABLE ES 3 TOTAL ECONOMIC CONTRIBUTION OF TOTAL CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct	Indirect		Total		Total as a share of GSP	
		Lower bound	*Upper bound*	*Lower bound*	*Upper bound*	*Lower bound*	*Upper bound*
	$A million	$A million	$A million	$A million	$A million	% of GSP	% of GSP
New South Wales	3,192	4,905	8,093	8,098	11,286	1.34	1.87
Victoria	3,001	4,720	7,539	7,721	10,541	1.79	2.45
Queensland	2,010	3,076	4,859	5,086	6,869	1.46	1.97
South Australia	461	775	1,225	1,236	1,685	1.15	1.57
Western Australia	2,049	2,993	4,542	5,042	6,591	1.94	2.54
Tasmania	147	227	332	374	480	1.21	1.56
Northern Territory	71	110	150	182	222	0.69	0.84
Australian Capital Territory	16	27	39	43	55	0.11	0.14
Australia	**10,948**	**16,833**	**26,780**	**27,781**	**37,728**	**1.50**	**2.04**

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively. Indirect economic activity due to interstate trade has been included in the regional contribution estimates based on their share of underlying activity.

SOURCE: ACIL ALLEN

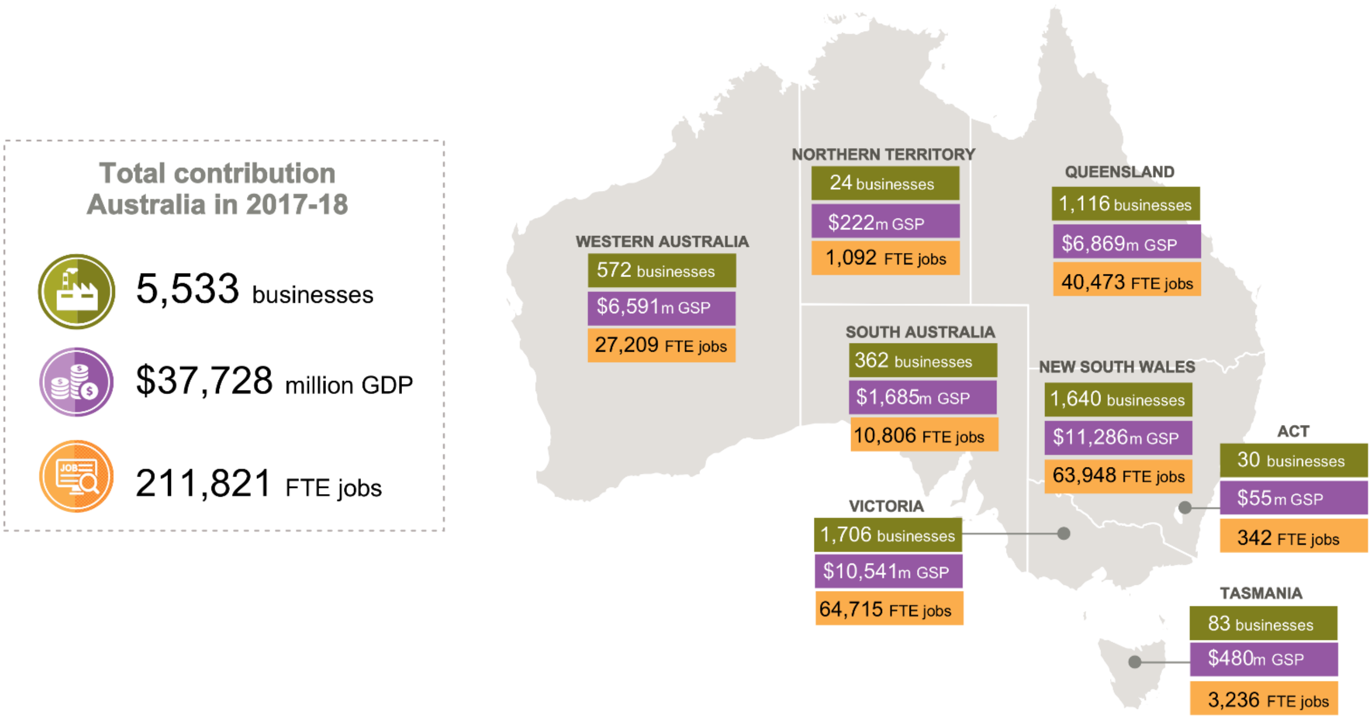
TABLE ES 4 TOTAL EMPLOYMENT SUPPORTED BY THE AUSTRALIAN CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct chemical industry	Indirect chemical industry		Total chemical industry	
		Lower bound	*Upper bound*	*Lower bound*	*Upper bound*
	FTE jobs	FTE jobs	FTE jobs	FTE jobs	FTE jobs
New South Wales	19,303	27,704	44,645	47,007	63,948
Victoria	19,550	28,236	45,164	47,786	64,715
Queensland	11,372	18,172	29,102	29,544	40,473
South Australia	3,641	4,467	7,165	8,108	10,806
Western Australia	6,105	13,229	21,104	19,335	27,209
Tasmania	1,075	1,435	2,161	2,510	3,236
Northern Territory	321	558	770	879	1,092
Australian Capital Territory	90	197	252	287	342
Australia	**61,458**	**93,998**	**150,363**	**155,456**	**211,821**

Note: FTE = full time equivalent.

SOURCE: ACIL ALLEN

FIGURE ES 3 TOTAL ECONOMIC CONTRIBUTION OF AUSTRALIAN CHEMICAL INDUSTRY BY STATE, 2017-18



SOURCE: ACIL ALLEN

Comparative analysis with other industries

In addition to the chemistry sector, other major sectors that use and add value to Australian gas include the:

— LNG industry for exports
— electricity generation sector.

Table ES 5 summarises the estimated direct, indirect, induced and total economic and employment contributions of these industries and compares it to the estimated contributions made by the chemical industry.

TABLE ES 5 A COMPARATIVE ANALYSIS OF VALUE-ADDED GAS IN AUSTRALIA, 2017-18

Industry	Gas consumption	Emissions	ECONOMIC CONTRIBUTION Direct	Indirect *Lower*	Indirect *Upper*	Total *Lower*	Total *Upper*
	PJ	Mt CO_2-e	GDP (A$ million)				
Total chemical industry	132	12.0	10,948	16,833	26,780	27,781	37,728
– *Gas feedstock chemical sector*	*116*	*7.7*	*3,252*	*4,725*	*7,349*	*7,977*	*10,601*
LNG industry (for export)	3,390	28.0	20,253	5,837	9,289	26,090	29,542
Gas-fired electricity generation	568	29.2	250	1,563	2,129	1,814	2,380
			A$ million economic contribution per PJ of gas use				
Total chemical industry			83.0	127.6	203.0	210.6	286.0
– *Gas feedstock chemical sector*			*44.6*	*64.9*	*100.9*	*109.5*	*145.5*
LNG industry (for export)			6.0	1.7	2.7	7.7	8.7
Gas-fired electricity generation			0.4	2.8	3.7	3.2	4.2
			Employment (FTE jobs)				
Total chemical industry			61,458	93,998	150,363	155,456	211,821
– *Gas feedstock chemical sector*			*9,232*	*24,396*	*39,269*	*33,628*	*48,500*
LNG industry (for export)			17,269	30,989	50,554	48,258	67,823
Gas-fired electricity generation			421	4,244	7,451	4,665	7,872
			FTE jobs contribution per PJ of gas use				
Total chemical industry			465.8	712.5	1,139.7	1,178.4	1,605.6
– *Gas feedstock chemical sector*			*126.7*	*334.9*	*539.1*	*461.7*	*665.8*
LNG industry (for export)			5.1	9.1	14.9	14.2	20.0
Gas-fired electricity generation			0.7	7.5	13.1	8.2	13.9

SOURCE: ACIL ALLEN

The total contribution of the chemical industry for every petajoule of gas use in 2017-18 was around $286 million, compared to $8.7 million and $4.2 million from the LNG and gas-fired electricity generation industries, respectively. This illustrates that the chemistry sector has significantly more value added per petajoule of gas used than LNG (33x) and electricity (68x).

1 INTRODUCTION

The chemical industry comprises the firms and businesses that produce industrial chemicals and plastics. The chemical industry converts raw materials such as oil, natural gas, air, water, metals and minerals into a variety of intermediate and finished products.

Since the reforming of gas to produce syngas (a mixture of hydrogen and carbon monoxide) was discovered, the importance of natural gas as a feedstock has become more attractive for making ammonia and methanol.

Natural gas can be transformed into everything from fertilisers to plastics because of its organic composition of several key chemicals.

Natural gas is an essential feedstock for the chemicals and plastics sector in Australia. More importantly, it is vital for transformation into high-value chemicals such as advanced engineering plastics, ingredients for detergents and crop protection chemicals, pharmaceuticals and advanced textiles.

Access to natural gas is therefore a critical issue for the competitiveness of the Australian chemical industry.

In this context, Chemistry Australia commissioned ACIL Allen to undertake a study to estimate:

- the direct and indirect economic value of gas used by the Australian chemical industry
- the comparative direct and indirect value of gas used by competing industries (such as power generation and LNG)
- the gas price points where the domestic gas feedstock chemical sector is negatively affected, impacting its competitiveness and economic contribution.

Chemistry Australia comprises a broad range of companies positioned across the entire chemical industry value chain. Companies include chemicals manufacturers, importers and distributors, logistics and supply chain partners, raw material suppliers, plastics fabricators and compounders, chemicals and plastics recyclers and service providers to the industry.[1]

This report provides an economic analysis of the first two of the above three aspects for the year 2017-18.

The estimates in this report are based on detailed data obtained from key members of Chemistry Australia. Members data is aggregated to provide an industry snapshot while maintaining confidentiality. Members data is supported by published and unpublished ABS and other industry data sources.

[1] https://chemistryaustralia.org.au/aboutus

2 CHEMICAL INDUSTRY AND DOMESTIC GAS POLICY

Eastern Australia faces a short-term gas supply problem and may face a long-term gas supply problem.

Owing to a lack of competitive gas supply alternatives and a market now shaped by the Asian LNG export alternative price, gas consumers in eastern Australia are currently facing sharply rising prices. Large gas users have been reporting difficulties in securing gas supply offers at an economically viable price and are faced with substantially more onerous, less flexible contract terms. Constrained gas supply and rising gas demand in the LNG and electricity generation sectors also mean that there is a risk of physical supply shortfalls that could result in curtailment of gas deliveries to the chemical industry.

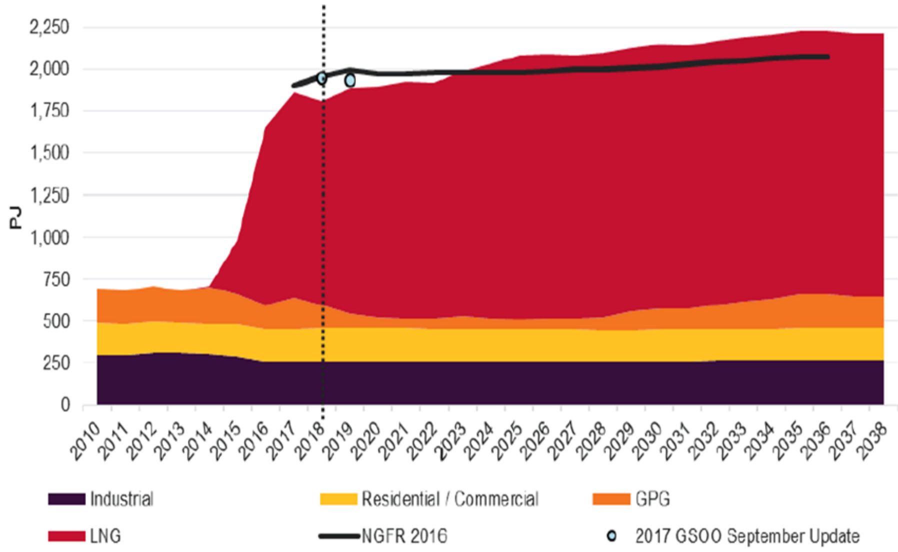
2.1 Eastern Australia: tightening gas supply with little relief

Over the past decade there has been a significant transformation of the eastern Australian gas market, driven by large-scale export LNG developments and associated upstream coal seam gas (CSG) field production facilities in Queensland. Three separate LNG export projects, with a combined production capacity of more than 25 million tonnes per year of LNG, were commissioned between late 2014 and late 2016. These facilities have a combined gross gas requirement of around 1,500 PJ a year—more than double the amount of gas currently used in the entire eastern Australia domestic gas market (see Figure 2.1).

The impact that these LNG projects have had on the eastern Australian domestic gas market would be difficult to overstate. They have affected the availability of gas to supply power generation, industrial, commercial and residential customers; pushed up the price of domestic gas and changed the ways in which gas prices are determined; and affected levels of domestic gas consumption – particularly in the power generation sector.

The LNG developments have seen the rapid expansion of gas production from CSG fields in Queensland. While the LNG export projects have been the primary driver for this increased production, some of this gas has been (and continues to be) supplied to the domestic gas market.

FIGURE 2.1 EAST COAST GAS DEMAND



SOURCE: AEMO, GAS STATEMENT OF OPPORTUNITIES 2019 Repo

Nevertheless, a large part of the gas production capacity in eastern Australia has been committed on a long-term basis to supply the LNG projects. This includes not only the Queensland CSG projects controlled by the LNG proponents, but also large volumes of third-party gas reserves that are now committed, under long-term contracts, to supply additional gas for LNG production. Some of the CSG fields developed to support LNG production have not performed as well as anticipated, with low gas flow rates and high production costs. This has created an opportunity for some third-party producers – traditionally suppliers to the domestic market – to secure long-term sales contracts to the LNG plants at relatively high prices.

In the longer term, there is significant uncertainty regarding gas supply adequacy in eastern Australia. In its 2016 inquiry into the east coast gas market (and reiterated in subsequent reports), the Australian Competition and Consumer Commission (ACCC) identified three key factors contributing to uncertainty about future gas supply:

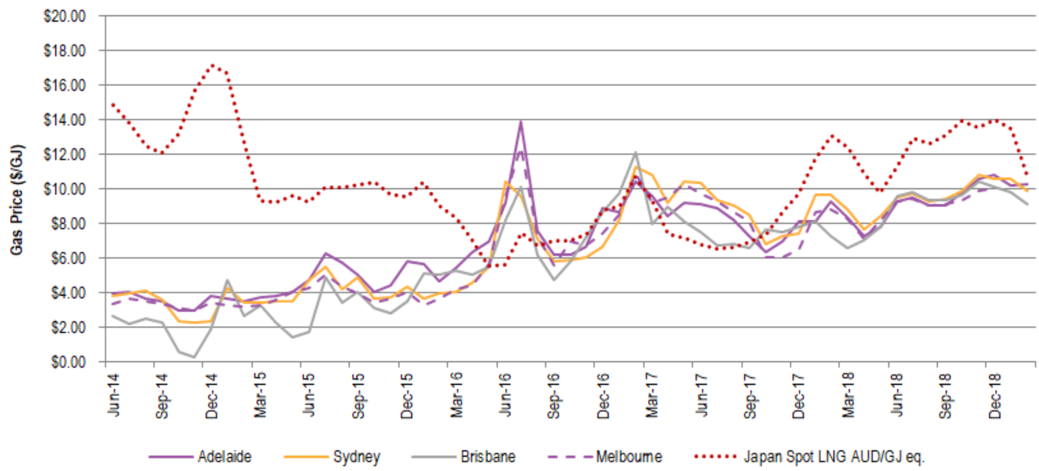
1. the magnitude of gas flows to the LNG projects, which are removing gas from the domestic market
2. low oil prices, which have seen declining investment in gas exploration and lower production forecasts for both domestic producers and LNG projects
3. moratoria and regulatory restrictions, which are affecting onshore gas exploration and development.

The current tight supply situation has been exacerbated by restrictive government policies in New South Wales and Victoria that have brought onshore oil and gas exploration in those jurisdictions to a virtual standstill.

2.2 The impact of LNG exports on domestic gas pricing

The emergence of the Gladstone LNG projects has had a transformative effect on gas prices in the eastern Australian domestic market. In particular, there has been a significant shift in the basis on which gas sold under long-term supply contracts is priced. In the past, the usual practice in the gas industry was to set a base contract price at a specified date. That base price was then subject to escalation on a periodic basis at a proportion (most often 100 per cent) of the Consumer Price Index or another relevant independent price index. Typically, the base contract price was also subject to periodic review.

FIGURE 2.2 EAST COAST CAPITAL CITY SHORT TERM TRADING MARKET GAS PRICES



SOURCE: ACIL ALLEN ANALYSIS OF AEMO AND ACCC DATA

With the advent of LNG export projects offering a pathway to an international market in which contract prices have traditionally been linked formulaically to the price of oil, it has now become commonplace for domestic gas supply contracts to incorporate oil price linkages. LNG netback prices based on Asian LNG spot prices now play an important role in influencing gas prices in the east coast gas market.

The ACCC in its 2016 East Coast Gas Market Inquiry made the following observation:

'Industrial gas users are now exposed to higher and more volatile domestic prices, which are influenced by fluctuating international LNG and world oil prices. This is likely to remain a feature of the east coast gas market into the future. Recent low oil prices have provided some price relief but have also stifled investment required to bring on additional gas, which perpetuates uncertainties about availability of gas. Industrial users are adapting their practices for acquiring gas in response to increased pricing and supply uncertainties, but limited publicly available information and risk management mechanisms are making this challenging'.

2.3 Future gas supply in eastern Australia

Analysis undertaken by the ACCC and the Australian Energy Market Operator (AEMO) on the eastern Australian gas market forecast that in the medium term (to around 2023) sufficient gas will be produced in the east coast gas market to meet domestic demand as well as the current export contract commitments of the three Gladstone LNG plants. This position was, however, reliant on a large quantity of currently undeveloped supply sources for both the LNG projects and others being brought into production. Furthermore, the analysis also showed that there would be insufficient gas produced in the east coast market – including all proposed but currently undeveloped supply for the LNG projects and other producers – to meet domestic demand and to allow the LNG projects to fully utilise their installed liquefaction plant capacity. The ACCC noted that this gap between current levels of LNG supply contracts and the full capacity of the LNG plants was influencing decisions made by gas producers on the east coast and was resulting in domestic gas prices being influenced by LNG netback prices.

While in the long run it is reasonable to expect that gas producers will respond to price signals in the market, new greenfield sources of gas supply will not be developed quickly. The process of exploring for and finding new gas fields, establishing their technical and commercial viability and bringing them into production involves long lead times.

2.3.1 Northern Territory supply

Gas production in the Northern Territory is becoming relevant to the eastern Australian supply-demand situation with the Northern Gas Pipeline now in operation. Current domestic gas supply sources in the NT gas market are:

– Offshore: Blacktip field in the Bonaparte Basin. Blacktip gas will provide the initial supply into Queensland via the Northern Gas Pipeline.
– Onshore: the Mereenie, Palm Valley and Dingo fields in the Amadeus Basin.

The Bayu-Undan field in the Bonaparte Basin has been supplying gas into the Darwin LNG project since 2006. It is not expected to supply any gas into the domestic market, with all reserves and production currently committed to LNG exports.

Gas and condensate from the Ichthys field, located in Western Australian waters in the Browse Basin some 890 km west of Darwin, is transported to the Inpex LNG plant at Darwin which has been in operation since November 2018.[2] There is currently no expectation that the Ichthys project will provide any gas to the domestic market in the Northern Territory or eastern Australia.

The Beetaloo Sub-basin (part of the Macarthur River Basin) in the Northern Territory is regarded as highly prospective for shale gas. Several exploration companies were actively working on Beetaloo Basin prospects prior to September 2016 when the Northern Territory Government announced a moratorium and independent scientific inquiry into hydraulic fracture stimulation in the Northern Territory. The moratorium was lifted in April 2018 and exploration has resumed.[3] The timing and scale of any commercial gas production from the Beetaloo Basin, and the level of supply into the eastern Australian states, remains uncertain.

2.3.2 Northern Gas Pipeline

Jemena has recently finished the construction of the Northern Gas Pipeline between Tennant Creek and Mount Isa with commercial gas flowing since January 2019.[4] This pipeline is currently capable of supplying up to 90 TJ/d of gas from the Northern Territory into the eastern Australian market at Mount Isa. Initially the pipeline transported gas supplied by Power and Water Corporation (PWC; Northern Territory Government) from its Blacktip (offshore Bonaparte Basin) contract entitlements. In the longer term, the Northern Gas Pipeline could carry gas from the Beetaloo Basin or other unconventional prospects from the onshore regions of the Northern Territory, subject to successful exploration following a resumption of onshore exploration and development activity after the Northern Territory Government's scientific inquiry into hydraulic fracturing was completed.

In order to deliver large quantities of gas from the Northern Territory to the main eastern Australian demand centres, there would be a need for further investment in infrastructure to expand the Northern Gas Pipeline and to provide additional transport capacity downstream of Mount Isa. It should, to a large extent, be possible to stage such investment to meet emerging market opportunities, without the need for large infrastructure investments ahead of demand.

2.4 Implications for the eastern Australia gas market

There are two key implications for consumers in eastern Australia from recent developments in the gas market – the increase in gas prices and impacts on reliability of future long-term supply.

2.4.1 Gas prices

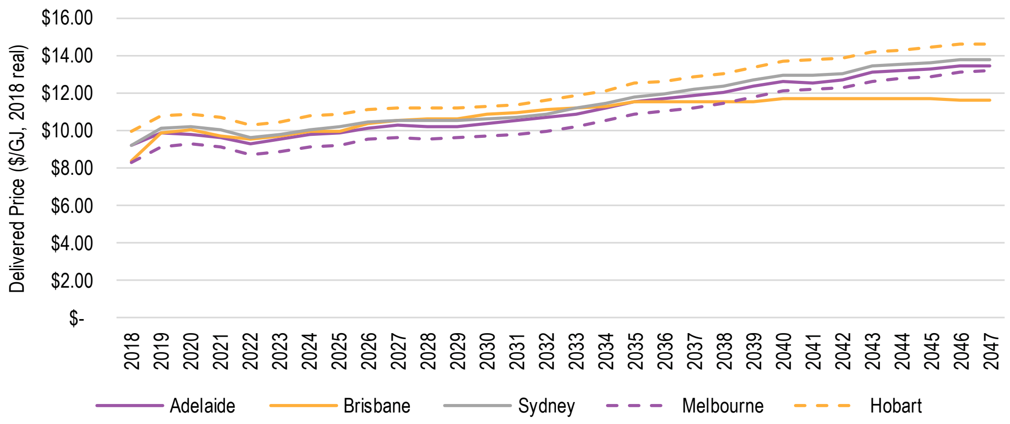
The typical price for large industrial consumers across eastern Australia has risen from around $5/GJ to $10-12/GJ. The wholesale price of gas accounts for approximately 85-90 per cent of the price with a small transport component on top.

[2] http://www.inpex.com.au/media/3179/ichthys-lng-bulletin-4pp-dec2018_web.pdf
[3] https://www.originenergy.com.au/about/investors-media/media-centre/origin-to-resume-beetaloo-exploration-in-nt.html
[4] http://jemena.com.au/industry/pipelines/northern-gas-pipeline

These higher gas prices have resulted in higher power prices for consumers. Gas is a key input cost for chemicals manufacturers and typically represents around 15-20 per cent of a gas-intensive user's operational costs (but sometimes up to 40 per cent).

ACIL Allen's projection for gas prices across the east coast is shown in Figure 2.3. Wholesale gas prices are expected to hover around $10/GJ for the next few years before beginning a climb towards $12/GJ in the early-to-mid 2020s.

FIGURE 2.3 FORECAST EAST COAST AUSTRALIA WHOLESALE GAS PRICES (DELIVERED)



SOURCE: ACIL ALLEN GASMARK MODELLING

Without any significant developments along the east coast that can ease supply pressure, gas prices are expected to increase over time. Even if more development was successful and extraction costs of gas developed from basins such as the Beetaloo were to be low, the cost of gas for consumers in eastern Australia will be primarily dictated by LNG netback prices into the future. Domestic prices will only potentially fall and be somewhat lower than the LNG netback if a new significant source of supply came online which substantially eased the pressure on domestic and LNG gas supply. At present, there is no foreseeable source that could radically address the fundamental problem of tight supply.

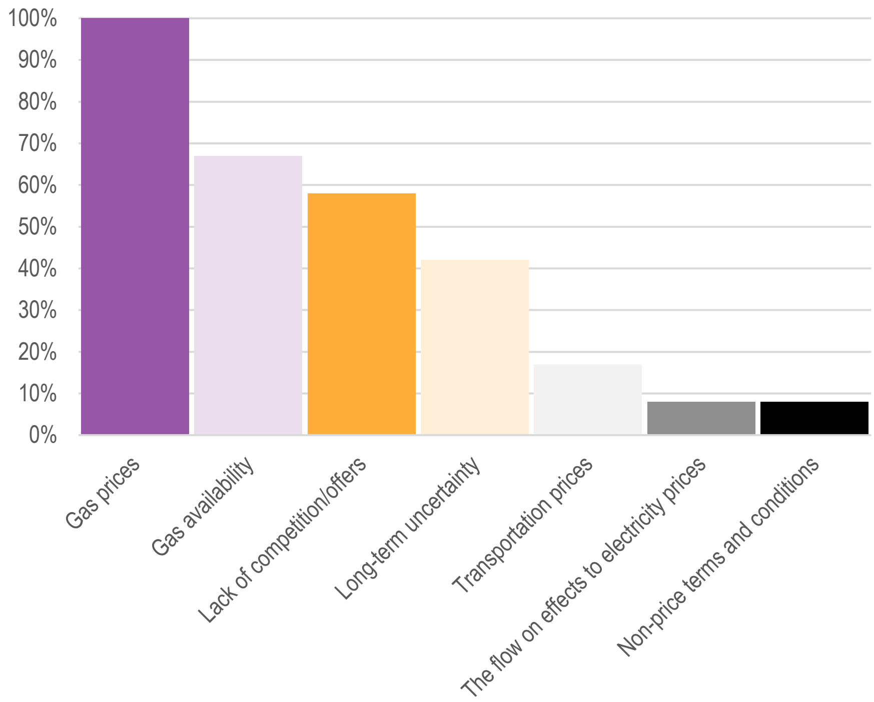
2.4.2 Long term supply

Another key consideration from recent developments in the east coast gas market is long term supply for customers. As discussed in the previous section, gas prices have been the main impact from the tightening of the east coast gas market and the evolution of the market to include LNG exports. However, another key impact has been on the reliability of supply. As conditions have tightened, the reliability of supply and the ability to negotiate long term supply contracts has notably diminished. Recent gas supply contracts for large industrial consumers have shortened in length and uncertainty on the ability to contract supply beyond 2-3 years has increased.

Previously, consumers have been able to negotiate long term gas supply contracts, some well in excess of 10 years. This has provided certainty for consumers and has allowed companies to match supply inputs with long term plans for their operations. However, in the past couple of years there have been many examples of consumers rolling off long-term gas supply contracts and failing to secure a further long-term contract. Many consumers have only been able to secure 12-month contracts or 2-year contracts. The December 2018 ACCC Gas Inquiry report confirmed that these issues are prominent concerns for consumers at present.

These price and supply considerations have increasingly become an issue for gas-intensive business in eastern Australia.

FIGURE 2.4 TOP CONCERNS FOR COMMERCIAL AND INDUSTRIAL GAS USERS



SOURCE: ACCC (2018), GAS INQUIRY 2017-2020 INTERM REPORT DECEMBER 2018, PAGE 90.
HTTPS://WWW.ACCC.GOV.AU/SYSTEM/FILES/GAS-INQUIRY-DECEMBER-INTERIM-REPORT-2018.PDF

3 AN OVERVIEW OF THE CHEMICAL INDUSTRY

3.1 Chemical industry definition

The chemical industry is a diverse sector that produces essential inputs to nearly every other sector in the economy.

The chemical industry for this study is based on definitions used by Cook et al (2013)[5] and the Department of Industry, Innovation, Science, Research and Tertiary Education (2011).[6]

The industry definition uses the ABS's 2006 Australian and New Zealand Standard Industrial Classification (ANZSIC) system.

Table 3.1 provides some details of the ANZSIC codes, descriptions and its concordance with the industry output and industry group (IOIG) industries.

Details of these industries are provided in Appendix A.

TABLE 3.1 CHEMICAL INDUSTRY IN THIS STUDY

IOIG	IOIG Descriptor	ANZSIC code	ANZSIC descriptor	Broad category[a]
1701	Petroleum and Coal Product Manufacturing	1709	Other Petroleum and Coal Product Manufacturing	Basic Chemicals
1803	Basic Chemical Manufacturing	1811	Industrial Gas Manufacturing	Basic Chemicals
		1812	Basic Organic Chemical Manufacturing	Basic Chemicals
		1813	Basic Inorganic Chemical Manufacturing	Basic Chemicals
		1821	Synthetic Resin and Synthetic Rubber Manufacturing	Basic Chemicals
		1829	Other Basic Polymer Manufacturing	Basic Chemicals
		1831	Fertiliser Manufacturing	Basic Chemicals
		1832	Pesticide Manufacturing	Consumer chemicals
		1891	Photographic Chemical Product Manufacturing	Speciality Chemicals

[5] Cook H, Hajkowicz S, King S, Cox F (2013) Elements in Everything: Current profile and future trends for the Australian chemicals and plastics industry. CSIRO, Australia

[6] DIISRTE. (2011). Australian Chemicals and Plastics Manufacturing Data Card. Canberra: Department of Industry, Innovation, Science, Research and Tertiary Education, Australian Government

IOIG	IOIG Descriptor	ANZSIC code	ANZSIC descriptor	Broad category[a]
		1892	Explosive Manufacturing	Speciality Chemicals
		1899	Other Basic Chemical Product Manufacturing	Speciality Chemicals
1804	Cleaning Compounds and Toiletry Preparation Manufacturing	1851	Cleaning Compound Manufacturing	Consumer Chemicals
		1852	Cosmetic and Toiletry Preparation Manufacturing	Consumer Chemicals
1901	Polymer Product Manufacturing	1911	Polymer Film and Sheet Packaging Material Manufacturing	Speciality Chemicals
		1912	Rigid and Semi-Rigid Polymer Product Manufacturing	Speciality Chemicals
		1913	Polymer Foam Product Manufacturing	Speciality Chemicals
		1914	Tyre Manufacturing	Speciality Chemicals
		1915	Adhesive Manufacturing	Speciality Chemicals
		1916	Paint and Coatings Manufacturing	Speciality Chemicals
		1919	Other Polymer Product Manufacturing	Speciality Chemicals
1902	Natural Rubber Product Manufacturing	1920	Natural Rubber Product Manufacturing	Speciality Chemicals

[a] Broad category is based on the American Chemistry Council 2017, Elements of the business of chemistry, 2017. https://www.americanchemistry.com/2017-Elements-of-the-Business-of-Chemistry.pdf

SOURCE: BASED ON ABS

Within these broad ANZSIC industry classes are a group of unique businesses which manufacture chemicals using natural gas as feedstock. These chemical processors convert the raw gas molecule into a range of significantly value-added intermediate and finished products which are used throughout the economy. The gas is used as a chemical feedstock in the same way that iron ore is used to make steel. The chemistry industry uses the methane (CH_4) and ethane (C_2H_6) components to manufacture a broad range of intermediate and final products which are then used throughout the economy's supply chain.

Specific examples include:

— Methane, which is made into Ammonia, Ammonium Nitrate, Sodium Cyanide, Methanol and Peroxide. These in turn are manufactured into fertilisers, mining inputs, agricultural chemicals, water treatment chemicals, cleaners, disinfectants and biodiesel.

Ammonia (produced from Methane) is an important feedstock for several industries. The most commonly used fertiliser in the world, urea, is produced from ammonia. Australian industries use 1.6 million tonnes of urea each year, and each tonne of urea requires 21 GJ of natural gas.

Ammonia is also used in explosives, cleaning products, fermentation, brewing and wine making.

— Ethane, which is made into Ethylene, Polyethylene and Ethylene Oxide:

- Ethylene is used as an industrial refrigerant in the LNG and other industries
- Polyethylene is manufactured by companies to package fresh milk for domestic use and is becoming an increasingly higher value export for regional economies. It is also manufactured into poly pipe that supplies natural gas to homes and businesses.
- Ethylene Oxide is used for a broad range of surfactants, glycols and other inputs to manufacturing and other sectors.

Table 3.2 sets out the main feedstock gas applications.

Natural gas isconsumed in two ways in the chemical industry: as energy to drive processes; and as feedstock. Processing energy consumption in the chemical industry is similar to other industrial sectors – fuels are consumed to provide direct heat, steam and electricity to drive the industry's processes, equipment and facilities. The use of gas to feedstock is unique to the chemical industry.

Feedstock describes the use of various gas, fuels and other materials as a material input. Akin to iron ore inputs to the iron and steel industry or alumina inputs to the aluminium industry, chemical feedstock is the source of the carbon and hydrogen used to constitute a range of chemical products. Feedstock is quantified in energy units because, before use, it is indistinguishable from the same energy products used as fuels. However, once feedstock undergoes transformation in the chemical industry, it is easier to think of it as a material, with its carbon and hydrogen atoms rearranged physically to constitute the plastics and other chemical products manufactured within the industry.

A key aspect of gas feedstock demand is that it is non-switchable, non-substitutable, operates within a narrow band of operational tolerances, and is energy intensive.

TABLE 3.2 GAS AS A CHEMICAL FEEDSTOCK IN VARIOUS APPLICATIONS

Feedstock	Chemistry	Applications
Natural gas (Methane)	Ammonia Ammonium Nitrate	– Fertilisers to increase agricultural yields – Refrigeration, supply chain storage – Explosives – Carbon dioxide, soft drinks / medical
	Sodium cyanide	– Gold extraction and processing
	Methanol	– Building products: medium density fibre board, particle board – Agricultural chemicals – Water treatment: wastewater, sewerage – Fuels: biodiesel, fuel cells
	Peroxide	– Cleaning products, pulp, paper, mining, food and textile manufacturing
Natural gas (Ethane)	Ethylene	– packaging, transportation, electrical/electronic, textile and construction industries as well as consumer chemicals, coatings and adhesives
	Polyethylene	– Agricultural piping, irrigation, tanks – Agricultural film: silage, grain bunkers – Packaging: bag and film; rigid containers; transport film and wrap – Industrial, mining, commercial, residential piping for water, gas and other reticulation
	Ethylene oxide	– Surfactants, glycols and polyols for personal care, agriculture, automotive, mining, textiles, furniture, bedding

SOURCE: CHEMISTRY AUSTRALIA 2018, CHEMISTRY AND GAS ENABLING THE ECONOMY.

Four sub-industries within the broader chemical industry defined in Table 3.1 have been grouped into the 'gas feedstock chemical sector' for additional analysis in this report:

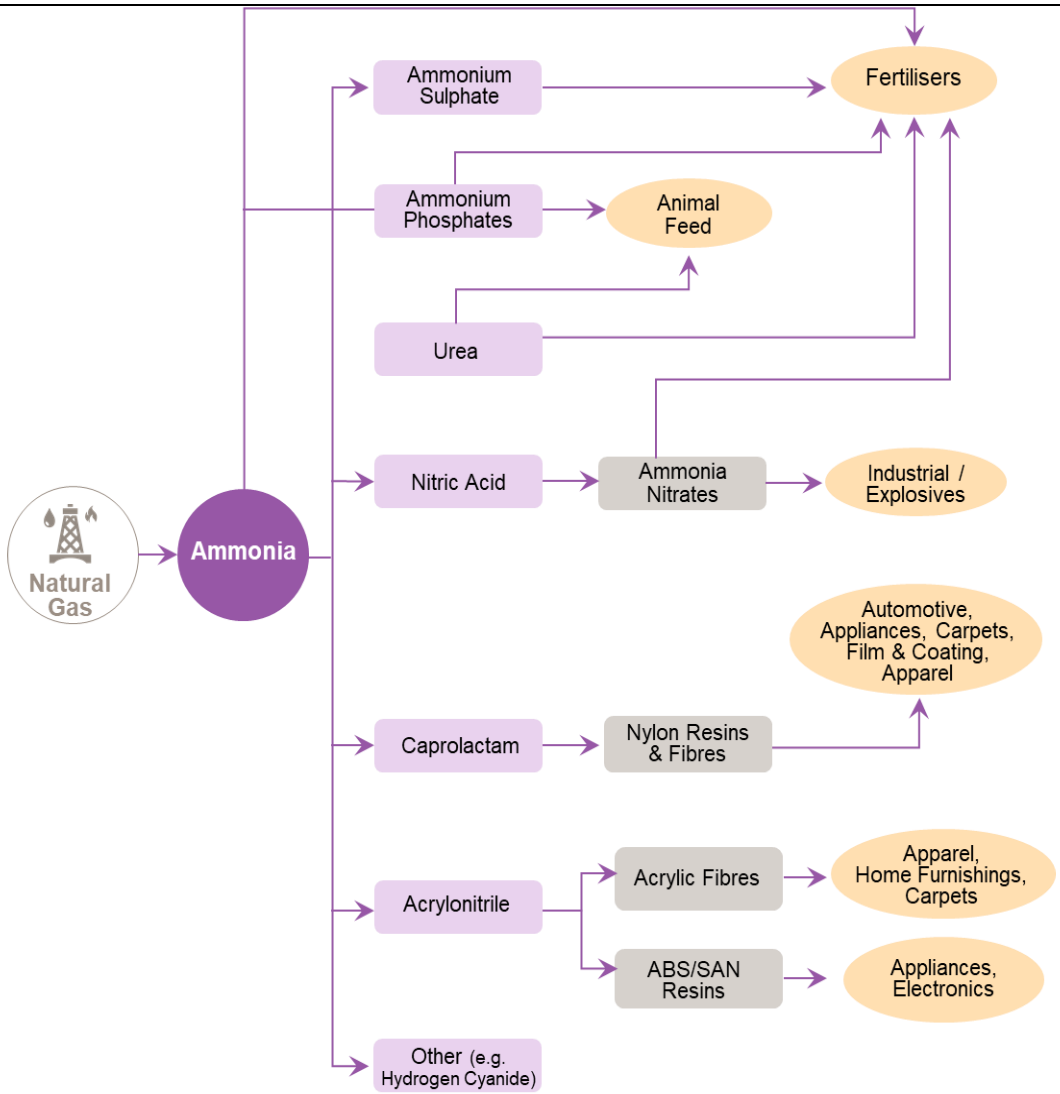
- industrial gas manufacturing (including micro-LNG for domestic uses)
- other basic polymer manufacturing
- fertiliser manufacturing
- explosive manufacturing.

The estimated economic contribution of these industries as a group is assessed in comparative analysis.

An example of natural gas (methane) as a feedstock for Ammonia chemistry is shown in Figure 3.1.

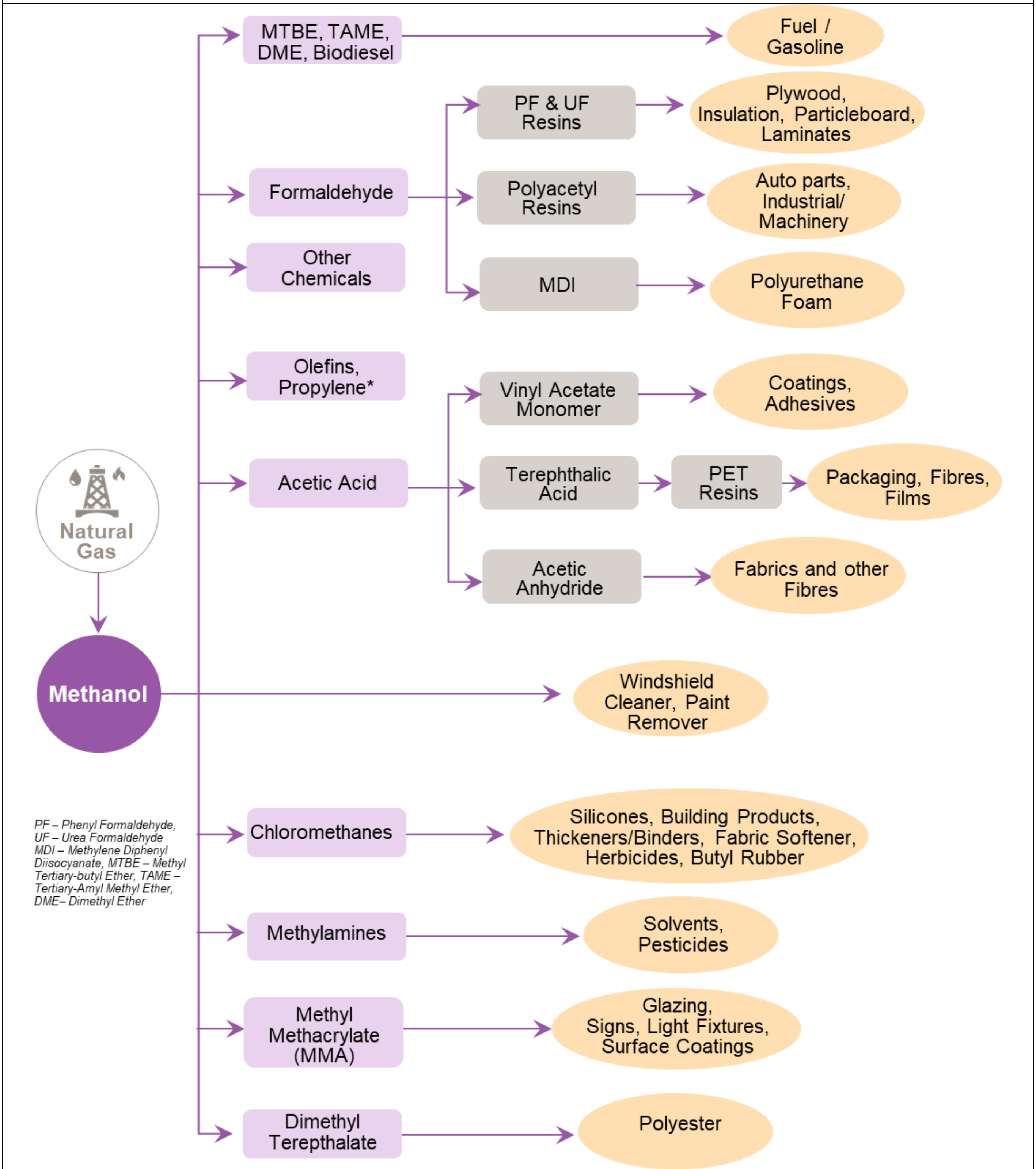
An example of natural gas (methane) as a feedstock for Methanol chemistry is shown in Figure 3.2.

FIGURE 3.1 NATURAL GAS (METHANE) AS A FEEDSTOCK FOR AMMONIA



SOURCE: ACIL ALLEN BASED ON AMERICAN CHEMISTRY COUNCIL 2017, ELEMENTS OF THE BUSINESS OF CHEMISTRY.

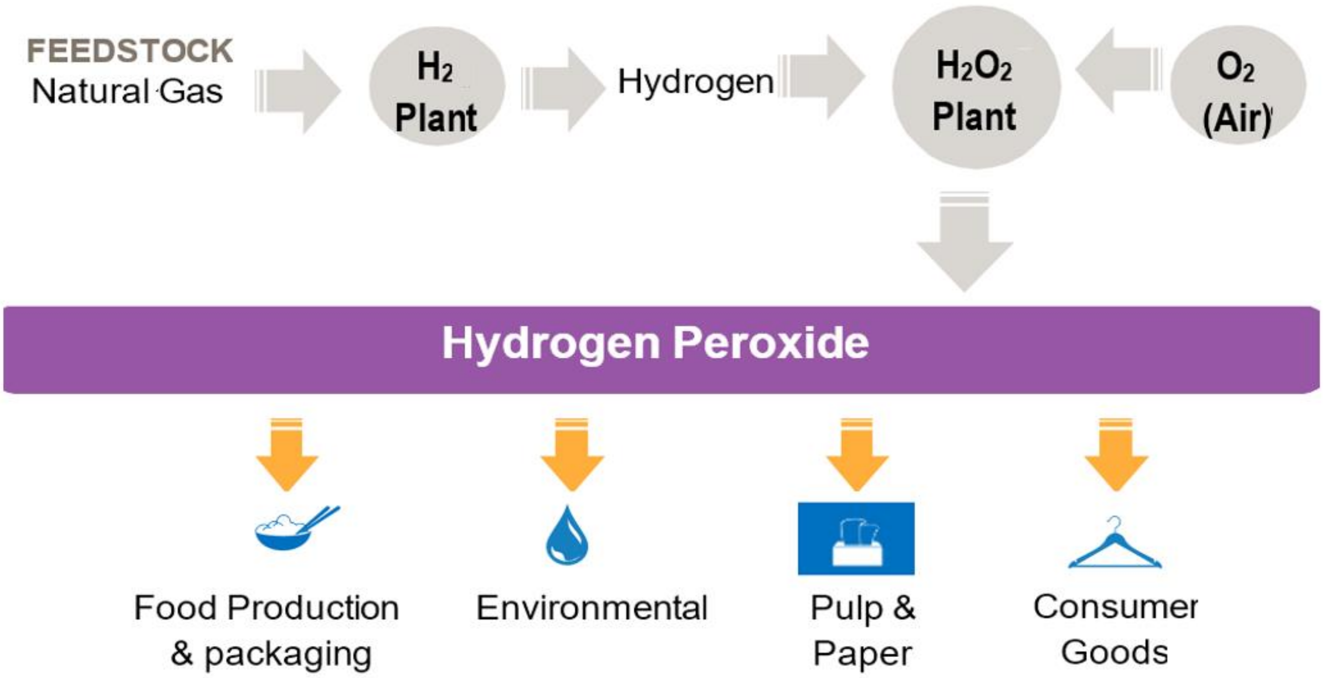
FIGURE 3.2 NATURAL GAS (METHANE) AS A FEEDSTOCK FOR METHANOL



SOURCE: ACIL ALLEN BASED ON AMERICAN CHEMISTRY COUNCIL 2017, ELEMENTS OF THE BUSINESS OF CHEMISTRY.

An example of Methane as a feedstock for Hydrogen Peroxide chemistry applications is shown in Figure 3.3.

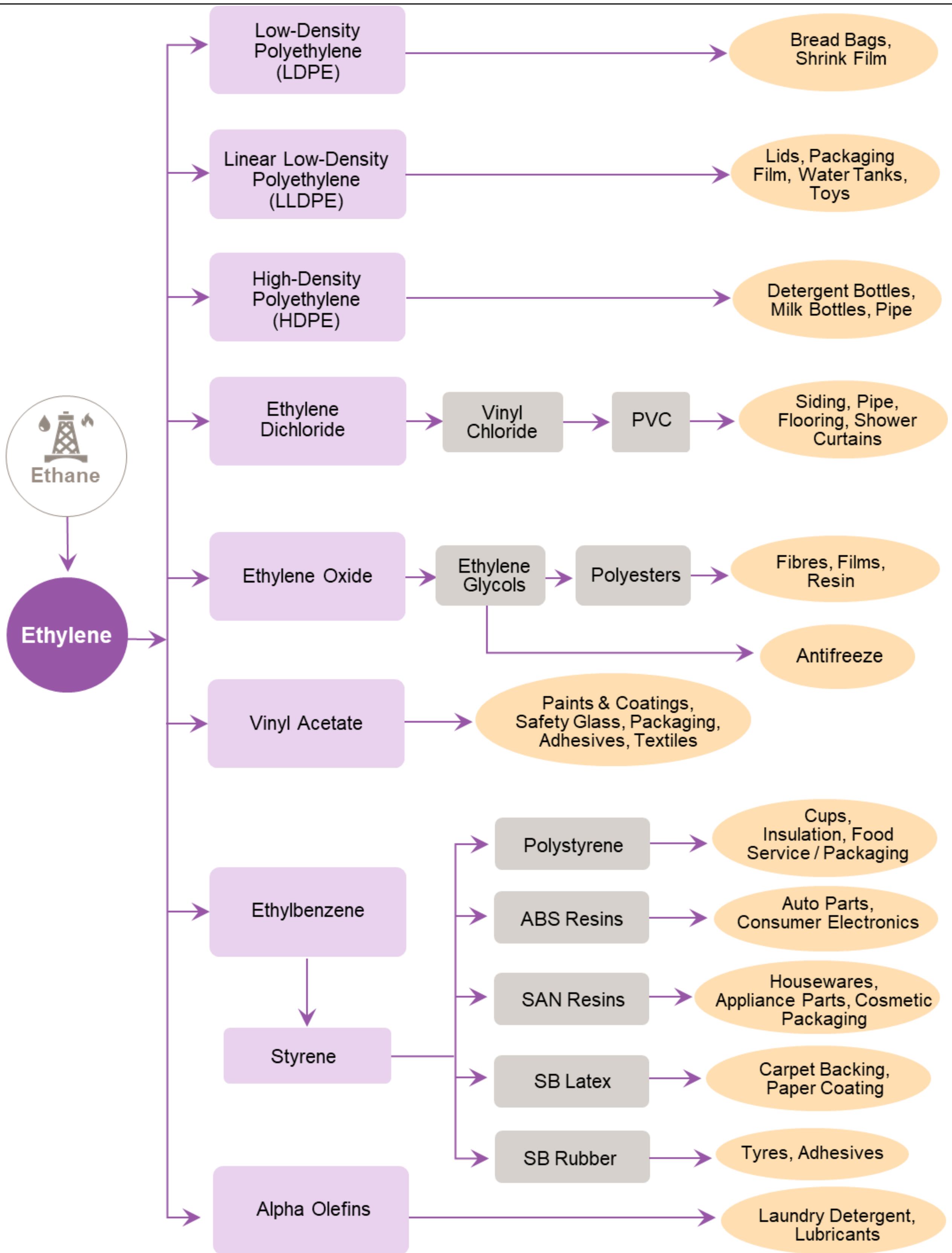
FIGURE 3.3 NATURAL GAS (METHANE) AS A FEEDSTOCK FOR HYDROGEN PEROXIDE



SOURCE: CHEMISTRY AUSTRALIA

An example of Ethane as a feedstock for Ethylene chemistry applications is shown in Figure 3.4.

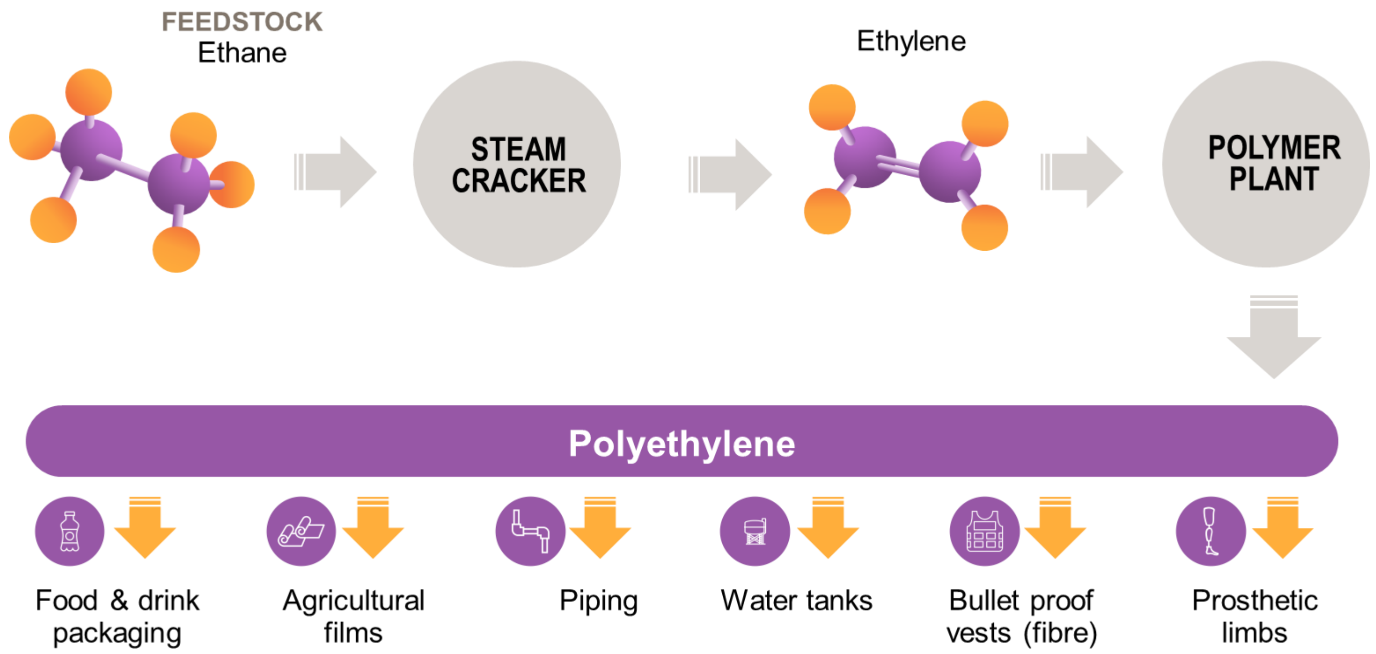
FIGURE 3.4 ETHANE GAS AS A FEEDSTOCK FOR ETHYLENE



SOURCE: ACIL ALLEN BASED ON AMERICAN CHEMISTRY COUNCIL 2017, ELEMENTS OF THE BUSINESS OF CHEMISTRY.

An example of Ethane as a feedstock for Ethylene/Polyethylene chemistry applications is shown in Figure 3.5.

FIGURE 3.5 ETHANE AS A FEEDSTOCK FOR ETHYLENE/POLYETHYLENE

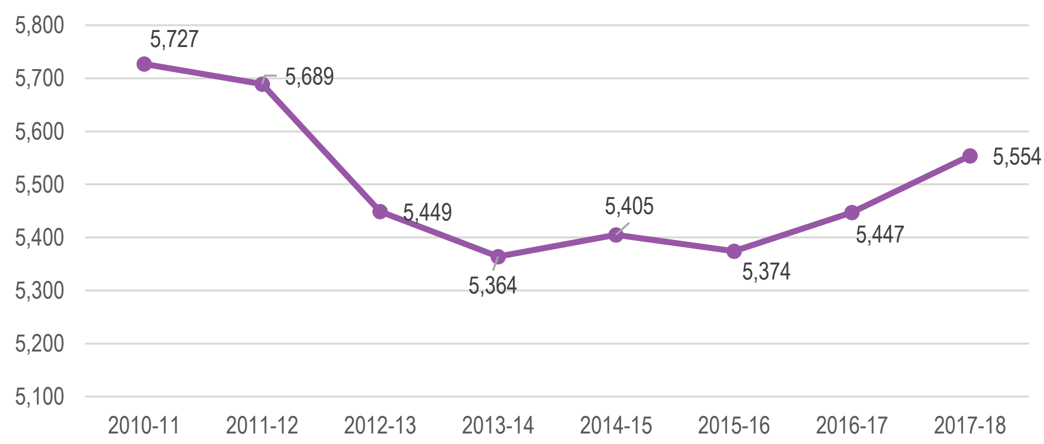


SOURCE: CHEMISTRY AUSTRALIA

3.2 Number of businesses

At June 2018, there were 5,554 businesses in the chemical industry in Australia. The total number of businesses in the industry had declined to 5,374 at the end of June 2016 from 5,727 in June 2011 – a decline of over 350 businesses. However, the number of business in the industry increased recently, mainly in the sub-class of Cosmetic and Toiletry Preparation Manufacturing (Figure 3.6).

FIGURE 3.6 NUMBER OF BUSINESSES OPERATING AT THE END OF FINANCIAL YEAR



SOURCE: ABS CAT NO: 8165 COUNTS OF AUSTRALIAN BUSINESSES, INCLUDING ENTRIES AND EXISTS

The number of businesses by state is provided in Table 3.3. Eighty per cent of businesses were in Victoria, New South Wales and Queensland. Victoria has the highest number of business (over 1,700) which produce chemical products, followed by New South Wales and Queensland.

TABLE 3.3 NUMBER OF BUSINESSES BY STATE, 2011 TO 2018

State	2011	2012	2013	2014	2015	2016	2017	2018
New South Wales	1,680	1,679	1,619	1,575	1,587	1,581	1,598	1,640
Victoria	1,776	1,785	1,699	1,680	1,694	1,677	1,702	1,706
Queensland	1,114	1,101	1,072	1,059	1,071	1,070	1,092	1,116
South Australia	353	346	326	319	333	316	343	362
Western Australia	671	652	600	595	591	579	576	572
Tasmania	64	63	72	77	68	76	75	83
Northern Territory	26	29	25	22	20	25	16	24
Australian Capital Territory	21	12	21	18	24	27	25	30
Unknown	22	22	15	19	17	23	20	21
TOTAL	**5,727**	**5,689**	**5,449**	**5,364**	**5,405**	**5,374**	**5,447**	**5,554**

SOURCE: ABS CAT NO: 8165 COUNTS OF AUSTRALIAN BUSINESSES, INCLUDING ENTRIES AND EXISTS

3.3 Industry value added

The chemical industry directly contributed $10.9 billion to the Australian economy in 2017-18. This is equivalent to 10.4 per cent of the manufacturing sector and 0.59 per cent of GDP in 2017-18.

Its direct economic contribution measured as industry gross value-added as a share of the Australian economy (GDP) has been declining over the past seven years (Table 3.4).

Approximately 67,000 persons (part-time and full-time) were directly employed in the chemical industry in 2017-18.

TABLE 3.4 SIZE OF THE AUSTRALIAN CHEMICAL INDUSTRY, 2010-11 TO 2017-18

Year	Wages and salaries	Sales and service income	Industry value added	Employment	Per cent of GDP
	A$m	A$m	A$m	Persons	%
2010-11	5,240	38,820	11,818	76,920	0.83
2011-12	5,494	38,161	11,356	75,377	0.76
2012-13	5,365	36,619	10,658	73,465	0.69
2013-14	5,352	36,734	11,056	71,270	0.69
2014-15	5,261	37,314	10,876	68,667	0.67
2015-16	5,317	37,935	11,432	69,093	0.69
2016-17	5,340	34,430	10,889	67,033	0.62
2017-18	5,338	36,225	10,948	66,913	0.59

SOURCE: ABS CAT NO: 8155 AUSTRALIAN INDUSTRY AND PREVIOUS YEARS

3.4 International trade

The chemical industry is a trade exposed sector. Trade in chemical products takes place at several points along the supply chain, enabling producers to focus on aspects in which they can maintain a competitive advantage.

Trade in primary chemicals tend to be modest relative to that of downstream derivatives, mainly because of high transportation costs and low margins. A step along the derivative chain (for example from ethylene to polyethylene) not only adds value but often results in easier transportation.

IEA 2018, The Future of Petrochemicals Towards more sustainable plastics and fertilisers, p.35.

As the industry has expanded across the globe, a significant portion of the international chemicals trade is actually between related parties producing in different countries. Imports comprise a significant proportion of the supply of chemicals in Australia, which imports more than it exports.

As a consequence of the structure and size of the Australian market for chemicals, and freight costs from Australia, the chemicals sector in Australia is typically import replacement focused. Local producers lack the scale and economies of plants in other producer countries.

Global competitiveness

The competitiveness of the chemical industry depends upon feedstock costs.

For a range of reasons prices for feedstock and energy have increased significantly in recent years. Rising costs have made Australian companies less able to meet demand from local customers for gas-based chemical products. Consequently, they have become less competitive.

This situation is not unique to the Australian chemical industry. In a McKinsey article[7] it was noted that:

Coming out of the financial crisis and economic slowdown of the past few years, the global chemical industry is seeing major changes. The first relates to energy-price dynamics. The chemical industry is confronting unprecedented hydrocarbon price volatility. In addition, energy prices are significantly higher than they have been for the past two decades—and they are higher than they were coming out of previous recessions.

Florian Budde

As noted above, the competitiveness of the Australian chemical industry depends on the price and accessibility to feedstocks. In Europe and Asia, the chemical industry mainly depends on a petroleum-based feedstock (naphtha) while in the United States and Australia, the chemical industry depends on natural gas and natural gas derivates as feedstock for their chemical production.

Consequently, the ratio of the oil price to the price of natural gas provides a measure of the competitiveness of the chemical industry in different parts of the world (Figure 3.7). When the ratio between the price of oil (as measured in US$ per barrel, Brent) and the price of natural gas (as measured in US$ per million BTUs, Henry Hub) is higher, gas-based chemical production is more competitive relative to petroleum-based feedstock users.

[7] https://www.mckinsey.com/industries/chemicals/our-insights/chemicals-changing-competitive-landscape

FIGURE 3.7 AN INDICATIVE CHEMICAL INDUSTRY COMPETITIVENESS: PRICE RATIO OF CRUDE OIL TO NATURAL GAS

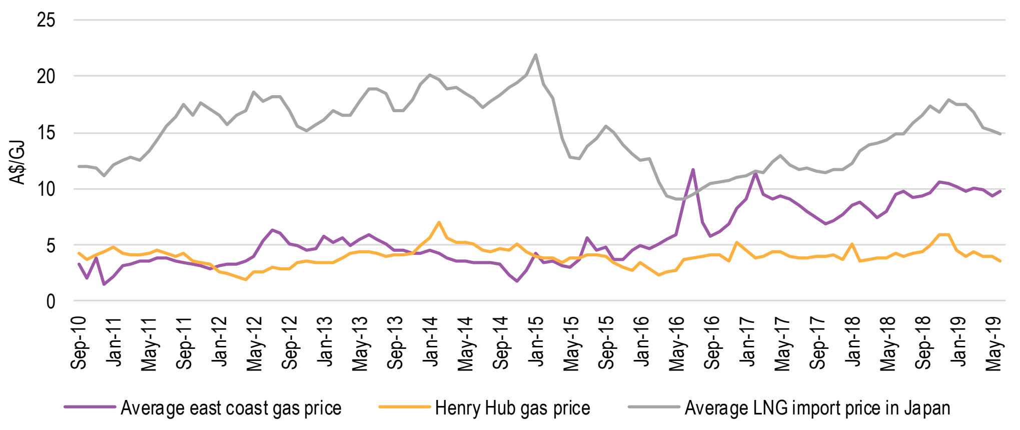
Note: Price ratio of crude oil (UK Brent (US$/bbl) to Natural Gas (Henry Hub (US$/mmbtu). The higher the ratio, the more competitive gas-based chemical production is relative to petroleum-based chemical production.

SOURCE: WORLD BANK, PINK SHEET

Australian chemical industry competitiveness

Figure 3.8 presents the Australian average east coast wholesale price (as reported by AEMO) with the Henry Hub natural gas price in A$/GJ. As can be seen, Australian east coast gas prices used to be comparable to the Henry Hub gas price but diverged significantly since the start of LNG exports from the east coast in mid-2016.[8] This divergence is indicative of the loss of international competitiveness of the Australian gas feedstock chemical industry compared to American producers.

FIGURE 3.8 AVERAGE EAST COAST GAS PRICE AND HENRY HUB GAS PRICE (A$/GJ)



Note: Australian east coast average price is short term trading market price for Brisbane, Sydney and Adelaide reported by AEMO. Henry Hub price is Natural Gas (U.S.), spot price at Henry Hub, Louisiana, converted into Australian dollars based on the RBA exchange rate. Natural gas LNG (Japan) price is, import price, CIF, recent two months' averages.

SOURCE: AEMO 2019 STTM_PRICE_AND_WITHDRAWALS SYDNEY BRISBANE ADELIADE AND WORLD BANK PINK SHEET

[8] ACCC (2016), Inquiry into the east coast gas market 2015, https://www.accc.gov.au/system/files/1074_Gas%20enquiry%20report_FA_21April.pdf

Australian chemical products trade

Australian chemical products trade in 2017-18 is provided in Table 3.5.

The chemical industry trade deficit was nearly $20 billion in 2017-18. Australia's major exports include basic inorganic products such as titanium dioxide, aluminium hydroxide and anhydrous ammonia. Imports are spread across all the major groups. Main imports include tyres, basic organic chemical products, synthetic resin and rubber products.

TABLE 3.5 CHEMICAL INDUSTRY TRADE BY PRODUCT TYPE, 2017-18

Chemical product	Domestic sales	Value of exports	Value of imports	Trade balance
	A$m	A$m	A$m	A$m
Other Petroleum and Coal Products	1,630	255	1,040	(785)
Industrial Gas	2,806	45	46	(2)
Basic Organic Chemical Products	690	324	2,609	(2,285)
Basic Inorganic Chemical Products	200	1,791	1,173	618
Synthetic Resin and Synthetic Rubber products	1,740	317	2,435	(2,119)
Other Basic Polymer products	291	68	52	16
Fertilisers	3,503	263	1,746	(1,483)
Pesticides	1,006	194	1,006	(812)
Cleaning Compounds	1,872	295	1,120	(825)
Cosmetic and Toiletry Products	484	883	2,051	(1,168)
Photographic Chemical Products	1	19	130	(111)
Explosives	2,964	29	196	(167)
Other Basic Chemical Products	172	327	1,125	(798)
Polymer Film and Sheet Packaging Material	1,932	125	1,942	(1,818)
Rigid and Semi-Rigid Polymer Products	4,695	402	2,001	(1,599)
Tyres	43	108	2,767	(2,659)
Adhesives	513	53	134	(81)
Paint and Coatings	2,920	202	808	(606)
Other Polymer Products	1,780	311	1,906	(1,595)
Natural Rubber Products	770	203	1,204	(1,001)
Total	**30,014**	**6,212**	**25,490**	**(19,278)**

SOURCE: ABS, SPECIAL DATA REQUEST AND ACIL ALLEN

Trade by state is provided in Table 3.6. Victoria and New South Wales imported more than any other states in 2017-18 — together importing two-thirds of total chemical products.

TABLE 3.6 CHEMICAL PRODUCTS TRADE BY STATES, 2017-18

State	Value of exports	Value of imports
	A$m	A$m
New South Wales	1,447	8,472
Victoria	1,939	8,590
Queensland	950	4,238
South Australia	303	1,000
Western Australia	1,532	2,861

State	Value of exports	Value of imports
Tasmania	12	206
Northern Territory	30	123
Total	**6,212**	**25,490**

SOURCE: ABS, SPECIAL DATA REQUEST

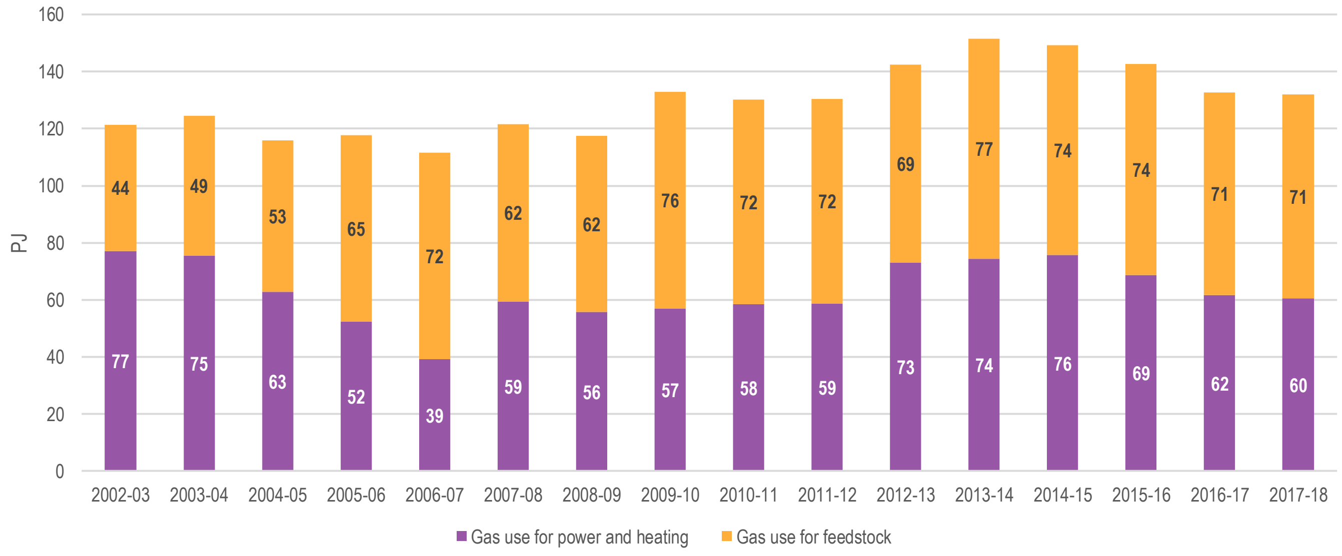
3.5 Gas use

The chemical industry transforms hundreds of millions of tons of natural raw materials from earth, water and air into valuable products. It is an energy intensive sector, being the second largest user of energy in the manufacturing sector after petroleum and coal products in Australia. The chemical industry relies upon natural gas inputs not only as fuel and power for its operations, but also as raw materials in the manufacture of its many products.

Approximately 132 PJ of gas was used in the chemical industry in 2017-18, of which 59 PJ was used for fuel and power and 71 PJ for feedstock (Figure 3.9). Feedstock gas use in the total chemical industry constitutes just over 55 per cent of total use of gas in the industry.

The total chemical industry's gas use in physical units (PJ) in 2017-18 was approximately 9 per cent of Australian total final gas use and around 34 per cent of final gas use by the manufacturing sector.

FIGURE 3.9 ESTIMATED GAS USE BY THE AUSTRALIAN CHEMICAL INDUSTRY, 2002-03 TO 2017-18



Note: 2017-18 data is estimated based on energy accounts data and Energy Quarterly data. Chemical industry feedstocks are not separately identified in the Australian Energy Statistics (AES) published by the DEE and have been sourced from the National Greenhouse Gas Inventory (NGGI).

SOURCE: BASED ON THE DEPARTMENT OF THE ENVIRONMENT AND ENERGY (2018) AUSTRALIAN ENERGY STATISTICS AND AUSTRALIA'S NATIONAL INVENTORY SUBMISSION 2019 CRF REPORTING TABLES (AVAILABLE AT HTTPS://UNFCCC.INT/DOCUMENTS/195780).

Compared with gas used for power or heat purposes which can be substituted for other energy sources, gas used for feedstock is largely non-substitutable. The feedstocks are the foundation of chemistry of plastics, fertilisers and thousands of other products. For the key sectors that use gas as feedstock, approximately 85 per cent of their total gas use was for feedstock and the remainder for heat and energy purposes.

Other gas uses include micro-LNG, which is a small but growing domestic LNG industry distinct from the export LNG industry. Micro-LNG is used for a variety of purposes including for remote area power and customers in the trucking, mining and industrial sectors that want to replace diesel fuel with less-polluting LNG.

3.6 GHG emissions

The production of chemicals leads to emissions of a range of greenhouse gases (GHG). Despite being one of the largest energy consumers within manufacturing, the chemical industry is not the largest source of emissions. This is because more than half of its energy input is used as feedstock and leaves the industry locked into products. The industry's emissions 12 Mt CO_2-e come from two key sources:

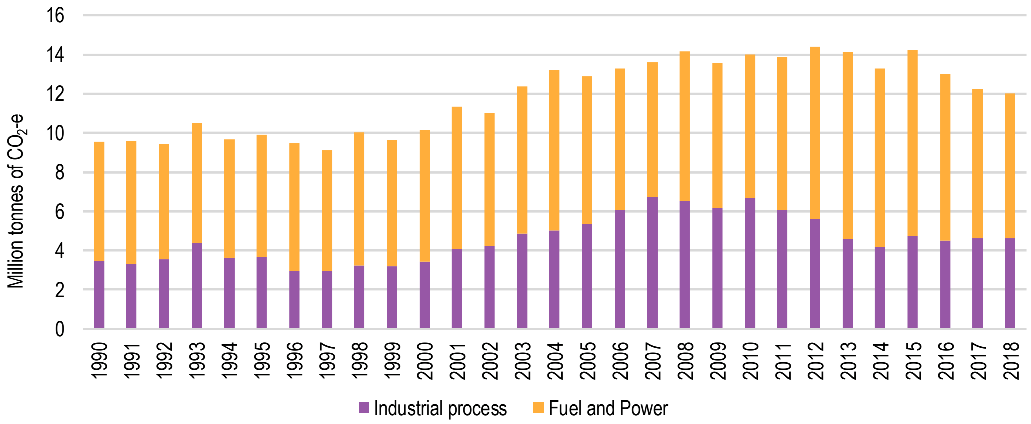
— Energy related emissions (7.4 Mt CO_2-e, or 61 per cent in 2018), which are released when fuel is combusted to generate heat, both directly and for the production of steam on-site.

— Industrial process emissions (4.6 Mt CO_2-e, or 39 per cent in 2018), which reflect the difference in carbon content between the feedstock and the product. For example, approximately 0.4 tonnes of methane (CH_4) feedstock (75 per cent carbon) is required to make a tonne of ammonia (NH_3). The process carbon dioxide (CO_2) emissions per tonne of ammonia product would be approximately 1.1 tonnes of CO_2.[9] For, Australia, based on recent DEE data, this was 0.94 tonnes of CO_2.

Historical greenhouse gas emissions from the Australian chemical industry are presented in Figure 3.10.

The chemical industry's greenhouse gas emissions constituted nearly 2.3 per cent of total Australian emissions in 2018.

FIGURE 3.10 GREENHOUSE GAS EMISSIONS FROM CHEMICAL INDUSTRY, 1990 TO 2018



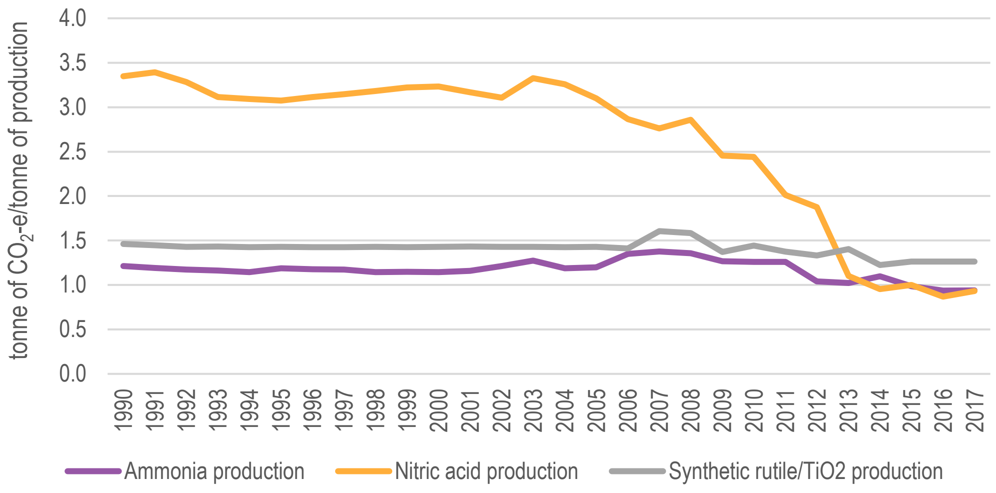
SOURCE: AUSTRALIAN GREENHOUSE EMISSIONS INFORMATION SYSTEM, DEPARTMENT OF THE ENVIRONMENT AND ENERGY (1990-2017) AND ACIL ALLEN ESTIMATES (2018).

Of the estimated 12 Mt CO_2-e from the chemical industry in 2017-18, an estimated 7.7 Mt CO_2-e came from the gas feedstock chemical sector (two-thirds of which were related to the use of natural gas as a feedstock for making other chemicals).

The emission intensity of production of the three main chemical products is provided in Figure 3.11. Since 2000, the emission intensity of nitric acid production declined by 7.7 per cent a year, while the emission intensity of ammonia production declined by 1.7 per cent a year and synthetic rutile declined by 0.8 per cent a year. The large decline in the emission intensity of nitric acid production is mainly due to the implementation of nitrous oxide abatement technologies in Australian plants.

[9] IEA (2018), The Future of Petrochemicals, Towards more sustainable plastics and fertilisers.

FIGURE 3.11 EMISSION INTENSITY, 1990-2017



Note: Covers only industrial process emissions

SOURCE: ESTIMATES BASED ON AUSTRALIAN GREENHOUSE EMISSIONS INFORMATION SYSTEM, DEPARTMENT OF THE ENVIRONMENT AND ENERGY

The contribution of the chemical industry to greenhouse gas emissions abatement is not explored in this study. However, a report commissioned by the International Council of Chemical Association (ICCA) conducted by McKinsey in 2009[10] explored the life cycle of the chemical industry and its products and found that the global chemistry industry enables abatement of around two times its direct emissions.

The reported indicated that:

For every GtCO$_2$-e emitted by the chemical industry in 2005, it enabled 2.1 to 2.6 GtCO$_2$-e in savings via the products and technologies it provides to other industries and users.

ICCA 2009, p.11

Among the top abatement contributors are products manufactured for insulation which result in significant energy savings.

Insulation materials for the construction industry, which reduce the heat lost by buildings and thus the use of heating fuel. Insulation alone accounted for 40 percent of the total identified CO$_2$e savings. This report did not address cooling applications where additional emission reductions in the building industry would be anticipated.

ICCA 2009, p.11

Other significant abatement contributors are in the agriculture sector: notably methane to ammonia fertilisers, and ethane to ethylene to ethylene oxide to surfactants widely used in crop protection.

The use of chemical fertilizer and crop protection in agriculture, which increases agricultural yields – so avoiding emissions from land-use change. Due to the uncertainties in land-use changes, yields, soil quality effects and modes of CO$_2$-binding and assimilation in different conventional and organic agricultural processes, this study adopts two scopes, one with and one without this case.

ICCA 2009, p.11

Similarly, the chemistry industry's role in the lighting sector provides abatement contribution.

Advanced lighting solutions: compact fluorescent lamps (CFLs), with longer lifetimes and greater luminous efficacy than incandescent bulbs, save significant energy.

ICCA 2009, p.11

[10] ICCA (2009), Innovations for Greenhouse Gas Reductions, A lifecycle quantification of carbon abatement solutions enables by the chemical industry. https://www.americanchemistry.com/Policy/Energy/Climate-Study/Innovations-for-Greenhouse-Gas-Reductions.pdf

The other important abatement sources identified by the report were:

— plastic packaging and automotive plastics: *Ethane to Ethylene to Polyethylene / Propylene to Polypropylene*
— marine antifouling coatings, synthetic textiles and low-temperature detergents: *Process energy*
— engine efficiency and plastics used in piping: *Ethane to Ethylene to Polyethylene.*

3.7 Chemical industry supply chain

Given the diverse range of products it produces, the chemical industry is intrinsically linked to the supply chains of many industries across the economy.

The chemical industry supplies inputs to 108 of Australia's 114 industries (ABS input output industry groups). Six sectors that did not use inputs from the chemical industry are:[11]

— textile manufacturing (no longer produced in Australia)
— knitted product manufacturing (no longer produced in Australia)
— internet service providers, internet publishing and broadcasting, web search portals and data processing
— insurance and superannuation funds
— auxiliary finance and insurance services
— computer systems design and related services.

Nearly 67 per cent of the industry's output forms inputs to other sectors of the economy. One-third of direct sales by the chemical industry were to the exporters and consumers.

Intermediate input usage of chemical industry outputs is summarised in Table 3.7.

TABLE 3.7 SALES OF CHEMICAL INDUSTRY OUTPUTS, 2015-16

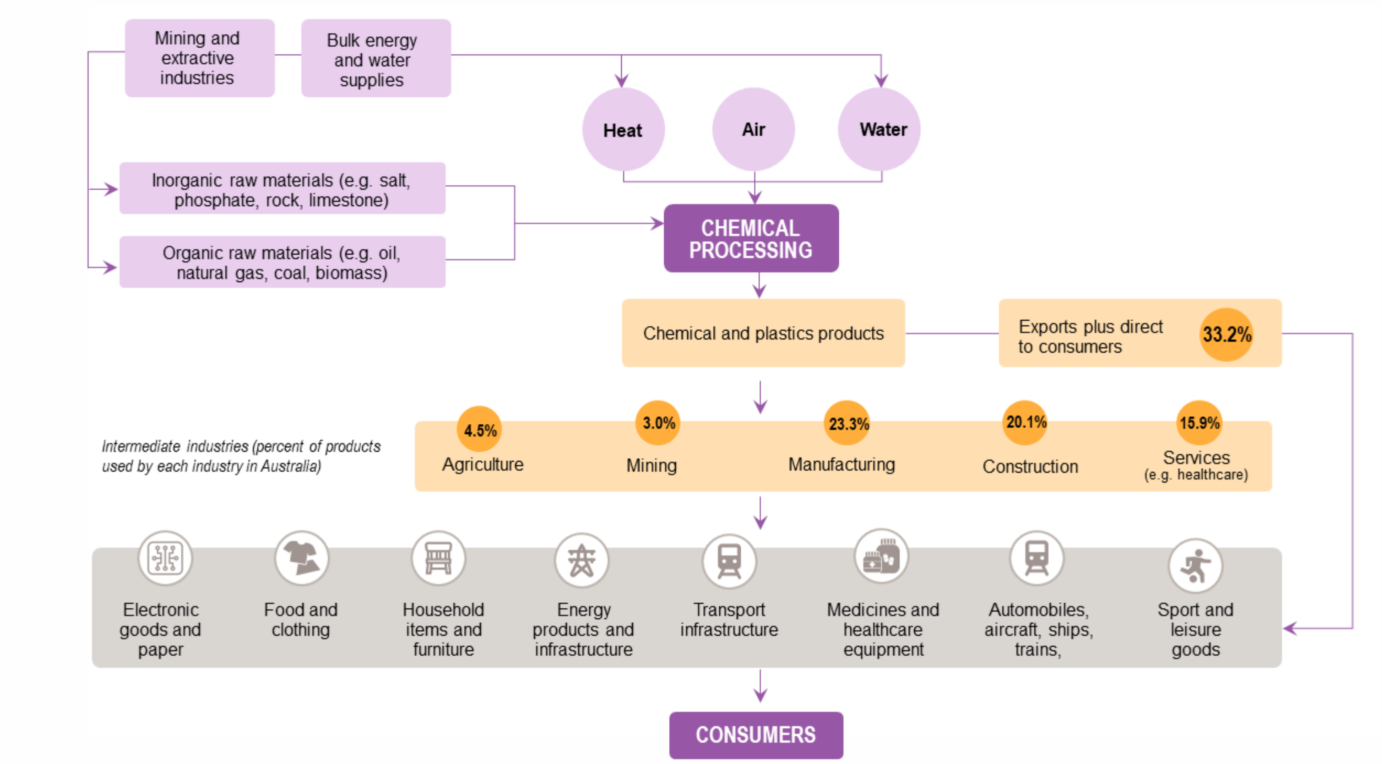
Broad industry	Usage (%)
Agriculture	4.5
Mining	3.0
Manufacturing	23.3
Construction	20.1
Services	15.9
Chemical industry sales to other industries	**66.9**

SOURCE: ABS 2018, AUSTRALIAN NATIONAL ACCOUNTS: INPUT-OUTPUT TABLES (PRODUCT DETAILS) - 2015-16.

A stylised chemical industry supply chain within the Australian economy is shown in Figure 3.12.

[11] The estimates are based on 2015-16 5215.0.55.001 Australian National Accounts: Input-Output Tables (Product Details) - 2015-16, released in November 2018.

FIGURE 3.12 CHEMICAL INDUSTRY INPUTS AND OUTPUTS IN AUSTRALIA



Note: This is based on 2015-16 ABS 2018, Australian National Accounts: Input-Output Tables (Product Details). Sales of explosives in mining are included in the construction sector.

SOURCE: UPDATED BASED ON COOK ET AL 2013, ELEMENTS IN EVERYTHING: CURRENT PROFILE AND FUTURE TRENDS FOR THE AUSTRALIAN CHEMICALS AND PLASTICS INDUSTRY. CSIRO, AUSTRALIA.

4 CHEMICAL INDUSTRY ECONOMIC CONTRIBUTION

4.1 Direct economic contribution

4.1.1 Total chemical industry at national level

The total estimated revenue of the Australian chemical industry in 2017-18 was $36,225 million. The direct economic contribution of the chemical industry embodied within this revenue is estimated to have been $10,948 million, mostly comprising pre-tax returns to owners of the industry and compensation of employees. The chemical industry is thus a high intermediate use sector with a value-add to revenue ratio of 0.3.

In 2017-18, Australian GDP was $1,848 billion, implying that the direct economic contribution of the chemical industry accounted for 0.59 per cent of Australia's 2017-18 GDP. The estimated direct FTE employment in the industry in 2017-18 was 61,458.

4.1.2 Gas feedstock chemical sector at national level

A component of the total chemical industry is separated based on the intensity of gas use as an intermediate input. This provides the estimates for the comparative value of gas as a feedstock to the Australian economy. The following sub-sectors are included in the gas feedstock chemical sector:

- industrial gas manufacturing (including micro-LNG for domestic use)
- other basic polymer manufacturing
- fertiliser manufacturing
- explosive manufacturing.

The total estimated revenue of the gas feedstock chemical sector in Australia in 2017-18 was $9,969 million (28 per cent of the total chemical industry). The direct economic contribution embodied within the revenue of this component of the chemical industry is estimated to have been $3,252 million, mostly comprising pre-tax returns to owners of the industry and compensation of employees.

This implies that the direct economic contribution of this component of the chemical industry accounted for 0.18 per cent of Australia's 2017-18 GDP. The estimated direct FTE employment in this part of the chemical industry in 2017-18 was 9,232.

4.1.3 Total chemical industry at state level

The estimated direct economic (value-add) and employment contribution of the chemical industry by Australian state and territory is provided in Table 4.1.

TABLE 4.1 TOTAL CHEMICAL INDUSTRY DIRECT CONTRIBUTION BY STATE, 2017-18

State	Direct contribution		Per cent of GSP
	Value-add (A$ million)	Employment (FTE)	%
New South Wales	3,192	19,303	0.53
Victoria	3,044	19,550	0.71
Queensland	1,985	11,372	0.57
South Australia	443	3,641	0.41
Western Australia	2,049	6,105	0.79
Tasmania	147	1,075	0.48
Northern Territory	71	321	0.27
Australian Capital Territory	16	90	0.04
Australia	**10,948**	**61,458**	**0.59**

Notes: FTE = full time equivalent.

SOURCE: ACIL ALLEN CONSULTING

Victoria, New South Wales, Western Australia and Queensland are major states for the chemical industry.

4.2 Indirect economic contribution

The direct contribution of an activity in terms of value added is confined to the initial impacts of the activity. However, purchases of intermediate inputs or spending of incomes made as a result of an activity will lead to further economic impacts. These are estimated as the indirect contribution.

In addition to the direct value added by sectors, there are two key indirect channels through which a sector contributes indirectly to the economy. These are:

1. Purchases of intermediate inputs by industry: The sector or industry purchase goods and services from various businesses in the region in order to produce its output e.g. gas, additional electricity use, other related chemicals within the sector, or services from other sectors. This creates demand for those services and further stimulates the economic activity in the region.
2. Employee spend: The additional income received by the employees in the industry is spent on purchasing various goods and services in the region. This additional spend generates additional economic activity.

As discussed in Appendix A, the above two effects are captured by the supply chain information embodied in input-output tables (and the associated 'input-output multipliers') of the Australian and state economies. The indirect economic contribution can be measured using the relevant multipliers. Based on information from the ABS, ACIL Allen has developed (and regularly updates) detailed input-output tables for Australia and each state and territory (along with various regional areas, when necessary). From these tables, ACIL Allen has calculated a range of multipliers to facilitate economic analysis for the chemical industry, LNG industry and electricity generation industry. By allocating the Australian intermediate inputs to their corresponding input-output industries and applying the appropriate multipliers for the Australian value added and employment data, it is possible to estimate the total Australian value added and employment contribution embodied in the Australian produced inputs and services demanded by the chemical industry in 2017-18.

The economic contribution of the chemical industry is reported both at the national and state levels. LNG industry and electricity generation industry economic contributions are reported at the national level only.

4.2.1 Total chemical industry at national level

It is estimated that the Australian chemical industry spent $25,278 million on goods and services in producing its outputs in 2017-18. Of this, it is estimated that $19,596 million was spent on domestically produced goods and services comprising:

- $2,442 million on gas
- $2,260 million on transport
- $2,219 million on basic chemicals (within the industry)
- $1,426 million on wholesale trade
- $1,148 million on polymer products
- $1,144 million on professional, scientific and technical services
- $815 million on electricity
- $8,155 million on other intermediate inputs.

It is estimated that the domestic spend of $19,596 million by sector indirectly contributed between $16,833 million and $26,780 million to the Australian economy, which is between 0.91 per cent and 1.45 per cent of GDP in 2017-18. This is in addition to the direct contribution of 0.59 per cent reported in Section 4.1.1.

It is estimated that between 93,998 and 150,363 FTE jobs were indirectly supported by chemical industry activities in the Australian economy.

4.2.2 Gas feedstock chemical sector at national level

It is estimated that the Australian gas feedstock chemical sector spent $6,717 million on goods and services in producing its outputs in 2017-18. Of this, it is estimated that $5,459 million was spent on domestically produced goods and services comprising:

- $1,320 million on gas
- $653 million on transport
- $423 million on basic chemicals (within the industry)
- $505 million on wholesale trade
- $120 million on polymer products
- $218 million on professional, scientific and technical services
- $90 million on electricity
- $2,132 million on other intermediate inputs.

It is estimated that the domestic spend of $5,459 million by the industry indirectly contributed between $4,725 million and $7,349 million to the Australian economy, which is between 0.26 per cent and 0.40 per cent of GDP in 2017-18. This is in addition to the direct contribution of 0.18 per cent.

It was estimated that between 24,396 and 39,269 FTE jobs were indirectly supported by this part of the chemical industry's activities in the Australian economy.

4.2.3 Total chemical industry at state level

The estimated indirect economic (value-add) and employment contributions of the chemical industry in each Australian jurisdiction are summarised in Table 4.2 and Table 4.3, respectively.

TABLE 4.2 INDIRECT ECONOMIC (VALUE-ADD) CONTRIBUTION OF TOTAL CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct	Indirect Lower	Indirect Upper	Direct	Indirect Lower	Indirect Upper
	$A million	$A million	$A million	% GSP	% GSP	% GSP
New South Wales	3,192	4,905	8,093	0.53	0.81	1.34
Victoria	3,001	4,720	7,539	0.70	1.10	1.75
Queensland	2,010	3,076	4,859	0.58	0.88	1.39
South Australia	461	775	1,225	0.43	0.72	1.14
Western Australia	2,049	2,993	4,542	0.79	1.15	1.75
Tasmania	147	227	332	0.48	0.74	1.08
Northern Territory	71	110	150	0.27	0.42	0.57
Australian Capital Territory	16	27	39	0.04	0.07	0.10
Australia	**10,948**	**16,833**	**26,780**	**0.59**	**0.91**	**1.45**

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively.
SOURCE: ACIL ALLEN

New South Wales

New South Wales is a major state for the Australian chemical industry, even though gas is not a major input for the state. It is estimated that the New South Wales chemical industry spent $7,382 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $4,950 million was spent on locally produced goods and services comprising:

- $159 million on gas
- $1,361 million on wholesale and retail trade and transport
- $733 million on professional and other business services
- $642 million on electricity
- $405 million on basic chemicals and polymer products
- $208 million on health care and public safety
- $1,441 million other inputs and services.

A local spend of $4,950 million by New South Wales contributed between an additional $4,905 million to $8,09 million to the state's economy, which is between 0.81 and 1.34 per cent of New South Wales' GSP in 2017-18. This is in addition to the direct contribution of 0.53 per cent.

In total, it is estimated that between 27,704 and 44,645 FTE jobs were indirectly supported by chemical industry activities in the New South Wales economy in 2017-18.

TABLE 4.3 INDIRECT EMPLOYMENT (FTE) CONTRIBUTION OF TOTAL CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct	Indirect Lower	Indirect Upper
New South Wales	19,303	27,704	44,645
Victoria	19,550	28,236	45,164
Queensland	11,372	18,172	29,102
South Australia	3,641	4,467	7,165
Western Australia	6,105	13,229	21,104
Tasmania	1,075	1,435	2,161
Northern Territory	321	558	770

State	Direct	Indirect Lower	Indirect Upper
Australian Capital Territory	90	197	252
Australia	**61,458**	**93,998**	**150,363**

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively.
SOURCE: ACIL ALLEN

Victoria

Victoria is the major state for the chemical industry in Australia. It is estimated that Victoria's chemical industry spent $6,907 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $4,839 million was spent on locally produced goods and services comprising:

- $538 million on gas
- $1,080 million on wholesale and retail trade and transport
- $724 million on professional and other business services
- $565 million on electricity
- $412 million on basic chemicals and polymer products
- $187 million on health care and public safety
- $1,333 million other inputs and services.

A local spend of $4,839 million by the Victorian chemical industry contributed between an additional $4,720 million to $7,539 million to the state's economy, which is between 1.10 and 1.75 per cent of Victoria's GSP in 2017-18. This is in addition to the direct contribution of 0.70 per cent.

In total, it is estimated that between 28,236 and 45,164 FTE jobs were indirectly supported by chemical industry activities in the Victorian economy in 2017-18.

Queensland

Queensland is also a major state for the Australian chemical industry. It is estimated that Queensland's chemical industry spent $4.54 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $3,179 million was spent on locally produced goods and services comprising:

- $187 million on gas
- $841 million on wholesale and retail trade and transport
- $381 million on professional and other business services
- $418 million on electricity
- $299 million on basic chemicals and polymer products
- $140 million on health care and public safety
- $914 million other inputs and services.

A local spend of $3,179 million by the Queensland chemical industry contributed between an additional $3,076 million to $4,859 million to the state's economy, which is between 0.88 and 1.39 per cent of Queensland's GSP in 2017-18. This is in addition to the direct contribution of 0.58 per cent.

In total, it is estimated that between 18,172 and 29,102 FTE jobs were indirectly supported by chemical industry activities in the Queensland economy in 2017-18.

South Australia

It is estimated that South Australia's chemical industry spent $991 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $801 million was spent on locally produced goods and services comprising:

- $72 million on gas

- $162 million on wholesale and retail trade and transport
- $102 million on professional and other business services
- $89 million on electricity
- $94 million on basic chemicals and polymer products
- $28 million on health care and public safety
- $254 million other inputs and services.

A local spend of $801 million by the South Australian chemical industry contributed between an additional $775 million to $1,225 million to the state's economy, which is between 0.72 and 1.14 per cent of South Australia's GSP in 2017-18. This is in addition to the direct contribution of 0.43 per cent.

In total, it is estimated that between 4,467 and 7,165 FTE jobs were indirectly supported by chemical industry activities in the South Australian economy in 2017-18.

Western Australia

It is estimated that Western Australia's chemical industry spent $4,856 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $3,243 million was spent on locally produced goods and services comprising:

- $797 million on gas
- $768 million on wholesale and retail trade and transport
- $283 million on professional and other business services
- $175 million on electricity
- $401 million on basic chemicals and polymer products
- $90 million on health care and public safety
- $729 million other inputs and services.

A local spend of $3,243 million by the Western Australian chemical industry contributed between an additional $2,993 million to $4,542 million to the state's economy, which is between 1.15 and 1.75 per cent of Western Australia's GSP in 2017-18. This is in addition to the direct contribution of 0.79 per cent.

In total, it is estimated that between 13,229 and 21,104 FTE jobs were indirectly supported by chemical industry activities in the Western Australian economy in 2017-18.

Tasmania

It is estimated that Tasmania's chemical industry spent $326 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $254 million was spent on locally produced goods and services comprising:

- $71 million on gas
- $42 million on wholesale and retail trade and transport
- $22 million on professional and other business services
- $31 million on electricity
- $20 million on basic chemicals and polymer products
- $7 million on health care and public safety
- $62 million other inputs and services.

A local spend of $254 million by the Tasmanian chemical industry contributed between an additional $227 million and $332 million to the state's economy, which is between 0.74 and 1.08 per cent of Tasmania's GSP in 2017-18. This is in addition to the direct contribution of 0.48 per cent.

In total, it is estimated that between 1,435 and 2,161 FTE jobs were indirectly supported by chemical industry activities in the Tasmanian economy in 2017-18.

Northern Territory

It is estimated that the Northern Territory's chemical industry spent $168 million on goods and services in producing chemicals and plastics for other industries and exports in 2017-18. Of this, it is estimated that $126 million was spent on locally produced goods and services comprising:

- $16 million on gas
- $33 million on wholesale and retail trade and transport
- $14 million on professional and other business services
- $9 million on electricity
- $15 million on basic chemicals and polymer products
- $4 million on health care and public safety
- $35 million other inputs and services.

A local spend of $126 million by the Northern Territory chemical industry contributed an additional between $110 million and $150 million to the state's economy, which is between 0.42 and 0.57 per cent of the Northern Territory's GSP in 2017-18. This is in addition to the direct contribution of 0.27 per cent.

In total, it is estimated that between 558 and 770 FTE jobs were indirectly supported by chemical industry activities in the Northern Territory's economy in 2017-18.

4.3 Total economic contribution

Adding the direct and indirect economic contributions from Sections 4.1 and 4.2 provides lower and upper bound estimates of the total economic footprint of the Australian chemical industry in 2017-18.

Total economic contributions estimated in this study at a national level are summarised in Table 4.4.

TABLE 4.4 TOTAL ECONOMIC (VALUE-ADD) CONTRIBUTIONS, 2017-18

Sector	Direct	Indirect		Total	
		Lower	*Upper*	*Lower*	*Upper*
	A$m	A$m	A$m	A$m	A$m
Total chemical industry	10,948	16,833	26,780	27,781	37,728
– *Gas feedstock chemical sector*	*3,252*	*4,725*	*7,349*	*7,977*	*10,601*
			Per cent of GDP		
Total chemical industry	0.59	0.91	1.45	1.50	2.04
– *Gas feedstock chemical sector*	*0.18*	*0.26*	*0.40*	*0.43*	*0.57*

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively. Totals may not add due to rounding.
SOURCE: ACIL ALLEN

Total employment contributions at national level are summarised in Table 4.5.

TABLE 4.5 TOTAL EMPLOYMENT (FTE) CONTRIBUTIONS, 2017-18

Sector	Direct	Indirect lower	Indirect upper	Total lower	Total upper
Chemical industry	61,458	93,998	150,363	155,456	211,821
– *Gas feedstock chemical sector*	*9,232*	*24,396*	*39,269*	*33,628*	*48,500*

SOURCE: ACIL ALLEN

4.3.1 Total chemical industry at national level

The total Australian economic contribution of the chemical industry in 2017-18 is summarised in Figure 4.1.

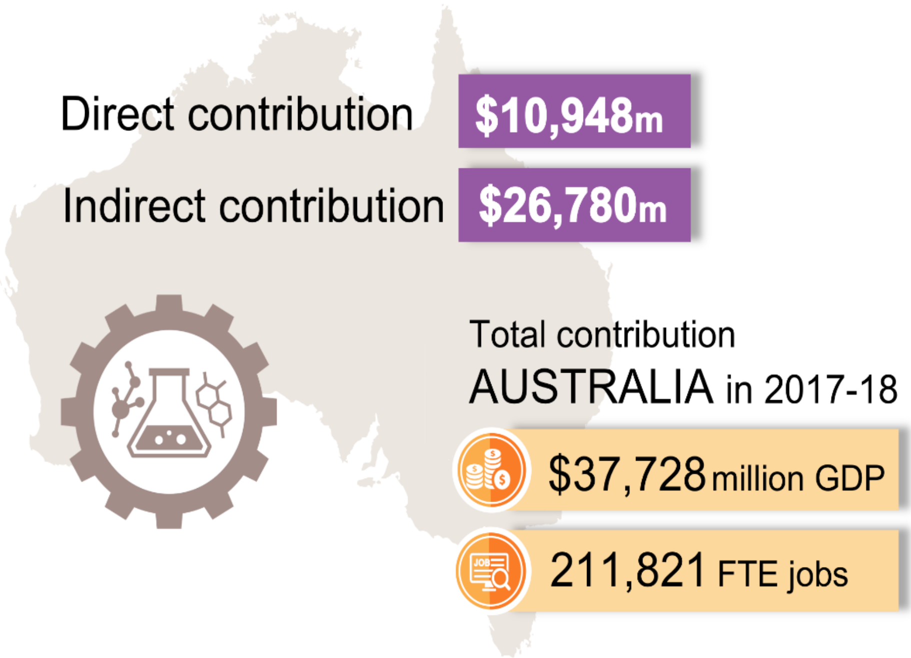
In 2017-18, it is estimated that the chemical industry in Australia had:

- a *lower bound* contribution of $27,781 million to Australian GDP, comprising $10,948 million directly from the industry (direct contribution) and $16,833 million indirectly from its input demand sources (indirect contribution). As a whole, the chemical industry contributed a minimum of 1.5 per cent to Australian GDP in 2017-18.
- an *upper bound* contribution of $37,728 million to Australian GDP, comprising $10,948 million directly from the industry (direct contribution) and $26,780 million indirectly from its input demand sources and an additional spend of employees of the chemical industry (indirect contribution). As a whole, the chemical industry contributed a maximum of 2.04 per cent to Australian GDP in 2017-18.

In 2017-18, it is estimated that the chemical industry in Australia supported up to 211,821 FTE jobs. To put this another way, for every one million dollars of revenue received by the Australian chemical industry, there are up to 4 FTE jobs that are supported elsewhere in the Australian economy.

In understanding the estimated number of jobs supported by the industry, it should be noted that they are presented as full-time-equivalent jobs for convenience. In reality, they represent the summation of many shares of individual jobs or include part-time and casual jobs. Consequently, the number of people whose employment is supported (partially or wholly) by the activities of the chemical industry will actually be greater than the estimated number of FTE jobs.

FIGURE 4.1 ESTIMATED ECONOMIC CONTRIBUTION OF THE TOTAL CHEMICAL INDUSTRY TO AUSTRALIA, 2017-18



SOURCE: ACIL ALLEN

4.3.2 Gas feedstock chemical sector at national level

The total Australian economic contribution of the major gas feedstock chemical sector in 2017-18 is summarised in Figure 4.2.

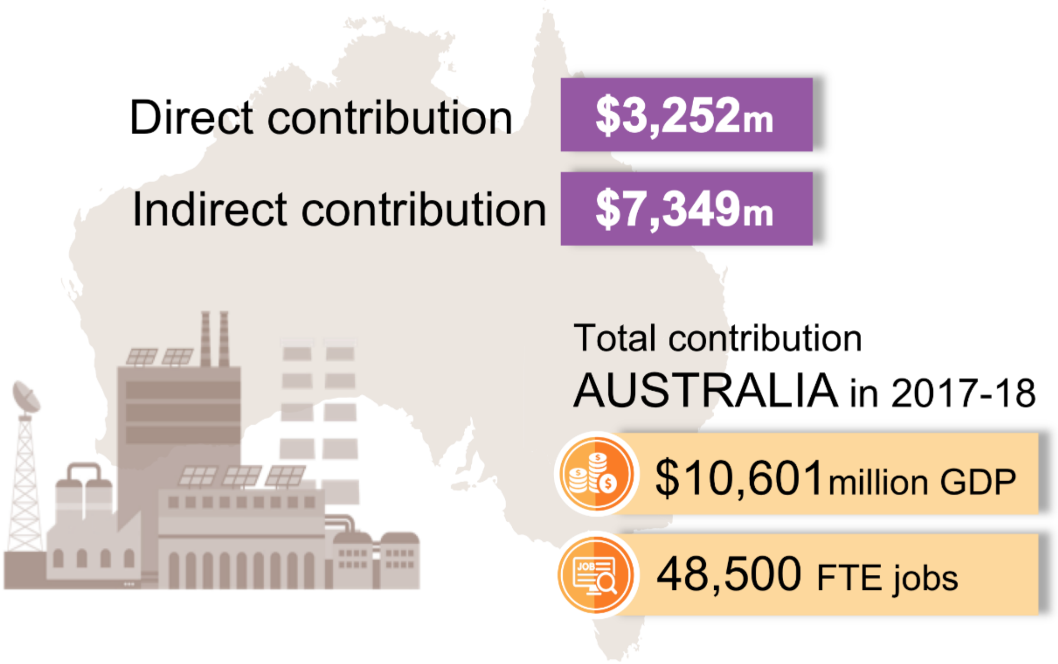
In 2017-18, it is estimated that the gas feedstock chemical sector in Australia had:

- a *lower bound* contribution of $7,977 million to Australian GDP, comprising $3,252 million directly from the sector (direct contribution) and $4,725 million indirectly from its input demand sources (indirect contribution). As a whole, it contributed a minimum of 0.43 per cent to Australian GDP in 2017-18.
- an *upper bound* contribution of $10,601 million to Australian GDP, comprising $3,252 million directly from the sector (direct contribution) and $7,349 million indirectly from its input demand sources and an

additional spend of employees of the sector (indirect contribution). As a whole, it contributed a maximum of 0.57 per cent to Australian GDP in 2017-18.

In 2017-18, it is estimated that this subset of the chemical industry in Australia supported up to 48,500 FTE jobs. To put this another way, for every one million dollars of revenue received by the gas feedstock chemical sector, there are up to 4 FTE jobs that are supported elsewhere in the Australian economy.

FIGURE 4.2 ESTIMATED ECONOMIC CONTRIBUTION OF THE GAS FEEDSTOCK CHEMICAL SECTOR TO AUSTRALIA, 2017-18



SOURCE: ACIL ALLEN

4.3.3 Total chemical industry at state level

The estimated total (direct and indirect) economic and employment contributions of the chemical industry in each Australian jurisdiction is summarised in Table 4.6 and Table 4.7, respectively. Australian states are economically interdependent; each state's economy depends on the inputs and services from other states and sell goods and services across the nation. Each state depends on the chemical industry's products to support their agriculture, manufacturing and services industries. Nearly all states have some chemical industry activity, however most production occurs in four states — New South Wales, Victoria, Western Australia and Queensland. Production is distributed mainly where the gas feedstock is available and where there is demand for the chemical industry products.

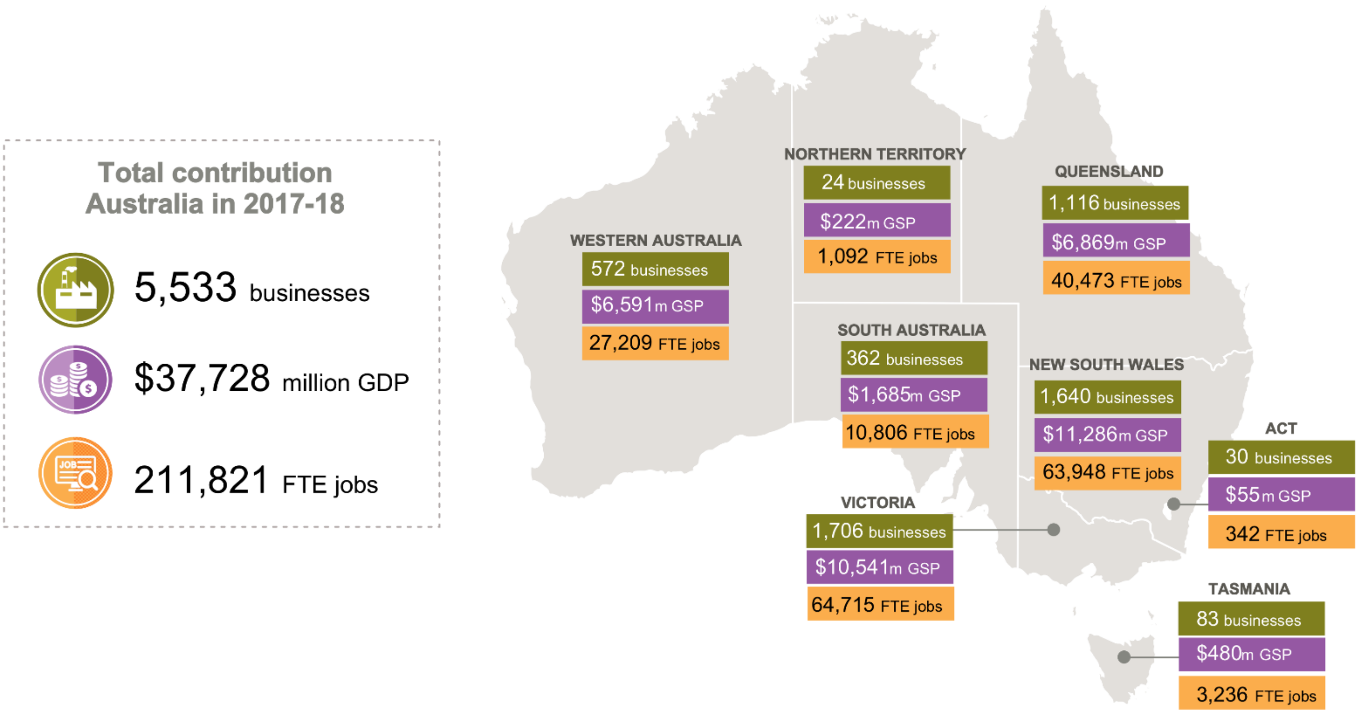
TABLE 4.6 TOTAL ECONOMIC CONTRIBUTION OF TOTAL CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct	Indirect		Total		Total as a share of GSP	
		Lower bound	*Upper bound*	*Lower bound*	*Upper bound*	*Lower bound*	*Upper bound*
	$A million	$A million	$A million	$A million	$A million	% of GSP	% of GSP
New South Wales	3,192	4,905	8,093	8,098	11,286	1.34	1.87
Victoria	3,001	4,720	7,539	7,721	10,541	1.79	2.45
Queensland	2,010	3,076	4,859	5,086	6,869	1.46	1.97
South Australia	461	775	1,225	1,236	1,685	1.15	1.57
Western Australia	2,049	2,993	4,542	5,042	6,591	1.94	2.54
Tasmania	147	227	332	374	480	1.21	1.56
Northern Territory	71	110	150	182	222	0.69	0.84
Australian Capital Territory	16	27	39	43	55	0.11	0.14
Australia	**10,948**	**16,833**	**26,780**	**27,781**	**37,728**	**1.50**	**2.04**

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively. Indirect economic activity due to interstate trade has been included in the regional contribution estimates based on their share of underlying activity.

SOURCE: ACIL ALLEN

FIGURE 4.3 TOTAL ECONOMIC CONTRIBUTION OF AUSTRALIAN CHEMICAL INDUSTRY BY STATE, 2017-18



SOURCE: ACIL ALLEN

TABLE 4.7 TOTAL EMPLOYMENT SUPPORTED BY THE AUSTRALIAN CHEMICAL INDUSTRY BY STATE, 2017-18

State	Direct chemical industry	Indirect chemical industry		Total chemical industry	
		Lower bound	*Upper bound*	*Lower bound*	*Upper bound*
	FTE jobs	FTE jobs	FTE jobs	FTE jobs	FTE jobs
New South Wales	19,303	27,704	44,645	47,007	63,948
Victoria	19,550	28,236	45,164	47,786	64,715
Queensland	11,372	18,172	29,102	29,544	40,473
South Australia	3,641	4,467	7,165	8,108	10,806
Western Australia	6,105	13,229	21,104	19,335	27,209
Tasmania	1,075	1,435	2,161	2,510	3,236
Northern Territory	321	558	770	879	1,092
Australian Capital Territory	90	197	252	287	342
Australia	**61,458**	**93,998**	**150,363**	**155,456**	**211,821**

Note: FTE = full time equivalent.

SOURCE: ACIL ALLEN

5

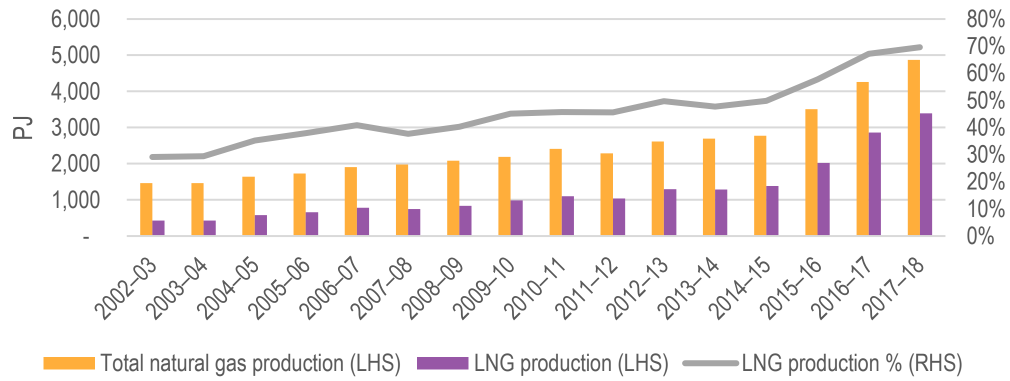
OTHER GAS USE COMPETING INDUSTRIES

Two other major users of gas in Australia are LNG and electricity generation. The economic contribution of these two industries to the Australian economy are estimated in this chapter.

5.1 LNG industry

LNG is natural gas that has been cooled to a liquid state, at about -162°C, for shipping and storage. The volume of natural gas in its liquid state is about 600 times smaller than its volume in its gaseous state. This process makes it possible to transport natural gas to places pipelines do not reach and to use natural gas as a transportation fuel. LNG is shipped in special ocean-going ships (tankers) between export terminals, where natural gas is liquefied, and import terminals, where LNG is returned to its gaseous state (regasified). At an import terminal it can be injected into pipelines for transmission to distribution companies, industrial consumers and power plants. Natural gas production and LNG production in Australia are shown in Figure 5.1. Currently the majority of LNG produced in Australia is exported. LNG production constituted 70 per cent of gas production in 2017-18, increasing from 29 per cent in 2002-03. LNG production has increased at an annual average growth rate of 14.8 per cent per annum between 2002-03 and 2017-18.

FIGURE 5.1 NATURAL GAS AND LNG PRODUCTION IN AUSTRALIA, 2002-03 TO 2017-18



SOURCE: BASED ON ABS (2018), CAT NO: 4604.0 ENERGY ACCOUNT, AUSTRALIA 2016-17 AND OFFICE OF CHIEF ECONOMIST (2019), RESOURCES AND ENERGY QUARTERLY, MARCH 2019.

Table 5.1 presents the size of the Australian LNG industry in recent years.

In 2017-18, the volume of Western Australia's LNG sales was 37.9 million tonnes (2,167 PJ), Queensland's LNG sales was around 20 million tonnes with the remainder from the Northern Territory.[12]

In total, in 2017-18 nearly 3,390 PJ gas was condensed by the LNG industry, which generated a gross value add of $20 billion (being 1.1 per cent of Australian GDP in 2017-18). Its share in the Australian economy has increased from 0.48 per cent in 2012-13 to 1.1 per cent in 2017-18.

Each PJ of gas condensed in the LNG industry directly contributed $6 million to the Australian economy in 2017-18.[13] This direct contribution could increase as production ramps up in the next couple of years from new projects.

TABLE 5.1 SIZE OF THE AUSTRALIAN LNG INDUSTRY, 2012-13 TO 2017-18

Year	Wages and salaries	Sales and service income	Industry value added	Employment	Per cent of GDP
	A$m	A$m	A$m	Persons	%
2012-13	1,103	10,904	7,319	5,513	0.48
2013-14	1,277	11,559	7,552	6,080	0.47
2014-15	1,675	12,313	8,733	7,597	0.54
2015-16	2,085	15,309	9,579	9,005	0.58
2016-17	3,026	22,223	13,905	12,449	0.79
2017-18	4,408	32,369	20,253	17,269	1.10

SOURCE: ACIL ALLEN ESTIMATES BASED ON ABS CAT NO: 8155 AUSTRALIAN INDUSTRY, ABS 5209.0.55.001 - AUSTRALIAN NATIONAL ACCOUNTS: INPUT-OUTPUT TABLES, 2015-16 AND PREVIOUS TABLES AND ABS NATIONAL ACCOUNTS

5.1.1 Direct economic contribution of LNG industry

The total estimated revenue of the Australian LNG industry in 2017-18 was $32,369 million. The direct economic contribution of the LNG industry is estimated to have been $20,253 million, mostly comprising pre-tax returns to owners of the industry. The LNG industry is thus a high value-adding sector with a value-add to revenue ratio of 0.63.

In 2017-18, Australian GDP was $1,847,675 million, implying that the direct economic contribution of the LNG industry accounted for 1.10 per cent of Australia's 2017-18 GDP.

The estimated direct employment in the LNG industry in 2017-18 was 17,269 FTE jobs.

5.1.2 Indirect economic contribution of LNG industry

It is estimated that the Australian LNG industry spent $12,116 million on goods and services in producing LNG for export in 2017-18. Of this, it is estimated that $6,550 million was on domestically produced goods and services comprising:

- $995 million on gas as a feedstock
- $868 million on mining supporting services
- $893 million on renting services
- $804 million on construction and construction services
- $398 million on other repairs and maintenance services
- $349 million on transport
- $283 million on electricity
- $196 million on professional, scientific and technical services

[12] Government of Western Australia (2019), WA Liquified Natural Gas Industry Profile, January 2019.

[13] This is calculated as LNG industry gross value add divided by the PJ of gas condensed for LNG exports in 2017-18, which is $\frac{\$20,253\ million}{3,390\ PJ} = \$6m/PJ$

— $1,765 million on other intermediate inputs.

It is estimated that the domestic spend of $6,550 million by the LNG industry contributed between $5,837 million to $9,289 million to the Australian economy, which is between 0.3 and 0.5 per cent of GDP in 2017-18. This is in addition to the direct contribution of 1.1 per cent reported in Section 5.1.1.

It was estimated that between 30,989 to 50,554 FTE jobs were indirectly supported by LNG industry activities in the Australian economy.

5.1.3 Total economic contribution of LNG industry

Adding the direct and indirect economic contributions from Sections 5.1.1 and 5.1.2 provides lower and upper bound estimates of the total economic footprint of the Australian LNG industry in 2017-18

TABLE 5.2 TOTAL ECONOMIC (VALUE-ADD) AND EMPLOYMENT CONTRIBUTIONS OF LNG INDUSTRY, 2017-18

Sector	Direct	Indirect		Total	
		Lower	*Upper*	*Lower*	*Upper*
	A$m	A$m	A$m	A$m	A$m
LNG industry	20,253	5,837	9,289	26,090	29,542
		Per cent of GDP			
LNG industry	1.10	0.32	0.50	1.41	1.60
		Employment (FTE)			
LNG industry	17,269	30,989	50,554	48,258	67,823

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively.

SOURCE: ACIL ALLEN

The total estimated economic contribution of the LNG industry in 2017-18 is summarised in Figure 5.2.

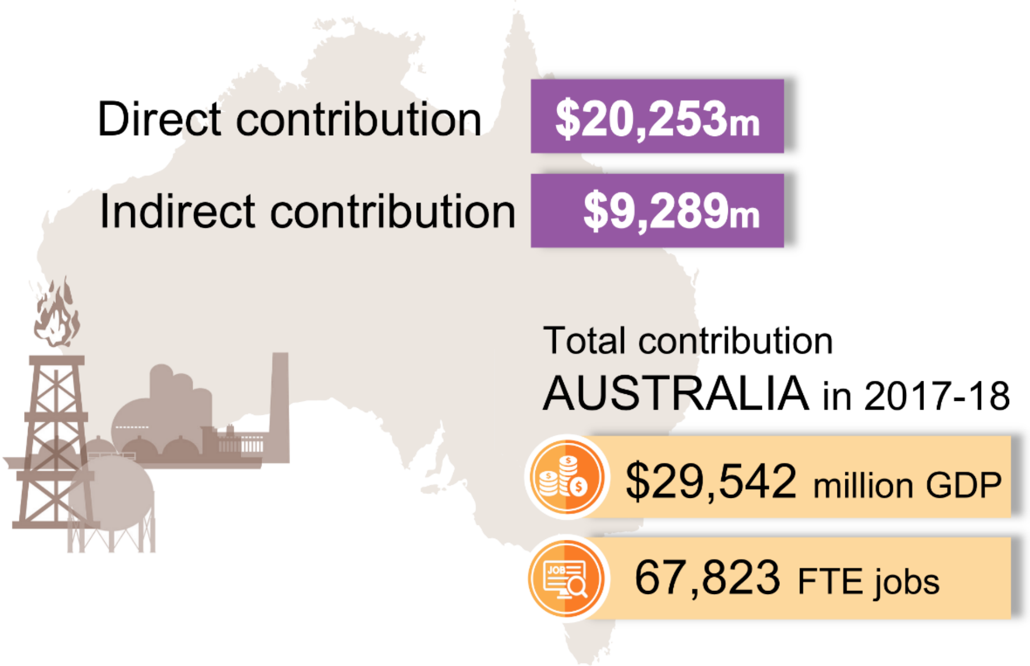
In 2017-18, it is estimated that the LNG industry in Australia resulted in:

— a *lower bound* contribution of $26,090 million to Australian GDP, comprising $20,253 million directly from the industry (direct contribution) and $5,837 million indirectly from its input demand sources (indirect contribution). As a whole, the LNG industry contributed a minimum of 1.4 per cent to Australian GDP in 2017-18.

— an *upper bound* contribution of $29,542 million to Australian GDP, comprising $20,253 million directly from the industry (direct contribution) and $9,289 million indirectly from its input demand sources and an additional spend of employees of the chemical industry (indirect contribution). As a whole, the LNG industry contributed a maximum of 1.60 per cent to Australian GDP in 2017-18.

It is estimated that the LNG industry in Australia supported up to 67,823 FTE jobs in 2017-18. To put this another way, for every one million dollars of revenue received by the Australian LNG industry, there are up to 1.6 FTE jobs that are supported elsewhere in the Australian economy.

FIGURE 5.2 ESTIMATED ECONOMIC CONTRIBUTION OF THE LNG INDUSTRY TO AUSTRALIA, 2017-18

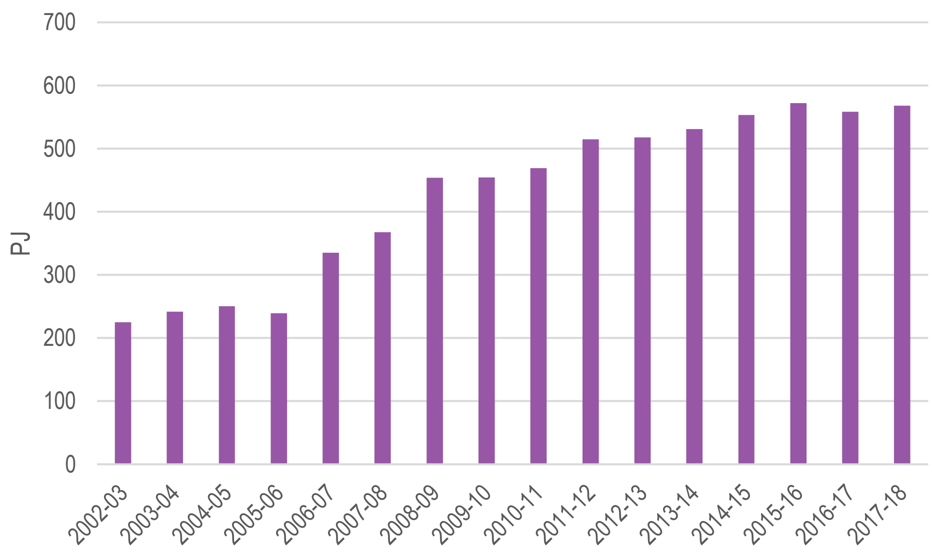


SOURCE: ACIL ALLEN

5.2 Gas-fired electricity generation industry

The quantity of gas used to generate electricity in Australia is shown in Figure 5.3. Nearly 36 per cent of natural gas (excluding LNG use) produced in Australia was consumed by the electricity generation sector in 2017-18. The natural gas share in the electricity generation industry increased from 13 per cent in 2002-03 to 21 per cent in 2017-18.

FIGURE 5.3 NATURAL GAS USE IN ELECTRICITY GENERATION INDUSTRY, 2002-03 TO 2017-18



SOURCE: DEPARTMENT OF THE ENVIRONMENT AND ENERGY, AUSTRALIAN ENERGY STATISTICS, TABLE F, AUGUST 2018

5.2.1 Direct economic contribution of gas-fired electricity generation industry

The total estimated revenue of the Australian gas-fired electricity generation industry in 2017-18 was $1,961 million. In 2017-18, the gas consumed (568 PJ) by the electricity generation industry to produce gas-fired electricity generated a gross value add of $250 million, which is 0.01 per cent of GDP.

The estimated direct employment in the gas-fired electricity generation industry in 2017-18 was 421 FTE jobs.

5.2.2 Indirect economic contribution of electricity generation industry

It is estimated that the Australian gas-fired electricity generation industry spent $1,711 million on goods and services in producing electricity in 2017-18. Of this it is estimated that $1,703 million was spent on domestically produced goods and services comprising:

- $1,588 million on gas
- $53 million on electricity transmission and distribution and marketing operations
- $32 million on finance and insurance services
- $30 million on other inputs and services.

It is estimated that the domestic spend of $1,703 million by the gas-fired electricity generation industry indirectly contributed between $1,563 million to $2,129 million to the Australian economy, which is between 0.08 per cent to 0.12 per cent of GDP in 2017-18. This is in addition to the direct contribution of 0.01 per cent.

It was estimated that between 4,244 and 7,451 FTE jobs were indirectly supported by gas-fired electricity generation industry activities in the Australian economy.

5.2.3 Total economic contribution of electricity generation industry

Adding the direct and indirect economic contributions from Sections 5.2.1 and 5.2.2 provides lower and upper bound estimates of the total economic footprint of the Australian gas-fired electricity generation industry in 2017-18.

TABLE 5.3 TOTAL ECONOMIC (VALUE-ADD) AND EMPLOYMENT CONTRIBUTIONS OF GAS-FIRED ELECTRICITY GENERATION INDUSTRY, 2017-18

Sector	Direct	Indirect		Total	
		Lower	*Upper*	*Lower*	*Upper*
	A$m	A$m	A$m	A$m	A$m
Gas-fired electricity generation industry	250	1,563	2,129	1,814	2,380
			Per cent of GDP		
Gas-fired electricity generation industry	0.01	0.08	0.12	0.10	0.13
			Employment (FTE)		
Gas-fired electricity generation industry	421	4,244	7,451	4,665	7,872

Notes: The lower and upper bounds are calculated using the Simple and Total multipliers, respectively.
SOURCE: ACIL ALLEN

The total estimated economic contribution of the gas-fired electricity generation industry in 2017-18 is summarised in Figure 5.4.

In 2017-18, it is estimated that the gas-fired electricity generation industry in Australia resulted in:

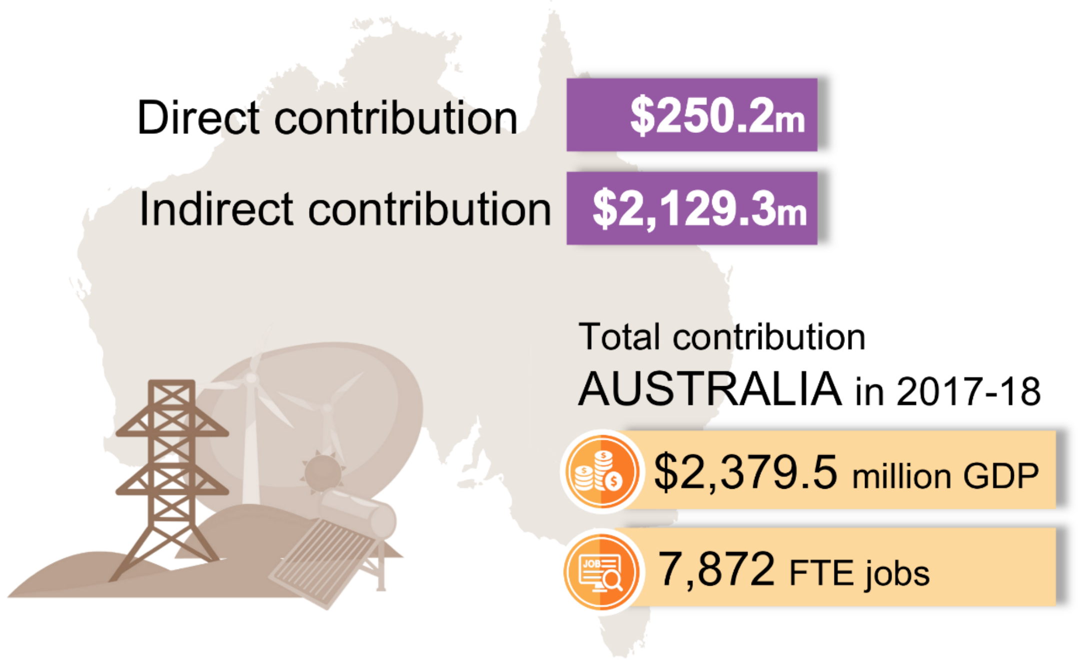
- a *lower bound* contribution of $1,814 million to Australian GDP, comprising $250 million directly from the industry (direct contribution) and $1,563 million indirectly from its input demand sources (indirect contribution). As a whole, the electricity generation industry contributed a minimum of 0.10 per cent to Australian GDP in 2017-18.

— an *upper bound* contribution of $2,379.5 million to Australian GDP, comprising $250.2 million directly from the industry (direct contribution) and $2,129.3 million indirectly from its input demand sources and an additional spend of employees of the chemical industry (indirect contribution). As a whole, the electricity generation industry contributed a maximum of 0.13 per cent to Australian GDP in 2017-18.

It is estimated that the electricity generation industry in Australia supported up to 7,872 FTE jobs in 2017-18.

To put this another way, for every one million dollars of revenue received by the Australian electricity generation industry, there are up to 3.8 FTE jobs that are supported elsewhere in the Australian economy.

FIGURE 5.4 ESTIMATED ECONOMIC CONTRIBUTION OF THE GAS-FIRED ELECTRICITY GENERATION INDUSTRY TO AUSTRALIA, 2017-18



SOURCE: ACIL ALLEN

6 A COMPARATIVE ANALYSIS

As discussed in the preceding chapters, in addition to the Australian chemistry sector, there are other major sectors that add value to Australian gas, including the:

— LNG industry for exports
— electricity generation sector.

Table 6.1 summarises the estimated direct, indirect, induced and total economic and employment contributions of these three industries as estimated in the previous chapters.

TABLE 6.1 COMPARATIVE ECONOMIC CONTRIBUTION OF GAS USED BY ALTERNATIVE MAJOR USERS IN AUSTRALIA, 2017-18

			ECONOMIC CONTRIBUTION				
				Indirect		Total	
Industry	Gas consumption	Emissions	Direct	*Lower*	*Upper*	*Lower*	*Upper*
	PJ	Mt CO_2-e	GDP (A$ million)				
Total chemical industry	132	12.0	10,948	16,833	26,780	27,781	37,728
– *Gas feedstock chemical sector*	*116*	*7.7*	*3,252*	*4,725*	*7,349*	*7,977*	*10,601*
LNG industry (for export)	3,390	28.0	20,253	5,837	9,289	26,090	29,542
Gas-fired electricity generation	568	29.2	250	1,563	2,129	1,814	2,380
			A$ million economic contribution per PJ of gas use				
Total chemical industry			83.0	127.6	203.0	210.6	286.0
– *Gas feedstock chemical sector*			*44.6*	*64.9*	*100.9*	*109.5*	*145.5*
LNG industry (for export)			6.0	1.7	2.7	7.7	8.7
Gas-fired electricity generation			0.4	2.8	3.7	3.2	4.2
			FTE jobs				
Total chemical industry			61,458	93,998	150,363	155,456	211,821
– *Gas feedstock chemical sector*			*9,232*	*24,396*	*39,269*	*33,628*	*48,500*
LNG industry (for export)			17,269	30,989	50,554	48,258	67,823
Gas-fired electricity generation			421	4,244	7,451	4,665	7,872

Industry	Gas consumption	Emissions	ECONOMIC CONTRIBUTION Direct	Indirect Lower	Indirect Upper	Total Lower	Total Upper
			FTE jobs contribution per PJ of gas use				
Total chemical industry			465.8	712.5	1,139.7	1,178.4	1,605.6
– *Gas feedstock chemical sector*			*126.7*	*334.9*	*539.1*	*461.7*	*665.8*
LNG industry (for export)			5.1	9.1	14.9	14.2	20.0
Gas-fired electricity generation			0.7	7.5	13.1	8.2	13.9

SOURCE: ACIL ALLEN

6.1 Cost to the economy when the chemical industry operates below full capacity

The above partial analysis indicates that the direct and indirect economic contribution of the chemical industry to the Australian economy was nearly $40 billion with the gas feedstock chemical sector contributing $10.6 billion. Every petajoule of gas that has been used in the chemical industry directly contributed over $83 million directly to the Australian economy, with every petajoule used by the gas feedstock chemical sector directly contributing approximately $45 million.

After considering the chemical industry's backward and forward linkages in the economy, its total contribution for every petajoule of gas use was around $286 million, with every petajoule used by the gas feedstock chemical sector contributing $145 million. As per the calculations in Table 6.1, however, the LNG and gas-fired electricity generation industries had a much smaller economic contribution per petajoule to the Australian economy due to their relatively low linkages with the rest of the Australian economy. In particular, in 2017-18, a petajoule of gas exported through LNG contributed $277 million less to the economy than a petajoule of gas used in chemical sector production. This highlights the potential impact to the economy of the chemistry sector operating at less than full capacity due to gas exports. In 2017-18, for every dollar gained from exporting LNG, $32 would have been indicatively lost in the economy due to lower chemical sector production.

Importantly, however, this does not mean that the LNG and gas-fired electricity industries are less important to Australian income, nor does it imply that the intertemporal return on capital and other scarce factors is smaller. It does however, provide an indication of the relative value add of gas that is currently being jeopardised by the difficulties facing the Australian chemical industry in obtaining reliable supplies — particularly supplies under long term contract arrangements, as such contracts are highly important in underpinning the investment decisions for building and maintaining the chemical industry's manufacturing facilities. The implications of alternative gas prices and the implications for investment in continuing operations of existing facilities, along with green field and brown field expansions of facilities, are explored in a companion report to this study.

A ECONOMIC CONTRIBUTION METHODOLOGY

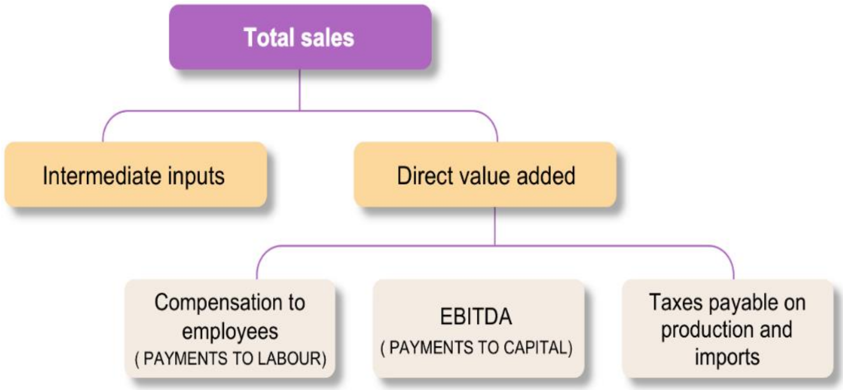
A.1 Direct economic contribution

The standard measure of economic contribution is the extent to which it increases the value of goods and services generated by the economy as a whole – in other words, the extent to which it increases economic activity as measured by gross domestic product (GDP). An economy has a range of factors of production (including labour and capital stock) and access to various intermediate inputs. By using the factors of production appropriately industries add value to intermediate inputs by converting them into a range of goods and services more suited for use by consumers or other industries.

The direct contribution of an industry or a company to the Australian economy can be estimated by determining their payments to the factors of production plus the taxes (less subsidies) payable on production and imports. This is shown graphically in Figure A.1.

Box A.1 provides a summary of the definitions used by the ABS as part of the System of National Accounts (SNA).

FIGURE A.1 CALCULATION OF VALUE ADDED



Note: EBITDA is equivalent to the SNA definition of gross operating surplus

SOURCE: ACIL ALLEN CONSULTING

BOX A.1 ABS DEFINITIONS OF VALUE ADDED

An industry's direct contribution to Gross Domestic Product or Gross State Product is well defined under the standard national accounting framework used by the Australian Bureau of Statistics (ABS), which is known as the System of National Accounts (SNA). SNA recognises three different measures of value added:

a) Value added at Purchasers' Prices. This is defined as output valued at purchasers' prices, less intermediate consumption valued at producer prices. This measure is equivalent to the traditional measure of value added at market prices.
b) Value added at Basic Prices. In this measure, the output is valued at basic prices while intermediate consumption is valued at producer prices. In the case of beer production this measure excludes beer excise as they are viewed as production taxes levied on output.
c) Value added at factor Cost. This measure excludes all production taxes net of subsidies. In other words it excludes all production taxes – such as payroll taxes, fringe benefit taxes etc – and not just those that are levied on output.

The measure of value added to be used depends on the nature of the analysis that is to be conducted. When presenting an industry view of GDP for example, the ABS uses value added at basic prices and adds an aggregate estimate of net taxes on products in question to give a total measure of GDP at purchasers' prices (ABS Catalogue No. 5216).

SOURCE: ACIL ALLEN CONSULTING

A.2 Indirect economic contribution

Indirect effects are a broader notion of the economic contribution that includes supply-side effects of employees' expenditure beyond the direct chemical production component. For example, when the industry buys gas as a feedstock, indirect effects are generated for the businesses supplying the gas, the transporter who made deliveries to the factory, the electricity company and other businesses that provided the inputs required to make the chemicals. To fully measure the indirect effects, account should also be taken of changes in incomes which may feed through to further changes in domestic demand.

The intermediate inputs used by an industry (gas and other intermediate inputs used for example) can be sourced either from within the Australian economy or from foreign economies. If purchased from within the Australian economy, then the portion of value added embodied in the intermediate input is indirectly associated with the activity of the purchaser. The calculation of the indirect contribution quickly becomes difficult as one considers that value-added embodied in the intermediate inputs of the intermediate input.

Input-output tables and the associated 'input-output multipliers' can be used to estimate the indirect economic contributions. Input-output multipliers are summary measures generated from input-output tables that can be used for predicting the total impact on all industries in the economy of changes in demand for the output of any one industry. The tables and multipliers can also be used to measure the relative importance of the production chain linkages to different parts of the economy.

It should be noted that some of the assumptions underpinning input-output multipliers can be an impediment to credible analysis. Understanding these assumptions is necessary to prevent the inappropriate application of input-output multipliers – for example, in situations where economic constraints are present or when the profile of a business or project differs substantially from the industry average. We do not consider that these conditions apply for the purpose of this analysis and that the use of input-output multipliers to estimate the economic footprint of the chemical industry is appropriate. Further information on input-output tables and the calculation of multipliers can be found in ABS Catalogue number 5246.0.

A.2.1 Lower and upper bounds

In this report we have estimated the likely lower and upper bounds of the indirect economic contribution of the chemical industry's activities. The lower bound estimate, derived from the 'Simple Multipliers', captures only the value added and employment associated with the supply chain of each purchase stream (see below for details). Consequently, they provide a conservative estimate – or lower level bound – of the indirect economic contribution of intermediate inputs. The difference between these estimates and the direct economic contribution are commonly referred to as the 'production induced' contribution. The estimates from simple multipliers indicates the embodied economic contribution of alternative production chains, which are additive and should sum to the national accounts estimates of gross state product and gross domestic product.

The upper bound estimate of the impact of the chemical industry, derived using 'Total Multipliers', captures all of the effects of inter-industry interactions and also captures the impacts of the purchasing decisions made by workers employed throughout the chemical industry's supply chain. This effect is commonly referred to as the 'consumption induced effect'.

A.3 Overview of IO tables

Input-output tables provide a snapshot of an economy at a particular time. The tables used in this analysis were for the 2017-18 financial year.

Input-output tables can be used to derive input-output multipliers. These multipliers show how changes to a given part of an economy impact on the economy as a whole. A full set of input-output multipliers for each region were estimated for the purpose of this analysis.

The input-output multipliers allow an analysis of the economic footprint of a particular facility, industry or event for the region of interest. Although input-output multipliers may also be suitable tools for analysing the impact of various types of economic change, caution needs to be adopted in their application for this purpose. Misuse of input-output multipliers for the purpose of impact analysis has led to scepticism of their general use in favour of other tools such as computable general equilibrium (CGE) modelling. Notwithstanding this, they are still eminently suitable for understanding the economic linkages between a given facility or industry to gain an appreciation of the wider interactions of the industry beyond its direct contribution.

A.4 Multiplier types

Input-output multipliers estimate the economic impact on a region's economy from a one dollar change in the final demand for the output of one of the region's industries. Generally, four types of multipliers are used:

- Output – measures the impact on the output of all industries in the economy
- Income – measures the effect on the wages and salaries paid to workers within the economy
- Employment – measures the jobs creation impact, and
- Value-added – measures the impact on wages and salaries, profits and indirect taxes.

The sum of wages and salaries, profits and indirect taxes for a given industry provides a measure of its contribution to the size of the local economy – its contribution to gross regional product (GRP). The value added multiplier can therefore also be considered to be the GRP multiplier.

Input-output multipliers are a flexible tool for economic analysis. Their flexibility stems from the different forms of each multiplier type. For each region, multipliers were estimated in the following forms:

- initial effects
- first round effects
- industrial support effects
- production induced effects
- consumption induced effects

— simple multipliers
— total multipliers
— type 1A multipliers
— type 1B multipliers
— type 2A multipliers
— type 2B multipliers.

Further information on input-output tables and the calculation of multipliers can be found in ABS Catalogue number 5246.0, but a brief overview of the different types of output multipliers is presented below.

A.4.1 Multiplier effects

When additional sales to final demand are made, for example through increased exports or sales to the public, production increases to meet the increased demand, and this is the initial effect. Since production increases to exactly match the increased final demand, the increase is always equal to one (noting that the multipliers are defined in terms of a one dollar increase in final demand).

The industry producing the additional output makes purchases to enable itself to increase production, these new purchases are met by production increases in other industries and these constitute the *first round effect*. These first-round production increases cause other industries to also increase their purchases, and these purchases cause other industries to increase their production, and so on. These 'flow-on' effects eventually diminish, but when 'added together constitute the industrial support effect.

The industrial support effect added to the first round effect is known as the production induced effect. So far this chain of events has ignored one important factor, the effect on labour and its consumption. When output increases, employment increases, and increased employment translates to increased earnings and consumption by workers, and this translates to increased output to meet the increased consumption. This is the consumption effect.

A.4.2 Multipliers

The simple and total multipliers are derived by summing the effects. The simple multiplier is the sum of the initial and production induced effects. The total multiplier is larger, because it also adds in the consumption effect. So far, all the effects and multipliers listed have had one thing in common, they all measure the impact on the economy of the initial increase in final demand.

The remaining multipliers take a different point of view, they are ratios of the above multiplier types to the initial effect. The type 1A multiplier is calculated as the ratio of the initial and first round effects to the initial effect, while the type 1B multiplier is the ratio of the simple multiplier to the initial effect. The type 2A multiplier is the ratio of the total multiplier to the initial effect, while the type 2B multiplier is the ratio of the total multiplier less the initial effect to the initial effect.

Given the large number of multiplier types to choose from, output, income, employment and value added multipliers, and each with numerous variations (simple, total, type 2A, etc) it is important that the analysis uses the most appropriate multipliers. Usually, the multipliers that include consumption effects (i.e. the added impact that comes from wage and salaries earners spending their income) are used. These are the total and type 2A multipliers. The total and type 2A multipliers will generally provide the biggest projected impact. Simple or type 1B (which omit the consumption effect) may be used to provide a more conservative result.

For this analysis, given that we were kindly provided with access to the detailed expenditure items for major chemical products, the Simple multipliers were used to calculate the lower estimates of the contribution the chemical industry make to their respective economies.

A.5 Limitations of input-output analysis

Although input-output analysis is valid for understanding the contribution a sector makes to the economy, when used for analysing the potential impacts of a change in production of a particular sector, input-output analysis is not without its limitations. Input-output tables are a snapshot of an economy in a given period, the multipliers derived from these tables are therefore based on the structure of the economy at that time, a structure that it is assumed remains fixed over time. When multipliers are applied, the following is assumed:

- prices remain constant;
- technology is fixed in all industries;
- import shares are fixed.

Therefore, the changes predicted by input-output multipliers proceed along a path consistent with the structure of the economy described by the input-output table. This precludes economies of scale. That is, no efficiency is gained by industries getting larger – rather they continue to consume resources (including labour and capital) at the rate described by the input-output table. Thus, if output doubles, the use of all inputs doubles as well.

One other assumption underpinning input-output analysis which is worth considering is that there are assumed to be unlimited supplies of all resources, including labour and capital. With input-output analysis, resource constraints are not a factor. It is thus assumed that no matter how large a development, all required resources are available, and that there is no competition between industries for these resources.

It is important to understand the limitations of input-output analysis, and to remember that the analysis provides an estimate of economic contribution of a facility or industry, not a measurement of economic impact if the facility or industry shut down or did not exist.

A.6 Key data sources

For this study, ACIL Allen have estimated an input cost structure for the sub-sectors in chemical industry based on following data sources:

- Confidential data provided by the main businesses in chemical industry through *Chemistry Australia*
- ABS published data sources:
  - 8155.0 Australian industry, 2017-18
  - 4604 Energy Accounts, 2016-17
  - 5204 Australian System of National Accounts, 2017-18
  - 5209.0.55.001 Australian National Accounts: Input-Output Tables - 2015-16
  - 5215.0.55.001 Australian National Accounts: Input-Output Tables (Product Details) - 2015-16
  - 6150.0.55.003 – Labour Account Australia
  - 5220.0 - Australian National Accounts: State Accounts, 2017-18
  - Census of Population and Housing, 2016
- ABS unpublished data source:
  - Special export and import data request at 4-digit ANZSIC at AHECC and HTIC levels
- Department of the Energy and Environment data sources
  - Resources and Energy Quarterly, March 2019
  - Australian Energy Statistics, March 2019
  - Australian Greenhouse Emissions Information System
- ACIL Allen *PowerMark* NEM Model Database
- ACIL Allen *PowerMark* SWIS Model Database

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