

Elements in Everything

Current profile and future trends for the Australian chemicals and plastics industry

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Hannah Cook, Stefan Hajkowicz, Sarah King, Felicity Cox

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FOR FURTHER INFORMATION

For further information on this report please contact the project lead scientist Dr Stefan Hajkowicz. E Stefan.Hajkowicz@csiro.au; P 07 3833 5540.

ABOUT THIS REPORT

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Executive summary

There is an element of the chemicals and plastics industry in just about everything we consume. The industry plays a vital role within Australia's supply chains. It produces goods and services essential for the agricultural industry, the mining industry, the manufacturing industry, the construction industry, the services sector and many other industries. The chemicals and plastics industry supplies inputs to 109 of the 111 industries in Australia.

As with all Australian industries, the chemicals and plastics industry faces challenges and opportunities in coming decades. An understanding of the industry's current profile and future trends can inform long-term strategic decisions.

This report is written in two sections. The first section presents a profile of current issues within the chemicals and plastics industry. The second section looks at major changes in the coming two decades – referred to as “megatrends”.

Current Industry Profile

The industry contributed A\$11,651 million to gross domestic product in 2010-11 by way of value added to the intermediate inputs used by the industry (ABS, 2012b). Within the manufacturing industry, this equates to approximately 11.5 percent of total Australian manufacturing, a figure that has remained reasonably steady since 2006-07 (ABS, 2012b). As such it is the second largest manufacturing industry in Australia (ABS, 2011c). Approximately 70,000 were employed in the industry in 2012 (ABS, 2012e). Although sufficient time series data for some indicators is unavailable to deduce long term trends, there is evidence that the industry is currently contracting.

The Australian chemicals and plastics industry is subject to a large degree of global trade and exposure. The global industry is large, mature, highly fragmented with numerous suppliers and customers and almost every nation has a chemicals industry of some size which is engaged in foreign trade (ACC, 2012). Australia is highly reliant on imports and Australia accounts for only 0.6 percent of world sales (PACIA, 2011c). The deterioration in Australia's trade balance has, however, been mainly driven by increasing imports rather than decreasing exports (ABS, 2013a). Despite this, relative to world trends, Australia's production has been declining (ACC, 2012).

Given the diverse range of outputs, the industry is intrinsically linked to supply chains across the economy.

Significant downstream industries include automotive, building and construction, packaging, medical, agriculture and mineral processing (Productivity Commission, 2008). The chemicals and plastics industry supplies inputs to 109 of the 111 industries in Australia (ABS, 2012c). Approximately 80 percent of the outputs from the industry become inputs to the other industry sectors in the economy (ABS, 2011b). Manufacturing is the biggest user of inputs from the chemicals and plastics industry, using 39 percent of chemicals and plastics production as intermediate inputs in the manufacturing sector in 2007-08 (ABS, 2011b).

Worldwide, the chemicals and plastics industry suffers from poor public perception. Public perception can be influenced by factors such as environmental impacts and health and safety concerns. While there is no formal estimate of the environmental concerns held by Australians community, one survey of public perception across Europe revealed that the largest concerns were around “water and air pollution from chemical factories” and “environmental damage from dumping chemical waste” (Cefic, 2006). Australian health and safety data is available. In Australia, there were 1675 claims for compensation for injuries caused by chemicals and other substances during 2004-05, down from 1890 in 1997-98 (Productivity Commission, 2008).

The lost time injury frequency rate has also been decreasing in the chemicals and plastics industry. However it still remains slightly above the lost time injury frequency rate for all Australian industries as a total although the margin has decreased significantly (Safe Work Australia, 2012).

Climate change and environmental pressures are a real risk threatening the global environment. The World Economic Forum (2013) identified rising greenhouse gas emissions as the most likely global risk to manifest over the next decade, behind severe income disparity and chronic fiscal imbalances. As such, it is envisaged that there will be increasing pressure over the next 20 years for the price of resources, products and services to reflect the full cost of production including environmental impacts (KPMG, 2012). Although the chemicals industry is a carbon-intensive industry, it is also an important solutions-provider and has the ability to enable other industries to save energy and reduce greenhouse gas emissions (ICCA, 2009). A lifecycle assessment of chemical products was commissioned by the International Council of Chemical Associations and conducted by McKinsey & Company and the Öko Institut. It was estimated that for every unit of greenhouse gas emissions emitted through chemical industry production, the resulting product saves two to three units of greenhouse gas emissions (ICCA, 2009).

Megatrends

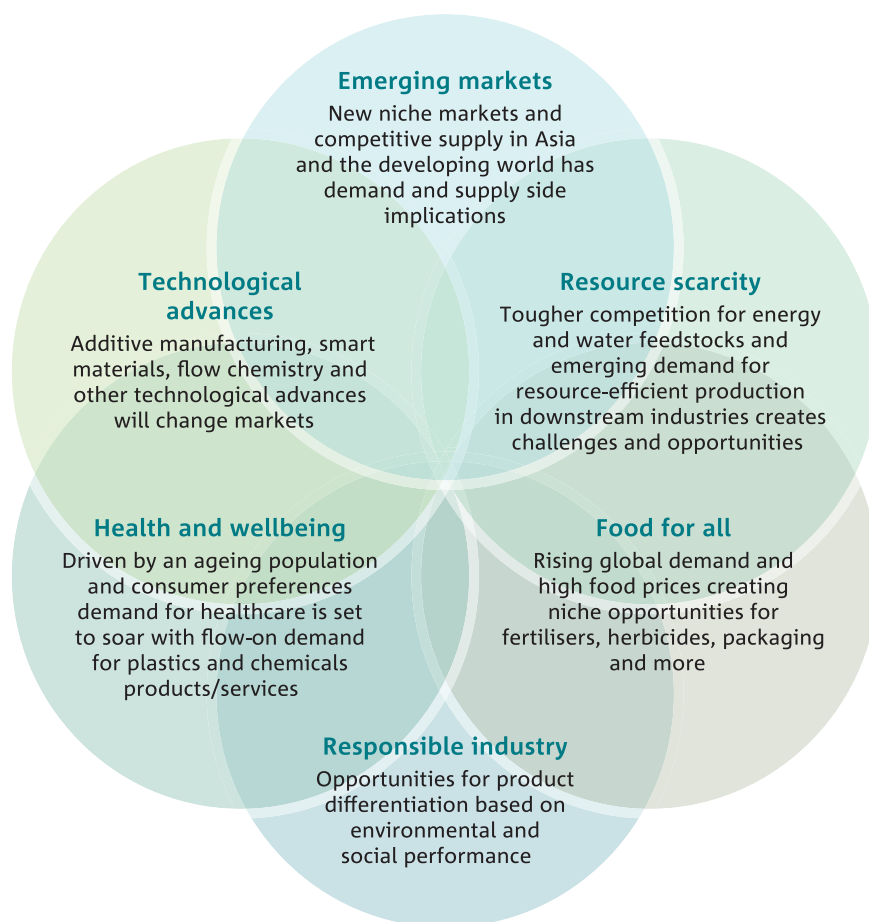
Major shifts in coming decades

A megatrend is defined as a substantial shift in social, economic, environmental, technological or political conditions that may reshape the way an industry operates in coming decades. Megatrends have both supply side and demand side implications. They can be associated with the emergence of new markets creating opportunities to supply new products. They may also be associated with constraints to production processes and/or changed operating costs.

The megatrends in this report are defined with a twenty year time horizon out to the year 2032. However, elements of the megatrends are already occurring and they will still be having impact beyond 2032. Some elements will have greater relevance in the short term while others will grow in importance over this 20 year horizon.

Megatrends are cross-sectoral and occur at the intersection of many sectoral trends. A trend is a significant pattern of activity typically occurring within an industry sector, societal sector or within a localised geographic region with implications for decision making. The megatrends identified for the Australian chemicals and plastics industry are shown below using an overlapping venn diagram.

These global megatrends draw upon multiple information sources. They include discussions with PACIA's Strategic Industry Roadmap Board Working Group and representatives from the Department of Industry, Innovation, Science, Research and Tertiary Education. Information was also drawn from the Australian Bureau of Statistics, the World Bank, the International Monetary Fund, the Organisation for Economic Cooperation and Development, the United Nations, the International Energy Agency, Federal, State/Territory and Local Government reports and datasets, industry reports, academic journals and other miscellaneous sources.



Consultation with key industry stakeholders was also conducted as part of the process of identifying the megatrends specific to the chemicals and plastics industry. Over 25 interviews were conducted with key industry experts. A workshop was held in November 2012 to validate the megatrends, attended by representatives from the industry, Government, the Cooperative Research Centre for Polymers and Monash University. Feedback from the interviews and the workshop has been incorporated into the final presentation of the megatrends.



1. Emerging markets. Rapid income growth and technological advancement in Asia, and the developing world, will open up new markets for Australian chemicals and plastics products. It will also introduce new and tougher competition for the Australian industry in both domestic and global markets. Over the past ten years Asian countries such as India, China, Singapore and Korea have been ramping up exports much more rapidly than Australia.

2. Resource scarcity. Energy, mineral and water resources are essential feedstocks for the chemicals and plastics industry. These resources have limited supply in the natural world. However, domestic and global demand is growing. The past decades have seen prices rise and become volatile. This has supply-side implications. There is also an opportunity. Chemicals and plastics products may be highly valuable in a resource constrained world as substitutes for scarce mineral resources in construction, energy storage and generation systems and recycling.

3. Food for all. Global population growth and economic growth will fuel increased demand for food in coming decades. Food prices are high and most forecasts suggest they will remain high, or increase even further, in the coming decades. The quantity of food traded across borders is also rising sharply. The interaction between demand and supply factors in the food sector may create opportunities for the chemicals and plastics industry in terms of packaging, fertilisers, herbicides, pesticides and food additives.

4. Responsible industry. Coming decades will see an increased emphasis on environmentally and socially responsible industry performance by companies, governments, communities and consumers. Environmental and social credentials will be an increasingly important differentiator for consumer products and major corporate or government contracts. The social licence to operate will obtain elevated importance. Recycling and waste management will also gain greater attention.

5. Health and wellbeing. Due to the ageing population, rise of chronic and lifestyle related illness and changing consumer preferences healthcare expenditure is set to rise. This creates a demand side opportunity for the chemicals and plastics industry to supply products and inputs to the pharmaceutical sector, hospitals and other parts of the healthcare industry.

6. Technological advances. There is a rapid pace of technological development in the chemicals and plastics industry. Future technological advances have the capability to substantially alter production processes, supply chains and the competitiveness of companies, industry sub-sectors and the whole industry.

Access to Natural Gas – A Critical Issue for Industry

Relating to the “Resource Scarcity” megatrend, access to gas was an issue repeatedly raised and emphasised by industry representatives in interviews and workshops held during this project. Also attracting much attention in other forums (NIEIR, 2012) (DomGas Alliance, 2012), access to gas is currently a top priority issue for Australia’s chemicals and plastics industry. It is likely to remain so for the foreseeable future. Natural gas is used as both an energy source and as feedstock for producing chemicals and plastics products. For these transformative industries to continue operating, reliable and competitively priced access to electricity, feedstock coal, gas and petroleum is imperative (Department of Resources Energy and Tourism, 2012).

However, many chemicals and plastics producers in Australia are struggling to obtain gas. The pressure partly comes from overseas energy markets. Australia’s combined identified gas resources are approximately 431,706 PJ (Geoscience Australia and BREE, 2012), equivalent to approximately 184 years of production at current rates (Prime Minister’s Manufacturing Taskforce, 2012). This resource is mostly, and increasingly, bound for export to overseas liquefied natural gas (LNG) customers. The proximity of gas reserves to Asian markets has helped attract foreign investment to develop new projects (IEA, 2011a).

Partly as a consequence of these drivers the gas market is considered illiquid. Gas is in short supply for new contracts in coming years (Queensland Government, 2012). Customers seeking new domestic supply contracts for gas lack access to basic market information such as forward prices, volumes available and potential delivery timeframes for forward contracting (Queensland Government, 2012). This is hindering the market’s ability function smoothly and is

contributing to a high level of uncertainty (Queensland Government, 2012).

Domestic gas prices are increasing due to the emerging export opportunity (Queensland Government, 2012). Over the last few years, natural gas prices in eastern Australia have increased 70 percent from around \$3.50 to \$6/GJ, with expectations of further rises to as high as \$9.00/GJ (Prime Minister’s Manufacturing Taskforce, 2012). Even if these higher prices do not eventuate, the expectation of higher prices is concerning to the industry. The uncertainty will negatively influence investment decisions regarding current and existing plant capacity and future additional capacity (NIEIR, 2012). Some new chemical manufacturing investments are now considered uneconomic as a result (DomGas Alliance, 2012).

Within Australia there is variation between markets in the priority given to domestic usage. Western Australia has a domestic reservation policy for natural gas, whereby 15 percent of the natural gas reserves are required to be used for domestic purposes (NIEIR, 2012). The eastern states do not have a reservation policy for domestic use.

The Australian Government has identified three factors that will dominate Australia’s energy future, including:

1. The need to deliver secure, reliable and competitively priced energy for a growing population and economy;
2. The further expansion of our energy exports to Asia and other growth markets; and
3. The need to become more energy efficient across the economy and to dramatically reduce carbon emissions and transform to a clean energy economy (Department of Resources Energy and Tourism, 2012).

The formal position of the Australian Government reflects a balance of these three factors. As new coal seam gas and LNG developments come on line and ramp up to full production, some transitional tightness is expected and is already evident, resulting in higher prices and tighter supply dynamics (Department of Resources Energy and Tourism, 2012). The Australian Government has acknowledged the calls to mandate a proportion of gas reserves for the domestic market (Department of Resources Energy and Tourism, 2012). However “the government does not believe that such an approach would effectively address current pressures or be in the long-term interests of consumers and the Australian community” (Department of Resources Energy and Tourism, 2012, p. xiv). Furthermore, the Australian Government states that:

“there is little convincing evidence that interventions designed to force non-commercial outcomes are effective. Given that they are more likely to constrain rather than increase incentives for exploration and new supply, they would impede the development of more efficient gas markets and should be considered only where there is clear market failure” (Department of Resources Energy and Tourism, 2012).

Much of the debate hinges upon whether, or not, there is evidence of market failure and if there is what action should be taken. In the current situation, pricing uncertainty and the inability to obtain forward contracts is creating uncertainty in the market and stalling investment decisions regarding the development of additional chemicals and plastics plant capacity. Such conditions are likely to place the industry under continued pressure (Department of Resources Energy and Tourism, 2012).



Most parties agree there is a need to identify the best use of natural gas to ensure the benefits of this valuable natural resource can be realised. The matter of access to natural gas has been highlighted many times by industry participants through the course of this research project. It is likely to stay high on the chemicals and plastics industry agenda for some time to come.

What Next?

This report will be followed by a second report, funded under the same project, which identifies and describes “strategic directions”. These are whole-of-industry actions that can help achieve desired future outcomes. This report talks about “what is likely to happen” and the next report talks about “what can we do to best position the industry for the benefit of Australia”.

The research is being conducted by CSIRO and is jointly funded by the Australian Plastics and Chemicals Industries Association and the Australian Government Department of Industry, Innovation Science, Research and Tertiary Education.

1 Introduction



There is an element of the chemicals and plastics industry in just about everything we consume. The industries play a vital role within Australia's supply chains (Figure 1). It produces goods and services essential for the agricultural industry, the mining industry, the manufacturing industry, the construction industry, the services sector and many other industries.

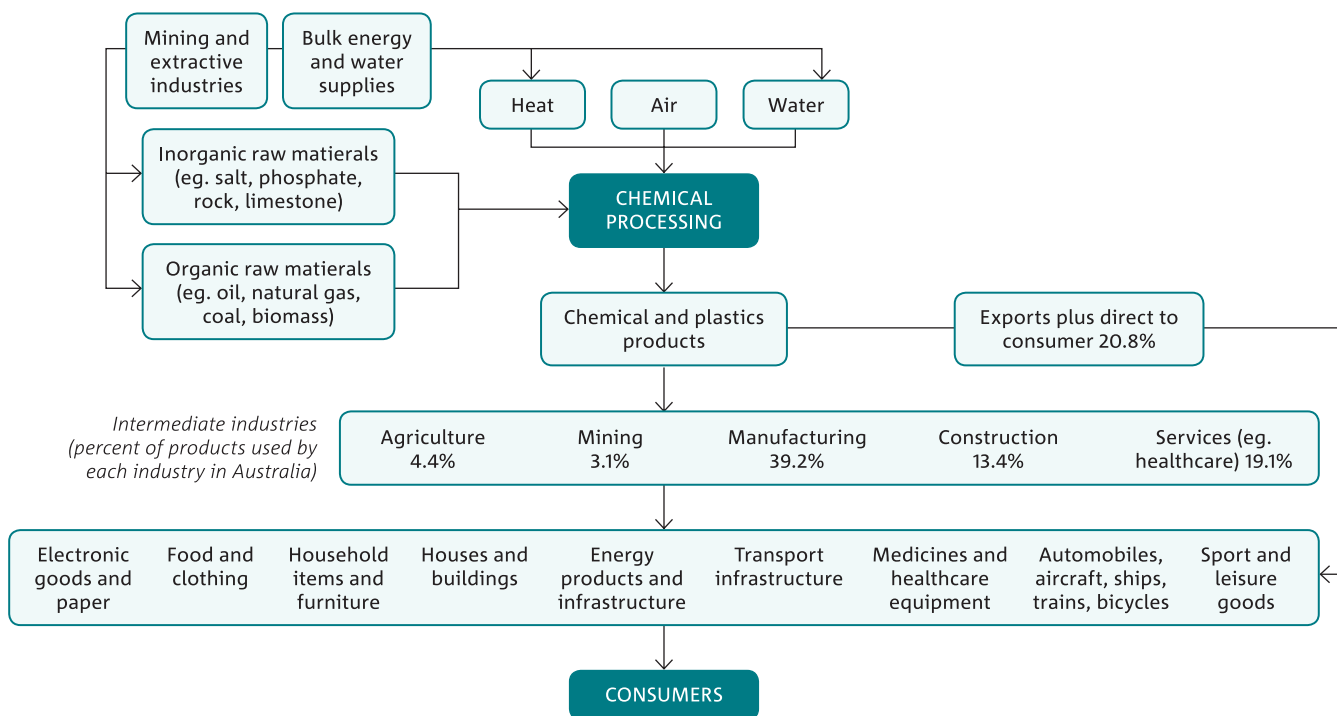
Every day the vast majority of Australians directly or indirectly consume chemicals and plastics products. If there is a significant disruption to normal operations in the chemicals and plastics industry, the impact on society and the economy can be rapid, far-reaching and of large magnitude. The impacts of supply chain disruptions are well documented (Craighead et al., 2007; Hendricks et al., 2005; Svensson, 2000) and easily run into billions of dollars and impact millions of people. The chemicals and plastics industry can be considered a linchpin for the Australian economy. We know its value acutely when it is not there.

Despite the ubiquity of chemicals and plastics products in people’s day-to-day lives the industry is invisible for many Australians. People tend to have low levels of awareness about what the industry does and what it produces. Often the industry only gains visibility when a supply chain disruption occurs. Because of its pivotal position, innovations within the chemicals and plastics industry can have magnified impact in social, economic and environmental terms.

As with all Australian industries, the chemicals and plastics industry faces challenges and opportunities in coming

decades. An understanding of the industry’s current profile and future trends can inform long-term strategic decisions. This report is written in two sections. The first section presents a profile of current issues within the chemicals and plastics industry. The second section looks at major changes in the coming two decades – referred to as “megatrends”. The megatrends in this report are defined with a twenty year time horizon out to the year 2032. However, elements of the megatrends are already occurring and they will still be having impact beyond 2032.

Figure 1. Generalised inputs and outputs from the Australian chemicals and plastics industry



Source: Estimates of intermediate industry usage from the Australian Bureau of Statistics (ABS, 2012c)

2 Current Industry



The chemicals and plastics industry is a diverse industry that produces essential inputs to nearly every sector of the economy.

2.1 What is the chemicals and plastics industry?

The chemicals and plastics industry is a diverse industry that produces essential inputs to nearly every sector of the economy. As defined by the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) (2011) and in accordance with the 2006 Australian and New Zealand Standard Industrial Classification system, the chemicals and plastics industry includes:

- ♦ Class 1709: Other Petroleum and Coal Product Manufacturing;
- ♦ Subdivision 18: Basic Chemical Manufacturing, excluding Group 184: Pharmaceutical and Medicinal Product Manufacturing; and
- ♦ Subdivision 19: Polymer Product and Rubber Product Manufacturing.

While the output of this industry is considerably diverse, it can be broadly categorised as follows:

- ♦ Basic chemicals: organic industrial chemicals, inorganic industrial chemicals, fertilisers, industrial gases, synthetic resins
- ♦ Specialty chemicals: explosives, plastics, paints, rubber products, other polymers and inks
- ♦ Consumer chemicals: pesticides, soaps and detergents, cosmetics and toiletries, medicinal and pharmaceutical (PACIA, 2010).

Hence the output of the industry includes base and feedstock products, speciality and refined chemicals, intermediate goods and components in addition to finished products (Productivity Commission, 2008).

2.2 Headline Statistics

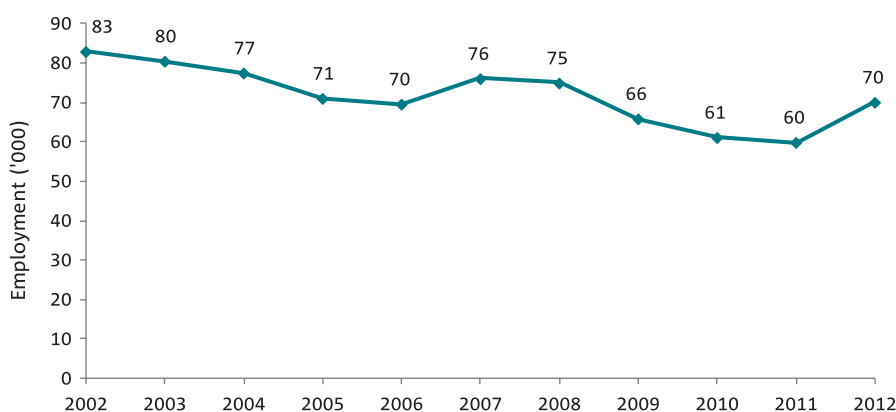
The industry contributed A\$11,651 million to gross domestic product in 2010-11 by way of value added to the intermediate inputs used by the industry (ABS, 2012b). Within the manufacturing industry, this equates to approximately 11.5 percent of total Australian manufacturing and this figure has remained reasonably steady since 2006-07 (Table 1) (ABS, 2012b). As such it is the second largest manufacturing industry in Australia (ABS, 2011c). Approximately 70,000 were employed in the industry in 2012 (Figure 2) (ABS, 2012e). Although sufficient time series data is unavailable to deduce long term trends, there is evidence that the industry is currently contracting.

Table 1. Key industry statistics

	WAGES & SALARIES (A\$M)	SALES & SERVICE INCOME (A\$M)	INDUSTRY VALUE ADDED (A\$M)
2006-07	4,913	34,799	10,559
2007-08	5,077	38,413	11,805
2008-09	5,045	38,103	11,038
2009-10	5,245	38,284	11,376
2010-11	5,283	38,631	11,651

Source: Australian Bureau of Statistics (ABS, 2011c, 2012b); Note: Current price estimates

Figure 2. Employment in the chemicals and plastics industry, 2002–2012



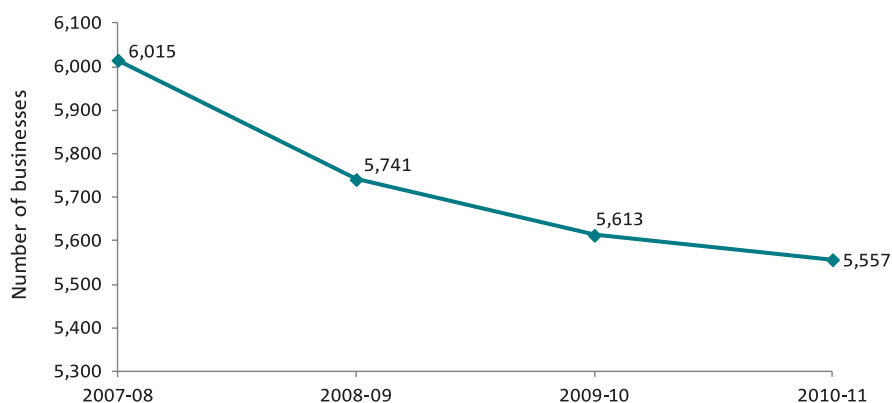
Source: Australian Bureau of Statistics (ABS, 2012e)

Note: Data excludes Class 1709: Other petroleum and Coal Product Manufacturing. Data includes Class 3323: Industrial and Agricultural Chemical Product Wholesaling. This class has been included to capture the wholesaling activities in the industry.

Given the wide range of outputs produced by the industry, the chemicals and plastics industry encompasses a diverse range of companies. Key functions of companies in the industry include chemical manufacturers, imports and distributors, logistics and supply chain partners, raw material suppliers, plastics fabricators and compounders, chemicals and plastics recyclers and service providers to the industry (PACIA, 2011a).

Across the industry, most businesses employ less than 20 employees (45 percent at the end of 2010-11) (ABS, 2012d). Thirty-nine percent of businesses are non-employing**, 14 percent employ between 20 and 200 and only one percent have more than 200 employees (ABS, 2012d). Since 2007-08, the total number of businesses in the chemicals and plastics industry has been decreasing (ABS, 2012d). The largest drop was experienced in 2007-08, likely due to economic conditions given that the industry is considered cyclical and sensitive to economic conditions (Euromonitor International, 2011). However, the total number of businesses operating has continued to decline (Figure 3).

Figure 3. Number of businesses operating at the end of the financial year



Source: Australian Bureau of Statistics (ABS, 2012d)

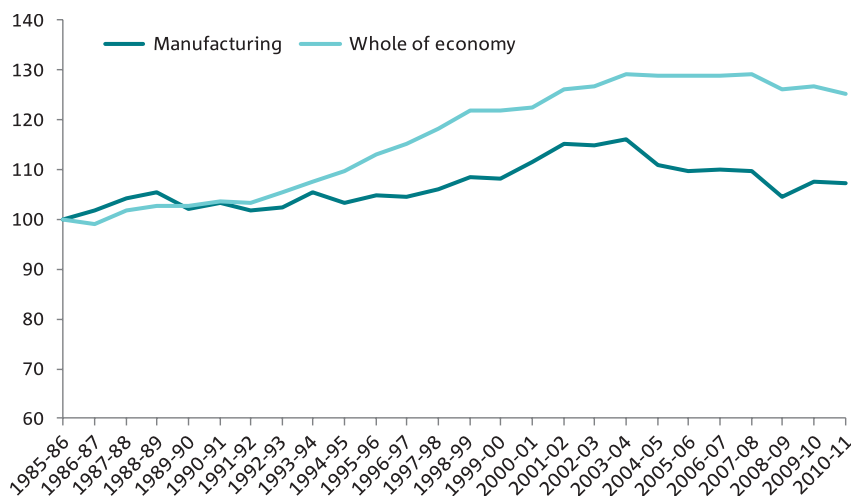
2.3 Productivity

Multifactor productivity (MFP) is defined as real output per combined unit of labour and capital. It measures how efficiently the main factors of production, labour and capital, are combined to generate output (OESR, 2011). Growth in MFP can be driven by enhanced efficiency and by technological advances, achieved mainly through human capital advances and innovation (OESR, 2011). As year-to-year variations in MFP growth can also reflect short-term influences aside from technological advancements, comparisons are made over 'MFP growth cycles' identified by reference to peak deviations from trend MFP and to general economic conditions at the time (P. Barnes, 2011). MFP has not been estimated for the chemicals and

plastics industry specifically and thus manufacturing MFP has been taken as the next best available proxy.

Manufacturing MFP growth cycles peak five times at 1988-99, 1993-94, 1998-99, 2003-04 and 2007-08 (Figure 4). MFP was trending upwards until approximately 2003-04 and has been trending downwards since then. Although industry MFP was slightly above economy-wide MFP prior to 1989-90, the industry MFP has not risen as rapidly as economy-wide MFP. In keeping with the cyclical nature of the industry, industry growth peak cycles follow that of the whole economy (P. Barnes, 2011), however continue to remain below economy MFP.

Figure 4. Estimates of manufacturing MFP index



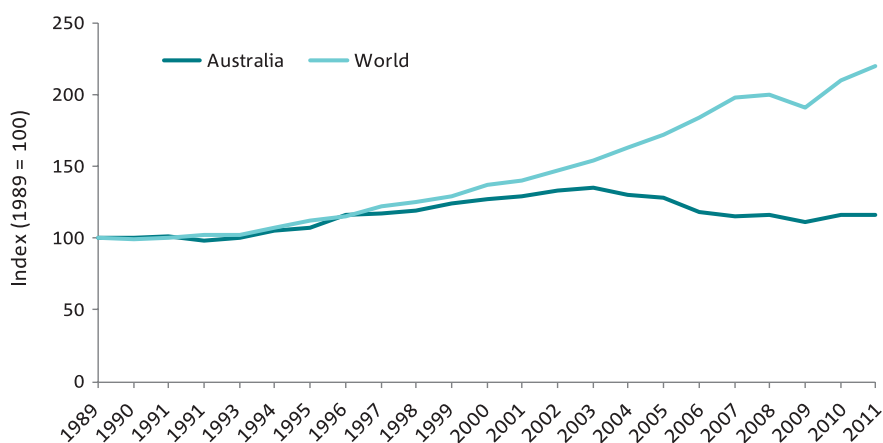
Source: Australian Bureau of Statistics (ABS, 2011d)

Note: 'Whole of economy' includes Divisions A to K and R as defined by ANZSIC Industry Classifications 2006. Although it is not a complete representation of MFP at an economy level, it has been included as an indication of economy-wide trend cycles for comparison.

2.4 Global market exposure

Since the 1960s the industry has become increasingly globalised and prices are now generally determined by global demand and supply (ACC, 2012). The global industry is large, mature and highly fragmented with numerous suppliers and customers (ACC, 2012). Nearly every nation has a chemicals industry of some size and is engaged in foreign trade with individual companies often operating simultaneously as suppliers, customers and competitors (ACC, 2012). Asia/Pacific is the largest regional market, followed by Western Europe then North America (ACC, 2012). The global chemistry industry is highly competitive and Australia accounts for only 0.6 percent of world sales (PACIA, 2011c). Figure 5 shows the American Chemistry Council (ACC) Global Chemical Production Regional Index which measures the production volume of the business of chemistry for 33 key nations, regions and sub-regions all aggregated to the world total. Relative to world trends, Australia's production has been declining.

Figure 5. The ACC Global Chemical Production Regional Index, 1989-2011



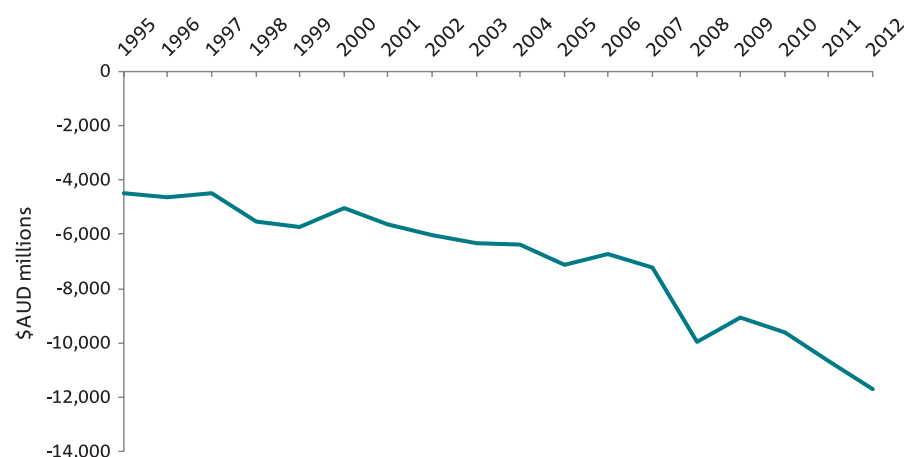
Source: American Chemistry Council (ACC, 2012)

The Australian economy is becoming increasingly reliant on imports of chemicals and plastics products as the trade balance continues to trend downwards (Figure 6). Australia is atypical to many industrialised countries in this sense, as the majority of industrialised countries hold trade surpluses in chemicals (ACC, 2012). Industrialised nations typically produce a wide variety of chemicals from commodity industrial chemicals to specialty chemicals for unique applications, whereas developing

nations produce simple chemical products such as fertilisers and inorganic commodity chemicals (ACC, 2012). The deterioration in Australia's trade balance has, however, been mainly driven by increasing imports rather than decreasing exports (ABS, 2013a). On the whole however, Australia has a strong import focus.

**Defined as a business without an active Income Tax Withholding (ITW) role or which has not remitted ITW for five consecutive quarters. Such a business has not withheld income tax from an employee's wages.

Figure 6. Chemicals and plastics annual trade balance (exports less imports), 1995–2012



Source: Australian Bureau of Statistics (ABS, 2013a)

Note: Trade data is classified according to the Harmonised Commodity Description and Coding System (HS). Specifically, data includes Chapters 28 to 40 excluding 30: Pharmaceutical Products

Australia has traditionally been regarded as a centre of innovation and high-quality research and development in the chemicals and plastics industry (Koryakovtseva et al., 2012). Basic chemicals patents accounted for 9 percent of total patent application in Australia in 2005 and soap, detergent, cosmetics and toiletries accounted for 4.7 percent (Productivity Commission, 2008).

2.5 Downstream industries

Given the diverse range of outputs, the industry is intrinsically linked to supply chains across the economy. The chemicals and plastics industry supplies inputs to 109 of the 111 industries in Australia, with ‘insurance and superannuation funds’ and ‘auxiliary finance and insurance services’ being the two omitted industries (ABS, 2012c), and thus plays a critical role in supply chains. Approximately 80 percent of the outputs from the industry become inputs to the other industry sectors in the economy (Table 2) (ABS, 2011b). Manufacturing is the biggest user of inputs from the chemicals and plastics industry. In 2007-08, 39 percent of chemicals and plastics were used as intermediate inputs in the manufacturing sector (ABS, 2011b). Further to this analysis, key downstream industries of the chemicals and plastics industry, as identified by

the Productivity Commission (2008), include:

- ◆ Automotive;
- ◆ Building and construction;
- ◆ Packaging;
- ◆ Medical and pharmaceutical;
- ◆ Agriculture; and
- ◆ Mineral processing.

Given the important role in many supply chains, the industry is a key enabler of improvement in general living standards. Many outputs from the industry are used to clean and protect the environment, promote health and improve the quality of life for a growing population, improve health and nutrition and provide safety (ACC, 2012). Were the industries’ output to decrease dramatically, inputs to nearly every industry in Australia would have to be sourced from overseas. This would place increased pressure on import capacity and require development of existing infrastructure (Koryakovtseva et al., 2012). Port Botany in Sydney has traditionally been the main point of entry for chemical trade, however it is rapidly becoming uncompetitive due to capacity constraints (Koryakovtseva et al., 2012).

Table 2. Intermediate usage of chemicals and plastics industry output, 2007-08

INDUSTRY	USAGE OF CHEMICAL & PLASTICS PRODUCTS AS INTERMEDIATE INPUTS (%)
Agriculture	4.4
Mining	3.1
Manufacturing	39.2
Construction	13.4
Services	19.1
Total intermediate usage	79.2

Source: Australian Bureau of Statistics (ABS, 2011b)

Given the high production of intermediate inputs, the chemicals and plastics industry is intrinsically built into supply chains across the economy. Indeed the chemical industry has been described as the ‘anchor’ of the modern economy (McKinnon, 2004). Due to the linkages to the Australian economy, the chemicals and plastics industry is a key enabler of environmental, social and economic change (PACIA, 2010). Indeed, there is a significant multiplier effect when productivity improvements are realised in this industry (PACIA, 2010). The competitiveness of downstream industries is closely linked to the efficient supply of output from the chemicals and plastics industry (McKinnon, 2004).

In Australia, inconsistent regulation across the states is a challenge to the transport and distribution of chemicals (Productivity Commission, 2008). Supply chain costs in the chemicals and plastics industry are generally greater than those in other industries, given the relatively low value per tonne of products and the relatively high costs of transport due to their bulky and hazardous nature (McKinnon, 2004). It has also been suggested that improvements to domestic infrastructure, in particular transport, would assist in minimising the impact of Australia’s relative distance from key markets (Australian Industry Group, 2008).

2.6 Public Perception and Workplace Incidents

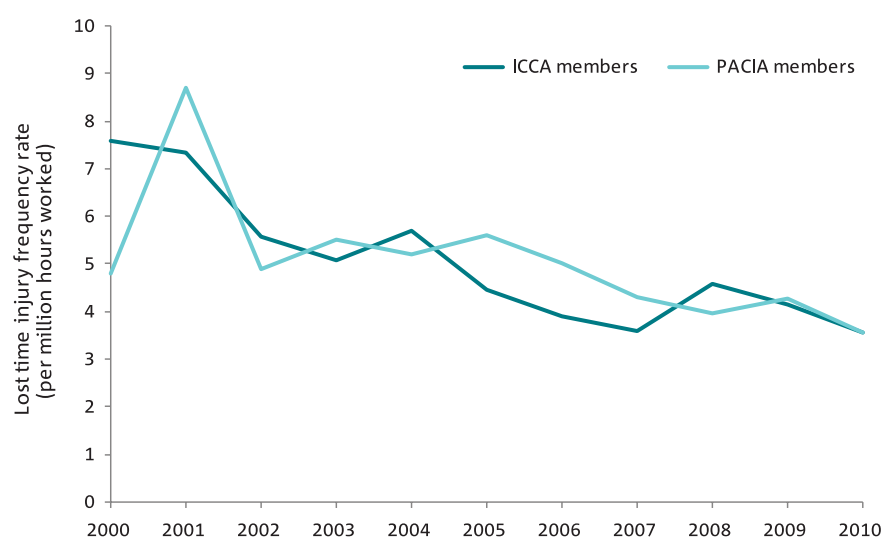
Despite the important contributions the chemicals and plastics industry makes to nearly every other industry, the public perception of the industry remains less than favourable. While there are no Australian specific surveys, a survey of public perception of the industry across Europe revealed that the largest

concerns were around ‘water and air pollution from chemical factories’ and ‘environmental damage from dumping chemical waste’ (Cefic, 2006). In light of those concerns however, there is still recognition of the contributions made by the industry as the most important benefit of the industry was found to be supplying ‘products that enhance the quality of daily life’, followed by providing ‘innovative technologies for other industries’ (Cefic, 2006). However, the pervading negative perception of the industry contributes to the lack of acceptance of the industry and is detrimental to the industries’ social license to operate.

However, in contrast to commonly held perceptions, the chemical industry in reality is relatively safe, with a low number of casualties and injuries per

million man-hours (Harmsen, 2010). A lost-time injury is defined as an occurrence that resulted in a fatality, permanent disability or time lost from work of one day/shift or more (Safe Work Australia, 2012). The lost time injury frequency rate (LTIFR) is equivalent to the number of lost-time injuries per million hours worked (Safe Work Australia, 2012). This measure captures all injuries in the industry and is not restricted to the injuries caused by chemicals. However, the LTIFR reflects the perceived risk of the industry according to the public. Based on survey data on members of PACIA and International Council of Chemical Associations (ICCA), the LTIFR for Australian members has been decreasing and is in line with the LTIFR of ICCA members (Figure 7).

Figure 7. Lost time injury frequency rates of ICCA (global) members and PACIA (Australia) members



Note: Data on ICCA members is representative of the global industry whereas data on PACIA members is representative of the Australian industry.

Source: International Council of Chemical Associations (ICCA, 2012); PACIA (PACIA, 2012b)

Workplace contact with chemicals and plastics products can present risks to people, property and the environment (Productivity Commission, 2008). Risks and hazards can have both short and long term consequences which may not be necessarily obvious. Worldwide, it has been estimated that 8.3 percent of total deaths and 5.7 percent of the total burden of disease in Disability Adjusted Life Years (DALYs) were attributable to environmental exposure and management of selected chemicals in 2004 (Prüss-Ustün et al., 2011).

Considering industrial and agricultural chemicals and acute poisonings only (that is, excluding the burden of disease attributable to air pollution and contaminated drinking water), the global burden of disease is 1.2 million deaths and 25 million DALYs, equivalent to 2 percent of total deaths and 1.7 percent of the total burden of disease worldwide (Prüss-Ustün et al., 2011). Although this is a global estimate of the burden of disease attributable to chemicals, given the high degree of international trade, industry essentially functions as a global industry (ACC, 2012). Hence, public perception of the industry can be influenced by global indicators. Although Australia is likely to enforce more stringent regulations and a small proportion of the global disease burden may be attributable to Australia, industry perception can still be influenced by international perceptions.

2.7 Environmental Services

Climate change and environmental pressures are a real risk threatening the global environment. The World Economic Forum (2013) identified rising greenhouse gas emissions as the most likely global risk to manifest over the next decade, behind severe income disparity and chronic fiscal imbalances.

As such, it is envisaged that there will be increasing pressure over the next 20 years for the price of resources, products and services to reflect the full cost of production including environmental

impacts (KPMG, 2012). Moving external environmental costs onto the balance sheet will have significant impacts. In the chemicals industry, it was estimated that external environmental costs are equivalent to 43 percent of earnings (EBITDA) in 2010 (KPMG, 2012). However, pricing environmental costs has the potential to change business decisions and improve the protection of natural ecosystems and natural capital (WBSCD, 2010).

Although the chemicals industry is a carbon-intensive industry, it is also an important solutions-provider and has the ability to enable other industries to save energy and reduce greenhouse gas emissions (ICCA, 2009). A lifecycle assessment of chemical products was commissioned by the International Council of Chemical Associations and conducted by McKinsey & Company and the Öko Institut. This report examined the emissions linked to the chemical industry from extraction of feedstock and fuel through to production to disposal (ICCA, 2009). It was estimated that for every unit of greenhouse gas emissions emitted through chemical industry production, the resulting product saves two to three units of greenhouse gas emissions (ICCA, 2009).

Outputs from the chemicals and plastics industry that enable the greatest emission savings are:

- ♦ insulation materials for buildings which reduce the amount of heat lost and therefore decrease the need for energy for heating;
- ♦ use of fertilisers and crop protection which result in increased crop yield and reduce the need for land-use changes; and
- ♦ lighting with more efficient lamps that deliver more light for every watt of energy (ICCA, 2009).

2.8 Nine Fundamental Needs – A View From Within the Industry

A working group from the Plastics and Chemicals Industries Association (PACIA) reviewed early drafts of the megatrends presented in this report. They also reviewed information emerging through the interviews CSIRO conducted with 26 industry representatives and a workshop in Melbourne on 13 November 2012 with 29 stakeholders in attendance including five CSIRO staff, two representatives from the Australian Government, three staff members from PACIA, two representatives from research and non-governmental organisations (NGOs) and the remaining 17 people from private companies.

In consideration of the megatrends and stakeholder feedback PACIA identified nine fundamental needs for the industry to achieve sustainable growth. The nine fundamental needs identified are as follows:

- 1. Social licence to operate** – The Australian chemicals and plastics industry already performs well in terms of health, safety, social and environmental performance. The high levels of performance need to be maintained and enhanced. An additional challenge is creating an awareness of what the industry does within government, other industries and the community. Although the chemicals and plastics products are used in our everyday lives, and are essential for almost all other industry sectors, the industry has low visibility.
- 2. Strong customer base** – There is a need within industry to build upon and strengthen links to domestic customers with products specifically designed for Australian conditions and applications. There is also a need to expand in the rapidly growing overseas markets for chemicals and plastics products especially in developing Asia, the Middle East and

Latin America. There will be market segments and niches that Australian industry is well positioned to supply.

- 3. Innovation and strong intellectual property** – Australia’s chemicals and plastics industry has developed many highly innovative products and advanced manufacturing systems. The industry has need to build upon and expand the strong IP base to ensure innovation into new spaces which opens new market opportunities.
- 4. Skilled and productive talent** – Accessing and retaining the world’s best chemical engineers, technicians and diverse skill-sets needed by the chemicals and plastics industry in Australia is a fundamental and ongoing need. The rising education and skills levels in India, China, Singapore, South Korea and other countries is making this space increasingly competitive. In addition reversing the recent decline in productivity in the manufacturing sector, and whole Australian economy, is a fundamental requirement for the industry to stay competitive.
- 5. Competitive capital** – Industry requires the private and public sector infrastructure used for chemicals and plastics production (and distribution) to be world-class. This is becoming increasingly challenging as other countries, especially in Asia and the Middle East, are rapidly upgrading their manufacturing plants with cutting edge technology.
- 6. Feedstocks** – To operate in Australia chemicals and plastics producers need access to natural gas feedstocks. Whilst technological advances might make other types of feedstocks available in the future most current, and economically feasible, production systems need gas. Other types of feedstock are also a fundamental industry need.

- 7. Energy and utilities** – Energy is a major cost component of the chemicals and plastics industry. The access to affordable and reliable energy sources is a fundamental need facing challenges in light of energy price rises likely to occur over the coming years. Water is also a vital input and water scarcity will impact prices in similar ways.
- 8. Stable government** – This is a fundamental need for all industry sectors. For chemicals and plastics producers stable government reduces the risk of investing in plant infrastructure and makes Australia a more attractive destination for companies. This is an ongoing fundamental need.
- 9. Balanced regulatory environment** – Many competing interests held by many stakeholders need to be resolved in the design and implementation of government regulations. The industry has an ongoing and fundamental need for these issues to be handled in a transparent, inclusive and evidence-based manner.

These nine fundamental needs of the chemicals and plastics industry arise from the megatrends presented in the following chapters of this report. They are a view from within the industry and have been compiled by PACIA in response to the megatrends. They provide insight to what the industry believes needs to occur to achieve sustainable growth.

2.9 Summary

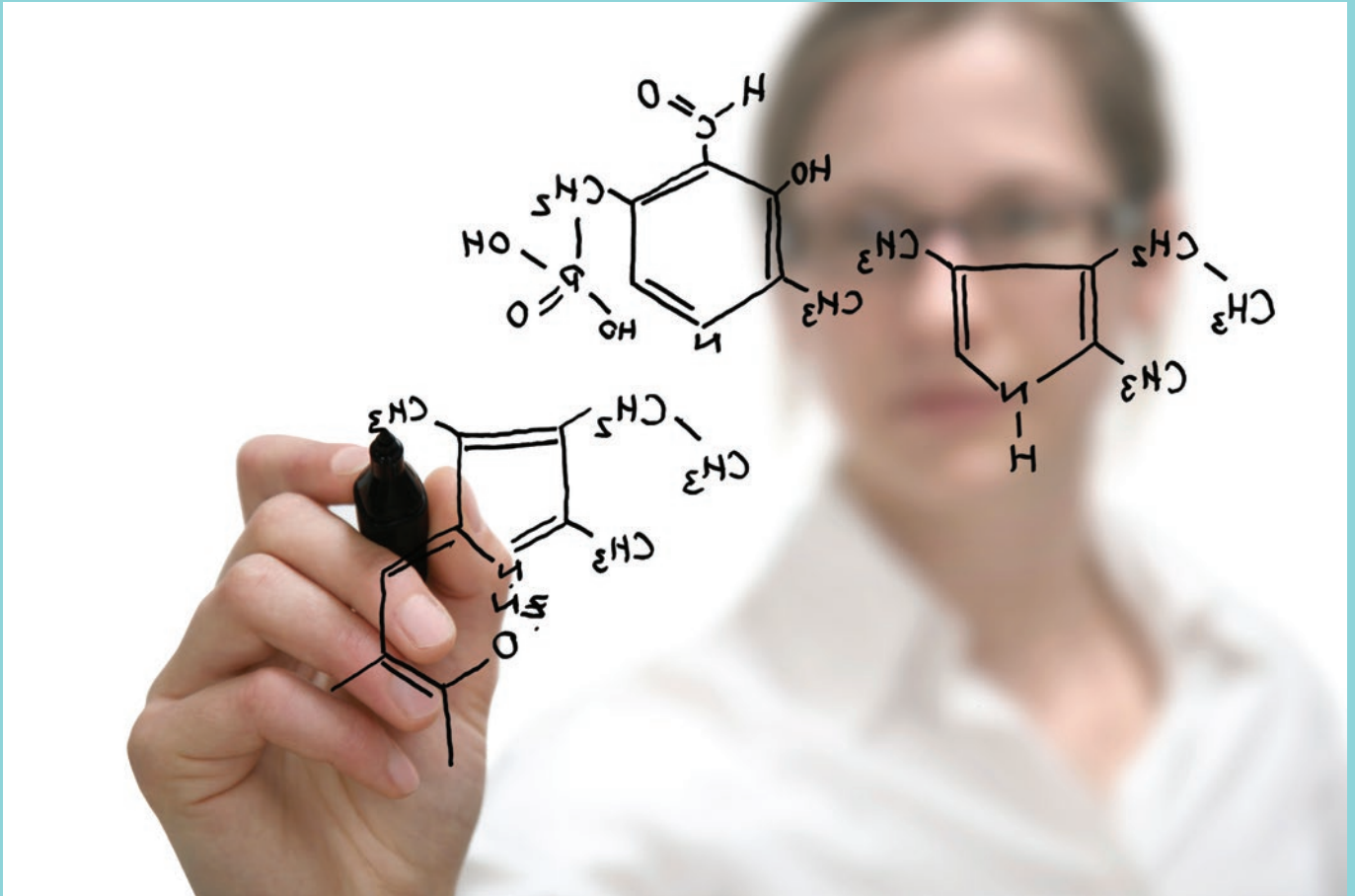
This section describes an industry with a unique set of challenges and opportunities. The chemicals and plastics industry holds a crucial and pivotal role within Australia’s industry supply chains and the whole economy. It supplies products essential to other industries which are also routinely used in the day-to-day lives of all Australians.

However, the industry faces challenges too. Over the last several years the industry has experienced contraction in the number of employees, decline in the number businesses and a growing trade deficit. Revenue and contribution (value-add) to the Australian economy have remained relatively stable. The supply of chemicals and plastics products from other countries is placing increased competitive pressure on the Australian industry both domestically and globally. The industry is not highly visible to many people and often only gains attention when there is a supply chain disruption or incident.

The downward trend in employment, the declining number of businesses and trade deficit in the chemicals and plastics industry may be important early signals. It may be important for internal and external stakeholders to think about ways to ensure the industry grows sustainably and profitably into the future.

Because it holds such a pivotal position within supply chains, innovations within the chemicals and plastics industry can have magnified social, economic and environmental impact. For example, the industry may be well positioned to supply cost effective reductions in greenhouse gas emissions. Wisely chosen and proactive actions can help harness the environmental, social and economic benefits of the chemicals and plastics industry.

3 Industry Megatrends



A megatrend is a major shift in social, economic, environmental, technological or political conditions that will impact the industry over coming decades.

3.1 Emerging Markets

Coming decades will see continued rapid economic growth in Asia and, to a lesser extent Latin America, both within the chemicals and plastics industry itself and within upstream and downstream industries. This will create challenges and opportunities. It will have demand-side and supply-side impacts on the Australian chemicals and plastics industry.

The demand-side opportunities are associated with income growth. Over one billion people in the Asian region will cross the income threshold into the middle-income classes over coming decades. Many will cross over into the upper income threshold. These people will demand new products and new services. New industries and continued urbanisation will place upward pressure on demand for chemicals and plastics products. There may be niche regions and markets that Australia is well positioned to supply.

However, growth in Asia also creates competitive challenges for Australian industry. Increased educational and skill levels in developing countries combined with a shrinking, but still large, wage differential will place pressure on domestic labour markets. Science, research and technology investments in Asia are leading to more advanced lower-cost production systems.

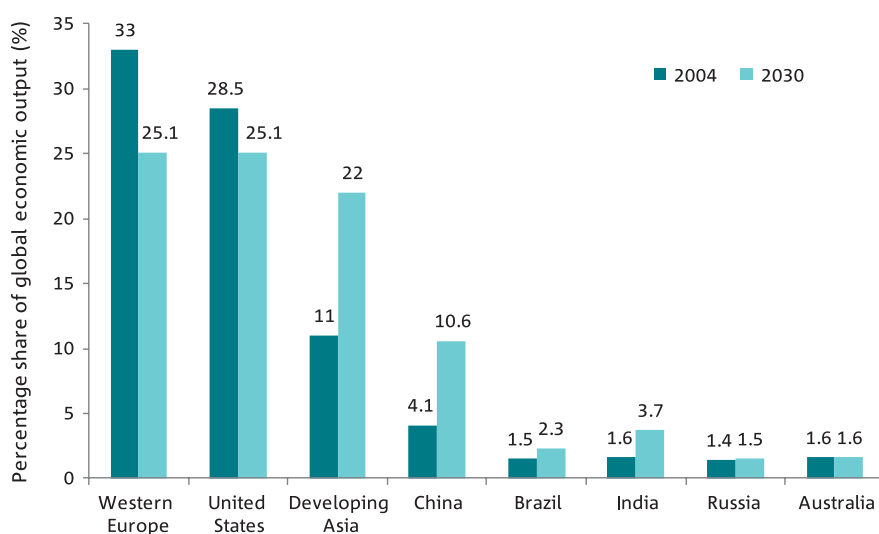
Asian countries are growing the production and export of chemicals and plastics products. China, India, South Korea and Singapore are amongst the region's most significant producers and exporters building large scale plants and facilities. Global supply chains are expanding and becoming more advanced. Overseas imports are likely to compete in the domestic market to a greater extent over coming decades.

Mid-term economic growth forecasts for 2012 to 2017. The International Monetary Fund (IMF, 2012) forecasts economic growth rates for world regions out to the year 2017. The bulk of world economic growth occurs outside the advanced economies. Developing Asia is the most rapidly growing region. For the six year period 2012 to 2017 average year-on-year growth forecasts for world regions are as follows:

- ◆ Developing Asia (including India and China) at 7.7 percent per year
- ◆ Central and Eastern Europe at 2.9 percent per year
- ◆ Middle East and Northern Africa at 5.4 percent per year
- ◆ Sub-Saharan Africa at 4.1 percent per year
- ◆ United States at 2.6 percent per year
- ◆ Latin America and the Caribbean at 3.9 percent per year

Long-term shifts in shares of global economic output. Economic growth in the Asian region will reshape the world economy over coming decades (Anderson et al., 2011). In the year 2004 developing Asia's share of global economic output was 11 percent. By 2030 it is forecast to be double at 22 percent. China will increase its share from 4.1 percent to 10.6 percent over the same time period. India's share will increase from 1.6 percent to 3.7 percent. By contrast the United States will decrease its share of output from 28.5 percent to 25.1 percent and Western Europe will decrease its share from 33 percent to 25.1 percent (Figure 8).

Figure 8. Shares of global economic output in 2004 and 2030



Source: Asian Development Bank (Anderson et al., 2011)

Strong economic ties with Asia. China is Australia's largest trading partner (DFAT, 2011) and Australia's trading links with Asia have been continually growing. Hence the growth of Australia's economy is more closely linked to the growth of China's and India's economies in preference to the growth of the OECD7, including US, UK, Japan, Germany, France, Italy and Canada. In 2009-10, Australia's exports to China were worth A\$52,219 million. In the following year of 2010-11, exports to China jumped 35 percent to A\$70,517 million with the largest growth in commodity exports. The total value of merchandise traded between China and Australia has grown at an average annual rate of 22 percent from 1999 to 2009, more strongly than any other trading partner over this period (ABS, 2009).

Urbanisation, building and construction growth in Asia.

Urbanisation in Asia is fuelling the growth in the building and construction industry. This industry is a major consumer of chemicals and plastics products. In the future plastics are likely to increasingly replace traditional materials such as timber decking, bathroom fixtures, decorative trim and skylights (PACIA, 2012a). As Asia and the developing world rapidly urbanises demand for building and construction plastics and chemicals products is likely to expand. In 2011 around 52 percent of the world's population lived in cities with the remainder inhabiting rural areas. This will grow to 67 percent by the year 2050 (United Nations, 2012). The rate of urbanisation is particularly rapid in developing Asia and especially in India and China (Figure 9). China is currently around 40 percent urban and will be 65 percent urban by 2025. India is around 30 percent urban and will be 37.2 percent urban by 2025.

Construction with chemicals and plastics.

Although chemical products account for approximately only 1 percent of construction costs, the chemicals and plastics industry provides critical inputs such as concrete admixtures, asphalt additives, adhesives, sealants, protective coatings, paints, plastic pipes and insulation (KPMG, 2011a). Protective coatings and sealers are the largest product segment in the global market although cement and asphalt additives is the fastest growing product segment (KPMG, 2011a).

Growth in construction chemicals market.

China has overtaken America to become the world's leading market for construction chemicals, driven by continuing mass urbanisation (KPMG, 2011a). High growth rates in the construction chemicals market are expected in countries that profit from natural resource endowments, such as the OPEC countries, Russia, Brazil and Australia (KPMG, 2011a). In contrast, the relative importance of markets in developed regions including North America, Western Europe and Japan is likely to continue to diminish (KPMG, 2011a).

Green consumer preferences driving demand.

The growing awareness of climate change is likely to drive the demand for the construction chemicals in energy-saving materials and technologies, chemicals that increase performance and environmentally friendly products such as waterborne coatings (Frost & Sullivan, 2011; KPMG, 2011a). For example, admixtures are able to reduce the use of cement and aggregates and therefore reduce the overall carbon footprint as these two products are both energy-intensive to manufacture (Frost & Sullivan, 2009a). Changing consumer preferences in favour of sustainable construction is likely to continue the demand for these products.

Figure 9. Actual and forecast urban populations in two large Asian cities

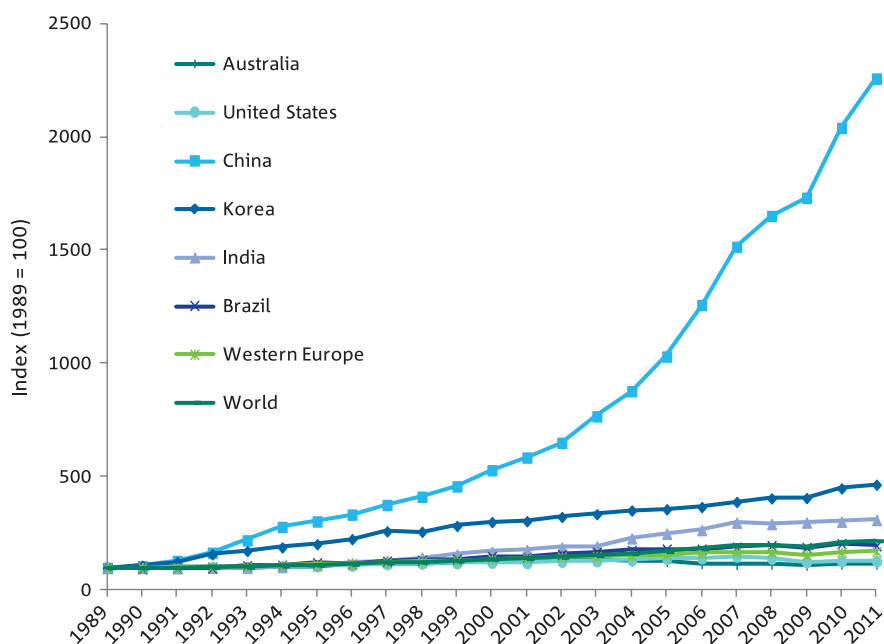


Source: United Nations (2012)

Direct foreign investment flows.

One of the consequences of Asian economic growth is the likelihood of increased investment funds flowing into Australia. The recent "World Investment Report" published by the United Nations lists Australia as fifteenth out of 200 countries for its direct foreign investment potential in the future. This is a major jump from its previous rank position of 72 out of 200 (The Conversation, 2012; UNCTAD, 2011). Over the six year period from 2005 to 2010, foreign direct investment outflows from China to the rest of the world increased from US\$12.3 billion to US\$68 billion or average growth of 76 percent per annum (UNCTAD, 2011). One example includes the merger of the Singapore and Australian stock exchanges (SGX and ASX) which was blocked by the Australian Government through the Foreign Investment Review Board (FIRB, 2011). Another example includes the recent 2012 sale of Cubbie Station – a large cotton farm in Queensland – to overseas interests which was approved by the Australian Government through the Foreign Investment Review Board.

Figure 10. The ACC Global Chemical Production Regional Index, 1989-2011, selected countries and world output



Source: American Chemistry Council (ACC, 2012)



Growth in chemicals and plastics output for the Asia Pacific region.

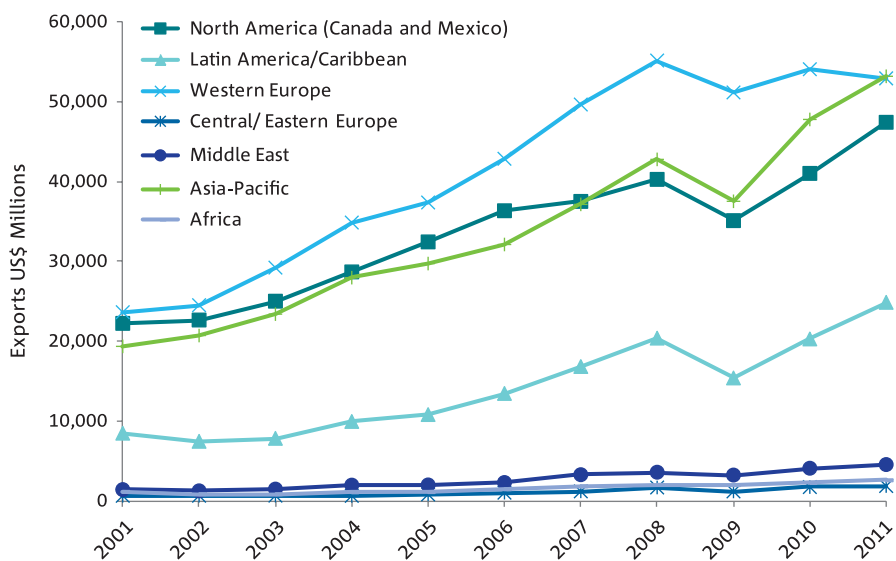
One of the most important changes in the global chemicals and plastics industry in recent times is a massive production increase in the Asia Pacific region. Over the ten year period from 2002 to 2011 China grew its chemicals and plastics production by 247 percent (Figure 10). This compares to a decrease of 13 percent in Australian chemicals and plastics production and an increase in world production of 49 percent over the same period (ACC, 2012).

China, India, South Korea and Singapore are ramping up exports.

Within the Asia Pacific region China, South Korea and Singapore are all publically investing in this sector by building hugely scaled plants which are very competitive and rapidly increasing exports of chemicals and plastics products to global markets. If this trend continues it will increase competitive pressures on domestic markets in Australia.

Over the 10 year period 2002 to 2011 China increased exports of chemicals and plastics products from US\$2,944 million to US\$13,270 million. That equates to growth of 351 percent or 35 percent per year. Over the same time period South Korea increased exports from US\$2,657 million to US\$6,381 million (140 percent increase) and Singapore increased exports from US\$1,448 million to US\$4,206 million (190 percent increase). Indian exports rose from US\$757 million to US\$4,393 million (480 percent increase). This compares to growth in chemicals and plastics exports of 98 percent in Australia from US\$1,490 million in 2002 to US\$2,955 million in 2011. Of all these countries China has the largest value of exports but India is growing most rapidly. Zooming out to world regions reveals that the Asia Pacific, North America and Latin America are all growing exports rapidly. By comparison Western Europe has decreased exports in recent years and the Middle East, Africa and Central Europe have held constant or slightly increasing exports (Figure 11).

Figure 11. Growth in exports of chemicals and plastics products by world region



Source: American Chemistry Council (ACC, 2012)

Pharmaceuticals industry in China is set to soar.

Whether considered a part of the chemicals industry or a downstream product user, the pharmaceuticals industry is set to grow substantially in China. A report by KPMG forecasts that with 20 percent per annum sales growth China will overtake Japan to become the world's second largest pharmaceutical market by 2015. This is due to growth in healthcare spending rising from 4.7 of GDP in 2009 to 5.5 percent in 2011 and RMB 850 billion government healthcare package for 2009-2011. The same KPMG report notes that hospital drug sales and retail pharmacy sales are set to grow by 20 percent and 13 percent by 2013 (KPMG, 2011b).

A capital intensive industry. The chemicals and plastics industry is a capital intensive industry whereby capital costs are cited as a driver for the sustainable development of the industry (Harmsen, 2010). Currently, capital costs for chemical plants in China are between 10 to 50 percent lower than equivalent plants in the West (McKinsey and Company, 2012). Prices vary according to the amount of local input in the construction (McKinsey and Company, 2012). Whether or not capital costs are pushed up as living standards increase, the cost structure in China gives the country an advantage over developed countries and is a strong international competitor.

Wage growth in the Chinese manufacturing sector.

In 2002 the average hourly rate for an employee in the Chinese manufacturing sector was US\$0.57 per hour. By 2008 it was US\$1.36. This represents average year-on-year growth of 20 percent over the seven year time period (Banister et al., 2011). By comparison in the year 2011 an Australian employee in the manufacturing sector earned an average wage of A\$30/hour (ABS, 2012f). In 2001 it was A\$19 per hour. This represents an average increase of 6 percent per annum over the same time period. Clearly income growth in the Chinese manufacturing sector is much more rapid. The rising cost of labour in the Chinese manufacturing sector will have implications for the competitive positioning of industry in the future.

Australia's labour costs in manufacturing are high on a global scale.

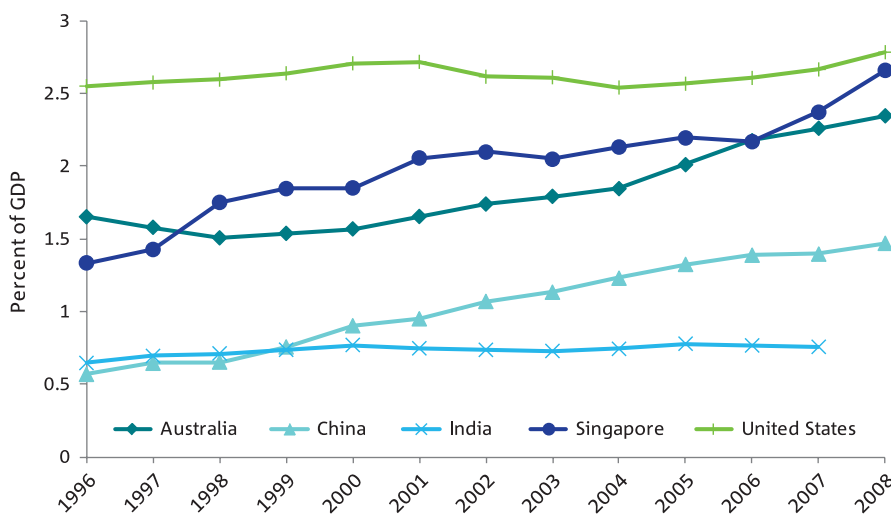
The United States Government Bureau of Labour Statistics estimates the average cost of labour in the manufacturing industry for 34 countries in the year 2010 (BLS, 2011). Australia ranks as the 10th most expensive with a labour cost of US\$40.60 per hour. This compares to the average over all 34 countries of US\$27 per hour. The top five countries are Norway (US\$57.53), Switzerland (US\$53.20), Belgium (US\$50.70), Denmark (US\$45.48) and

Sweden (US\$43.81). The lowest wages are for Hungary (US\$8.40), Taiwan (US\$8.36), Poland (US\$8.01), Mexico (US\$6.23) and Philippines (US\$1.90).

Growth in research and development expenditure.

Australia and other Asian countries are devoting an increased portion of economic output to science, research and technology (The World Bank, 2012) (Figure 12). For example, China and Singapore have grown the portion of GDP spent on research from 0.5 percent and 1.3 percent in 1996 to 1.5 and 2.7 percent by 2008. Korea grew from 2.4 percent to 3.4 percent over the same time period. Australia's research and development spend increased from 1.7 percent of GDP in 1996 to 2.3 percent of GDP by 2008. This data reveals that the rapidly developing Asian economies are placing an increasing share of resources into innovation. This is likely to increase the competitiveness of their chemicals and plastics industry in global and domestic markets.

Figure 12. Portion of economic output devoted to science, research and technology development



Source: The World Bank (2012), World Development Indicators Database (<http://data.worldbank.org>)

3.2 Resource Scarcity

The world has limited supplies of mineral, energy, water and agricultural resources. As the world population and the world economy grow these resources are under increasing pressure. This will have demand side and supply side impacts on the Australian chemicals and plastics industry.

On the supply side resource scarcity is likely to push up prices of essential feedstocks. Feedstocks are crucial to the operation of the chemicals and plastics industry. Price increases may lead to innovation within the industry to identify alternative feedstocks. On the demand side resource scarcity will lead to increased effort and investment in more efficient production techniques. The chemicals and plastics industry may be in a position to support the development of advanced energy storage and demand management systems and recycling of waste as mineral ore grades decline via the supply of innovative products.

More people will place increased pressure on natural resources. The world and Australian population will continue to grow over coming decades. Australia's population is forecast to grow from 22 million persons to 34 million persons by 2050 with upper and lower estimates of 40 and 30 million persons (ABS, 2008). The global population will grow from 7 billion persons in 2012

to 9.3 billion persons by 2050 (United Nations, 2011). This will place increasing pressure on scarce environmental resources required for food, energy, shelter, manufacturing and human sustenance. In 2011, 60 percent of the global population lived in Asia (Frost & Sullivan, 2012a). The greatest population increases are expected to take place in developing countries (FAO, 2009), further exaggerating this dichotomy and challenging the demographic distribution of resources. By 2021, is it

expected that biofuels will consume 24 percent of global production of sugarcane, 16 percent of vegetable oil and 14 percent of coarse grains (OECD & FAO, 2012).

A bigger world economy. World economic output in 2011 was US\$78 trillion. The International Monetary Fund forecast growth to US\$111 trillion by the year 2017. The median growth rate for advanced economies will be in the range of 0.8 percent to 2.1 percent over the six year period. In comparison emerging and developing economies will grow 4.1 percent to 4.4 percent per year (IMF, 2012). This will place pressure on scarce natural resources due to the increasing demand from the rising middle class of emerging and developing countries (S. Hajkowicz et al., 2012a).



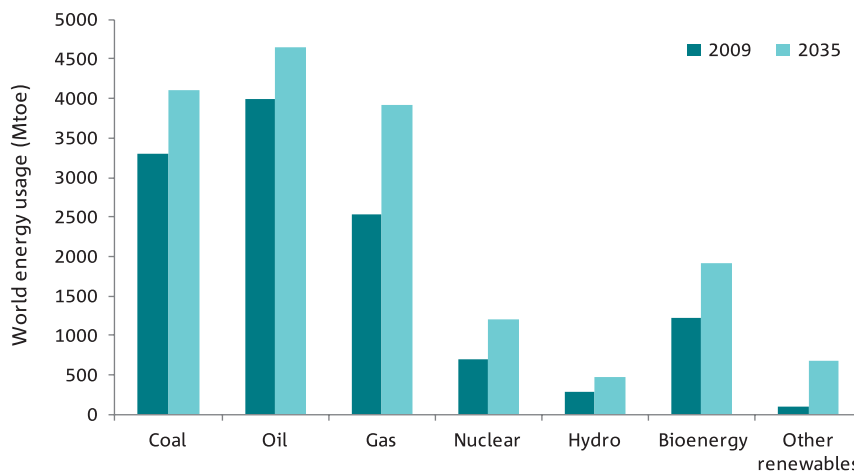
A forecast decrease in commodity prices.

Commodity price movements underpin the performance of the Australian mining sector which is a large downstream user of the chemicals and plastics industry (ABS, 2012c). The past decade has seen commodity price growth higher than experienced in recent history. Commodity prices are generally expected to decline from 2012 levels due to a slowdown in demand and growth in supply following the growth in investment following sustained high commodity prices (Fraser Institute, 2012; World Bank, 2012a). Declining commodity prices translate to decreasing profitability in the mining sector and therefore have a flow on impact on the chemicals and plastics industry.

Increasing global energy demand.

Driven by economic growth and population growth, worldwide energy usage is forecast to rise by 40 percent between the years 2009 and 2035 (IEA, 2011b). All sources of energy experience growth (Figure 13). Oil demand increases by 18 percent, coal by 25 percent and nuclear by 70 percent. Despite a rapid growth rate, renewable energy is starting from a small base and will still make only a minor contribution to world energy use by the year 2035. Over 90 percent of the growth in energy demanded occurs in developing countries. China is forecast to consume 70 percent more energy than the United States by 2035. The increased consumption of energy may place pressure on feedstocks such as gas used in the chemicals and plastics industry.

Figure 13. Growth in world energy demand, by energy type



Source: International Energy Agency (IEA, 2011b)

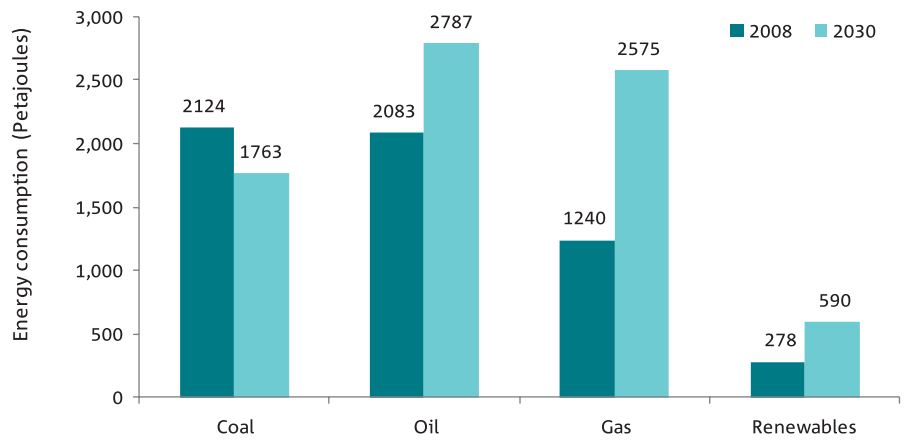
Increasing resource costs. Chemicals and plastics production is water and energy intensive. Therefore, it is vulnerable to domestic and international regulations limiting greenhouse gas emissions and water usage (KPMG, 2012). Increases in energy costs will have an impact on production costs. For example, plastics SME's operate in a highly trade exposed market with tight margins and use electricity volumes equating to between 2 to 18 percent of input costs (PACIA, 2008).

Non-OECD countries are the key drivers of energy demand. From the period 2010 to 2035, non-OECD countries are expected to account for 90 percent of population growth, 70 percent of the increase in economic output and 90 percent of the growth in energy demand (IEA, 2011b). As such, non-OECD countries are expected to play an increasingly significant role in energy markets. Almost two-thirds of the required \$38 trillion in global investment in energy supply infrastructure will be in non-OECD countries (IEA, 2011b).

Increasing energy demand in Australia.

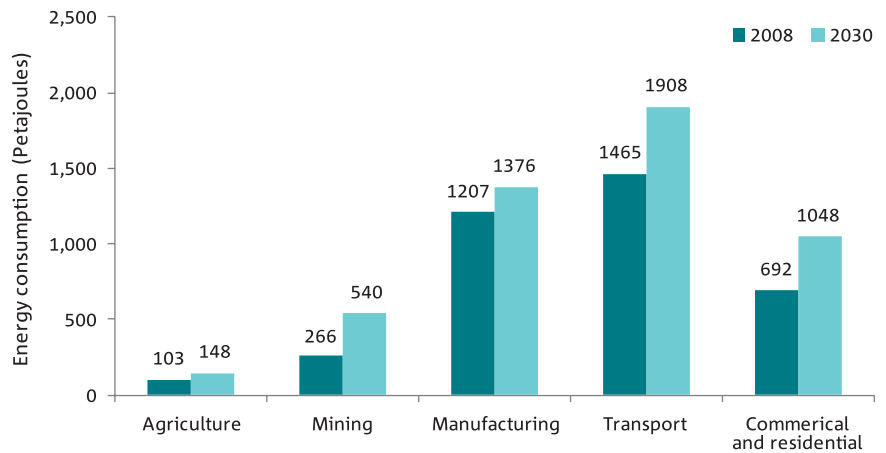
Income growth, lifestyle patterns, industry growth and population growth will drive increased demand for energy in Australia over coming decades (Figure 14, Figure 15). The Australian Bureau of Agricultural Resource Economics and Sciences (Syed et al., 2010) forecasts 35 percent growth in total energy consumption over the period 2008 to 2030. The most rapidly growing sources of energy will be natural gas and coal seam gas (3.4 percent per year) and renewables (3.5 percent per year). Nevertheless, by the year 2030 coal and oil will still continue to supply the bulk of Australia's energy requirements. Chemicals and plastics play a role in improving the energy efficiency in various sectors. In the commercial and residential sector for example, chemicals and plastics used in insulation, and in lighter materials and composites in the construction and fittings all help improve the energy efficiency and thus decrease final demand (PACIA, 2008).

Figure 14. Growth in Australian energy consumption, by fuel source



Source: Australian Bureau of Agricultural Resource Economics and Sciences (Syed et al., 2010)

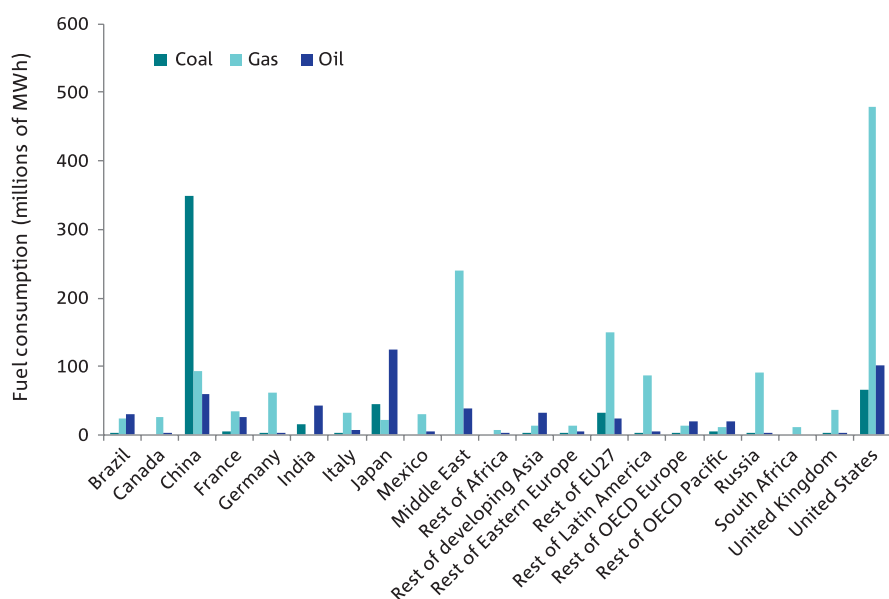
Figure 15. Growth in Australian energy consumption, by sector



Source: Australian Bureau of Agricultural Resource Economics and Sciences (Syed et al., 2010)

An energy intensive industry. The chemical industry requires energy to extract raw materials and transform into useful products so is therefore an energy-intensive industry (ICCA, 2009). Natural gas, coal and petroleum are utilised both as raw materials and as energy sources to power facilities (Figure 16) (ICCA, 2009). The chemical sector worldwide consumes more than 30 percent of total industrial energy usage (including feedstocks) (IEA, 2009). As energy source prices rise and carbon dioxide emissions are beginning to be taxed (Harmsen, 2010), production processes will have to be increasingly more energy efficient.

Figure 16. Fuel consumption in the chemical industry in 2005, by country and fuel source



Source: International Council of Chemical Associations (ICCA, 2009)

Oil prices forecasts. Crude oil prices are expected to rise moderately over the next five years (IBISWorld, 2012b). Forecasting out to 2035, the International Energy Agency (2011b) expects the average IEA crude oil import price to remain high at around \$120/barrel in 2035, given continued pressure on both the demand and supply sides. This compares to an average price of \$102/barrel in 2011. Crude oil prices will directly feed into the price of plastics given oil is an input into the production process (IBISWorld, 2012b).

Transitivity from energy into fertiliser and food markets. Oil prices feed into the prices of most primary commodities through the use of energy-intensive inputs (Baffes, 2007). Fertilisers and food are most sensitive to oil price changes (Baffes, 2007). The cross price elasticity of demand from crude oil to fertilisers is approximately 0.33, such that a 10 percent increase in price of crude oil would lead to a 3.3 percent increase in the price of fertilisers (Baffes, 2007). This would then flow through into other commodities for which fertiliser is an input. Food has a cross price elasticity of 0.18 so a 10 percent increase in price of crude oil would lead to a 1.8 percent increase in food prices (Baffes, 2007).

Energy technology developments will change the cost effectiveness of supply options. Technology advances will change the financial performance of competing energy supply options (Inwood, 2011). Currently coal is the most cost effective energy supply technology, ranging from US\$54 to US\$60 per megawatt hour. Coal has relatively high carbon emissions compared to other energy supply options at 0.84 tonnes of carbon per megawatt hour. However, technology developments will alter the cost effectiveness of different energy supply options. For example, by 2025 natural gas will cost between US\$47 and US\$74 per megawatt hour – potentially cheaper than coal (Inwood, 2011). Chemicals and plastics play a critical role in renewable energy technologies such as wind turbines, solar panels and installation equipment, piping for geothermal systems, fuel cells and hydrogen production and storage (PACIA, 2008).

Increasing biofuel production. As energy prices rise and carbon pricing becomes a reality, alternative fuel sources will become economically viable. One such alternative fuel source is biofuel. Biofuels are an alternative fuel source with lower emissions and a higher degree of fuel security than other fuel sources (O’Connell et al., 2007). Currently one percent of the world’s arable land area is devoted to biofuel

production and this is forecast to grow to between 2.5 percent to 3.8 percent by the year 2030 (IEA & OECD, 2006).

Biofuels and food production.

To be a viable fuel alternative, biofuels should provide a net energy gain, have environmental benefits, be economically competitive and production should not significantly reduce food supplies (Hill et al., 2006). While biofuel may help achieve energy security and climate mitigation outcomes, it may also place pressure on food production systems. The extent of the impact is debated. One statistical study finds no direct long run relationship between biofuel production and food prices and limited, if any, short run relationship (Zhang et al., 2010). However, another study using similar methods finds that biofuel production had a 3 to 30 percent contribution to the 2008 food price surge (Mueller et al., 2011).

Increasing economic viability of biofuel production.

In order for biofuels to contribute to Australia’s energy security, it has been estimated that a 10 to 20 percent contribution to the total fuels mix would be necessary (O’Connell et al., 2007). Major challenges to achieving this contribution include reducing capital requirements, improving conversion efficiency and sourcing feedstocks (IEA, 2011a). Low-cost scenario estimates indicate that advanced biofuels may reach parity with fossil fuels only by 2030 as scale and efficiency increase (IEA, 2011a). However, a high cost scenario or greater feedback between oil prices and biofuels production could worsen competitiveness. Alternatively, non-feedstocks such as switchgrass, woody plants, prairie grasses and forbs offer advantages in terms of meeting a significant proportion of energy demand (10-20 percent is deemed reasonable), representing a net social benefit in terms of environmental costs and benefits and (Hill et al., 2006). While biofuels are an attractive alternative fuel source, the impact will be dependent on the on the profitability of biofuels and the technological developments in the energy content of crops (World Bank, 2012b).

Alternative sources for bio-based products. As with any bioderived product, the use of food crops introduces a potential conflict between the use of crops for food or other products such as fuel. Second generation feedstocks, however, are non-food crop-derived. This includes the utilisation of lignocellulosic biomass (wood), algae, straw and inedible oilseed crops (Sheldon, 2011). With the conflict of ‘food versus fuel’ resulting from first generation feedstocks, it is widely acknowledged that the next generation of biofuels and platform chemicals will be derived from second generation feedstocks (Sheldon, 2011).

Declining mineral ore grades and the rise of recycling. Mining sector data reveal a gradual and permanent decline in ore grades for major mineral commodities produced in Australia (Mudd, 2010). High grade deposits in general are becoming increasingly uncommon (Mudd, 2010). At the same time waste generation is expected to rise (OECD, 2008). As such, there is a push to redefine the concept of waste so it is no longer viewed as something to be discarded but rather a resource-rich ‘non-waste’ from which resources can effectively be ‘mined’ for future use (Pongrácz et al., 2004). Metals recycling is likely to be an important source of production (Mudd, 2010). It is likely that what was once perceived as waste will become a valuable resource. The chemicals and plastics industry provides critical inputs to the recycling process.

Increasing water demand. Global water demand is forecast to increase 55 percent between 2000 and 2050, with the largest increases coming from manufacturing, electricity and domestic use (OECD, 2012). In Australia population growth and economic growth will cause water consumption to rise. The Water Services Association of Australia (WSAA) forecasts total water consumption to rise by 42 percent by the year 2026 and 76 percent by the year 2056 compared to 2009 levels (WSAA, 2010). The increase is expected to be greatest in the South East Queensland region (Figure 17). The increased demand for water is likely to be associated with price rises. Water is an essential feedstock for the chemicals and plastics industry and may come under increased competitive demand from other sectors.

Figure 17. Total water consumption forecasts for Australian cities, compared to 2009 levels



Source: Water Services Association of Australia (WSAA, 2010)

Global water scarcity. The International Water Management Institute (IWMI, 2007) estimates that 1.2 billion people live in regions with insufficient water to meet human needs. It is also estimated that 1.6 billion people live in water-scarce river basins with inadequate financial and human capacity to develop future water resources. The World Economic Forum (2013) identified water supply crises, arising from declining quality and quantity combined with increased competition among resource intensive systems, as the fourth most likely global risk to manifest over the coming decade. The majority of water initiatives within the chemicals industry are operational and concerned with water reduction and water treatment as opposed to adaptation or mitigation strategies to adjust to future trends in water availability (KPMG, 2012). Some companies however have implemented greater change. Australian Vinyls have invested in a water treatment plant which has reduced fresh water usage in its manufacturing plant by 50 percent (PACIA, 2011d). By recycling water used in the treatment process, over four years Genos, a manufacturer of raw plastic materials, achieved a reduction in water consumption by 30 percent and also reduced trade waste by 46 percent (PACIA, 2011e).

Access to natural gas (a critical issue for industry). Natural gas is a highly valued resource in the chemicals and plastics industry. It is used as an energy source and is also a critical feedstock for producing many products. Obtaining access to gas at feasible and stable prices is one of the main challenges identified by the Australian chemicals and plastics industry. It has featured heavily in the interviews and workshops with industry representatives conducted during this study. Some companies in the industry may choose to set up operations offshore if they are unable to access gas in Australia.

The pressure partly comes from overseas energy markets. Australia is in the process of establishing itself as a lead country for unconventional gas supply with a focus on coal seam gas (CSG). Australia is poised to become the first CSG-based LNG exporter (IEA, 2011a). The majority of CSG reserves are located on the East Coast where 2P (i.e. proved and probable) gas reserves amount to 50,385 PJ, with CSG accounting for 82 percent of the total (Queensland Government, 2012). Australia also has reserves of shale gas located in the Canning Basin in Western Australia and the Cooper Basin extending from South Australia into South-West Queensland (IEA, 2011a). Nationally, it has been estimated that Australia's combined identified gas resources are approximately 431,706 PJ (Geoscience Australia and BREE, 2012), equivalent to approximately 184 years of production at current rates (Prime Minister's Manufacturing Taskforce, 2012). The proximity of gas reserves to Asian markets has helped attract foreign investment to develop new projects (IEA, 2011a).

The Queensland gas market is considered relatively illiquid. Gas is in short supply for new contracts in coming years (Queensland Government, 2012). Customers seeking new domestic supply contracts for gas lack access to basic market information such as forward prices, volumes available and potential delivery timeframes for forward contracting (Queensland Government, 2012). This is hindering the market's ability to function smoothly and, as expected, is contributing to a high level of uncertainty in a market that is already suffering from the uncertainty of domestic and international LNG and future gas prices (Queensland Government, 2012).

In addition to access issues, developments in the gas market are affecting domestic prices. Historically, gas markets in Australia have not had a highly competitive structure and prices have reflected the all-up costs of supply rather than reflecting the short-run marginal production costs as would be the case in a competitive market (Queensland Government, 2012). As the Australian LNG market opens up to the international market however, it appears that prices are beginning to reflect the export-opportunity value (Queensland Government, 2012). Over the last few years, natural gas prices in eastern Australia have increased from around \$3.50 to \$6/GJ, with expectations of further rises to as high as \$9.00/GJ (Prime Minister's Manufacturing Taskforce, 2012). Even if these higher prices do not eventuate, the expectation of higher prices is concerning to the industry as it will negatively influence the investment decisions regarding the competitiveness of current and existing plant capacity and also future additional capacity (NIEIR, 2012).

These access and pricing issues are concerning to the domestic industry. A study by the National Institute of Economic and Industry Research (NIEIR, 2012) reports that it is not uncommon for domestic users to be offered 'surplus' gas volumes at prices that do not reflect domestic supply, demand or extraction costs but rather are linked to East Asia's LNG market (NIEIR, 2012). Users of gas have reported on the growing difficulty in securing long-term gas contracts and the impact of rising gas prices on project feasibility and plant expansion (Prime Minister's Manufacturing Taskforce, 2012). There is evidence that gas prices have hindered investment in new value-adding chemical processing and have forced some companies to switch to coal after previously using gas (Prime Minister's Manufacturing Taskforce, 2012). Some new chemical manufacturing investments are now considered uneconomic as a result (DomGas Alliance, 2012).

Opening up the domestic market to international competition is reshaping the domestic market and exposing domestic industries to higher prices (NIEIR, 2012). Some domestic users of natural gas are advocating prioritisation of reserves for the domestic market. DomGas Alliance (2012) cites that Australia is the only country to allow

international oil companies to access and export natural gas without prioritising local supply. While the United States and Canada allow international oil companies access to reserves, local needs are prioritised. The United States monitors export markets to ensure that LNG exports do not lead to a reduction in the supply of natural gas required to meet essential domestic needs (DomGas Alliance, 2012). Canada places the same priority on domestic needs and requires export permits and export price tests to ensure that the domestic markets is not disadvantaged by exporting gas (Innovative Energy Consulting, 2011).

Within Australia there is variation between markets in the priority given to domestic usage. Western Australia has a domestic reservation policy for natural gas, whereby 15 percent of the natural gas reserves are required to be used for domestic purposes. (NIEIR, 2012). A global comparison has shown that a 15 percent gas reservation policy is considered small (Leonard et al as cited in DomGas Alliance, 2012). Comparatively, the eastern states do not have a reservation policy for domestic use.

The Australian Government has identified three factors that will dominate Australia's energy future, including:

1. The need to deliver secure, reliable and competitively priced energy for a growing population and economy;
2. The further expansion of our energy exports to Asia and other growth markets; and
3. The need to become more energy efficient across the economy and to dramatically reduce carbon emissions and transform to a clean energy economy (Department of Resources Energy and Tourism, 2012).

As such, the formal position of Government reflects a balance of these three factors. As new coal seam gas and LNG developments come on line and ramp up to full production, some transitional tightness is expected and is already evident, resulting in higher prices and tighter supply dynamics (Department of Resources Energy and Tourism, 2012). The Australian Government has acknowledged the calls to mandate a proportion of gas reserves for the domestic market (Department of Resources Energy and Tourism, 2012). However 'the

government does not believe that such an approach would effectively address current pressures or be in the long-term interests of consumers and the Australian community' (Department of Resources Energy and Tourism, 2012, p. xiv). Furthermore, the Australian Government cites that: "there is little convincing evidence that interventions designed to force non-commercial outcomes are effective. Given that they are more likely to constrain rather than increase incentives for exploration and new supply, they would impede the development of more efficient gas markets and should be considered only where there is clear market failure" (Department of Resources Energy and Tourism, 2012).

Natural gas is used as an input to production in many industries such as non-ferrous metals, basic chemicals, plastics, pharmaceuticals, paints and chemicals (NIEIR, 2012). For these transformative industries to continue operating, reliable and competitively priced access to electricity, feedstock coal, gas and petroleum is imperative (Department of Resources Energy and Tourism, 2012).

In the current situation, pricing uncertainty and the inability to obtain forward contracts is creating uncertainty in the market and stalling investment decisions regarding the development of additional chemicals and plastics plant capacity. While such industries are expected to continue to operate, such conditions are likely to place the industry under continued pressure (Department of Resources Energy and Tourism, 2012).

Most parties agree there is a need to identify the best use of natural gas to ensure the benefits of this valuable natural resource can be realised. The matter of access to natural gas has been highlighted many times by industry participants through the course of this research project. It is likely to stay high on the chemicals and plastics industry agenda for some time to come.

3.3 Food For All

World population growth and world economic growth are two fundamental drivers that will see increased demand for food in coming decades. Whilst demand is growing supply is constrained. The amount of agricultural land is shrinking and pressures on scarce water resources are intensifying. It would seem that demand is outstripping supply.

In recent years supply and demand forces have caused global food prices to reach their highest levels on record. Prices remain high and volatile. Most forecasts suggest that food prices will remain high over the next ten years. Today over one billion people are hungry and many countries face severe food insecurity which is linked with economic and political instability.

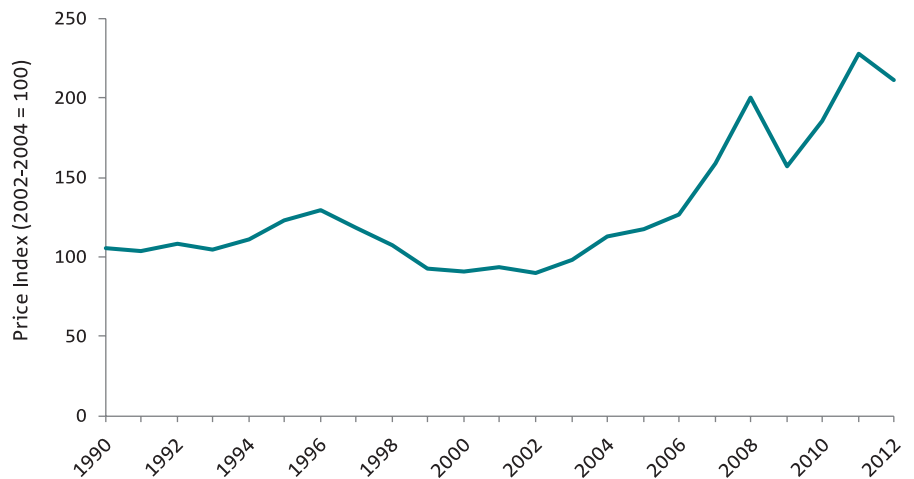
The possibility of continued high food prices, driven by enduring supply and demand forces, and a political spotlight on food security is likely to create growth opportunities in the food and agriculture sectors. This will have spill-over impacts on the chemicals and plastics industry. In particular there may be opportunities in the areas of food packaging, fertiliser, herbicide, pesticide and food additives.

Price volatility. The Food and Agriculture Organisation (FAO) Food Price Index is a measure of the change in international prices of a basket of food commodities (FAO, 2012). It consists of the average of five commodity group price indices (including meat, dairy, cereals, oil and fat and sugar) weighted by the average export share of each of the groups in the base year (FAO, 2012). In 2008 and 2011 global food prices surged to levels higher than experienced for the past thirty years (Figure 18). In February 2011 FAO Food Price Index reached an all time high of 238 points.

Higher food prices. There are approximately 1.02 billion undernourished people globally (FAO, 2009). For many countries between 25 to 50 percent of the household budget is allocated to food expenditure (OECD & FAO, 2012; World Bank, 2012b). Where a significant proportion of income is devoted to food expenditure, food price increases mean that expenditure will be reallocated away from other goods and services necessary for economic growth (OECD & FAO, 2012). Food price



Figure 18. FAO Food Price index



Source: The United Nations Food and Agriculture Organisation (FAO, 2012)

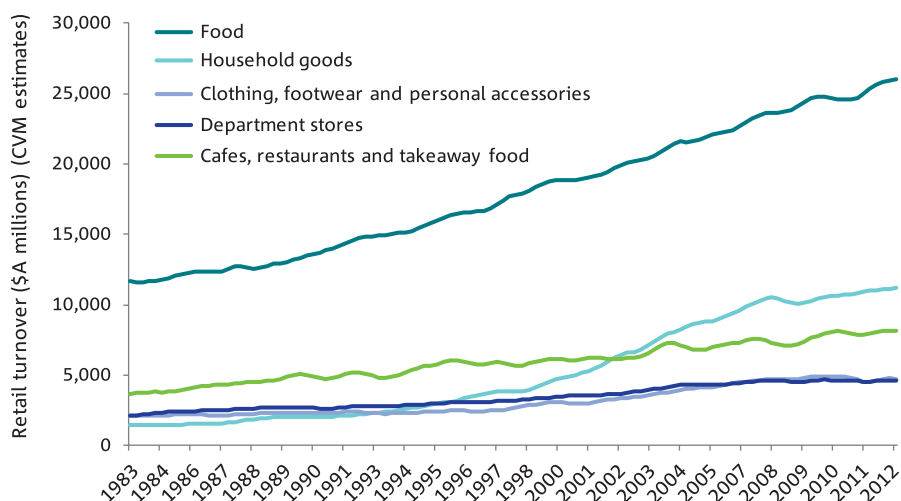
surges throw hundreds of millions of people into malnutrition and are widely considered crises. Food prices are generally considered likely to rise into the future (World Bank, 2012b). For example, forecasts by the FAO and the Organisation for Economic Cooperation and Development (OECD & FAO, 2011) estimate world wheat and rice price rises of 14 and 35 percent by 2020.

The drivers of higher food prices.

The increase in food prices is expected to be driven by gradually improving macroeconomic conditions, stronger demand for agricultural products, growing biofuel demand, higher input costs of fertiliser and chemicals and resource pressures on water and land availability (OECD & FAO, 2012; World Bank, 2012b). High and rising energy prices are likely to place further upward pressure on food prices (World Bank, 2012b). Energy markets are linked to food markets via biofuel production which consumes scarce land, water and labour resources that would otherwise be used in agriculture. Oil is also a major input production factor for modern agriculture and is to power machinery and for fertilisers. Weather events have a significant impact on yield variability (OECD & FAO, 2012). Global agriculture is becoming increasingly linked to energy markets (OECD & FAO, 2012). Higher oil prices are a key driver behind the high commodity price projections given its links to both oil-related production costs and the increasing demand for biofuels and agricultural feedstocks used in their production (OECD & FAO, 2012).

Growth in food turnover dominates the Australian retail sector. The retail sector has been under pressure in recent years with negative growth in turnover for department stores, clothing, footwear, personal accessories and household goods. The two sectors with strong positive growth include food retail and cafes/restaurants (ABS, 2013b). A longer term view – since 1982 – provides a clearer indication of the extent to which food retail turnover has grown compared to other retail sectors (Figure 19).

Figure 19. Trend estimates for quarterly turnover in the Australian retail industry



Source: Australian Bureau of Statistics (ABS, 2013b)

Note: Prices are quarterly chain volume measures which measure the change in value after the direct price effects of price changes have been eliminated. Hence changes in CVM prices reflect only volume changes. Prices are expressed based on the prices of the previous year.

Increased global food demand.

Based on assumptions about population growth, changing diets and agricultural systems the FAO (2011) forecast that food production needs to increase by 70 percent by the year 2050 to meet demand. This includes growth in annual cereal production from 2.1 billion tonnes to 5.1 billion tonnes and meat production from 200 million tonnes to 470 million tonnes (Stefan Hajkowicz et al., 2012b) (FAO, 2009). Whilst this is occurring the world loses 12 million hectares of productive agricultural land, capable of producing 20 million tonnes of grain, each year to land degradation (UNCCD, 2011). Given these resource constraints, increasing productivity will be crucial to containing food prices and reducing global food insecurity (OECD & FAO, 2012). In addition to rising food demand, diets are shifting. People in developing countries are, on average, increasing meat consumption at the rate of 5 percent per year with expectations of future growth ahead (FAO, 2003). Diets are shifting towards greater consumption of processed foods, fats and animal protein, driving the demand for higher value meats and dairy products, and indirectly the demand for coarse grains and oilseeds for livestock feed (FAO, 2011; OECD & FAO, 2012). Fish production is one of the fastest growing sources of animal protein and world

fisheries and aquaculture production are expected to grow by 15 percent from 2012 to 2021 (OECD & FAO, 2012). Although food prices eased slightly in 2011, the global food demand and supply remains in tentative balance. Demand and supply forces are likely to keep prices high in coming decades due to:

- ◆ Population growth;
- ◆ Rapid income growth in developing Asia;
- ◆ Changing dietary preference towards high protein foods;
- ◆ Rising demand and costs of energy leading to increased agricultural production costs; and
- ◆ Increasing biofuel production.

Australia and global food demand.

The Australian agri-food industry is a significant player in world trade for several agricultural commodities and in 2010-11 the value of food exports was \$27.1 billion (DAFF, 2012a). The outlook for the domestic agri-food industry is positive: the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) expects significant demand for Australian exports, especially beef, wheat, dairy, sheep meat and sugar, by 2050 (Linehan et al., 2012). Demand for these products will primarily come from China (beef, wheat, sheep meat and sugar) and India

(dairy products) (Linehan et al., 2012). In the National Food Plan, the Australian Government acknowledged the capacity of the Australian agricultural sector to not only meet domestic food demand but to make substantial contributions towards ensuring global food security, with a particular focus on Asia (DAFF, 2012b). To support future growth in the Australian agricultural industry, the National Farmers' Federation launched the Blueprint for Australian Agriculture. This blueprint aims to ensure the agricultural sector can deliver a strong and sustainable future given identified future challenges that may threaten this ability (NFF, 2013).

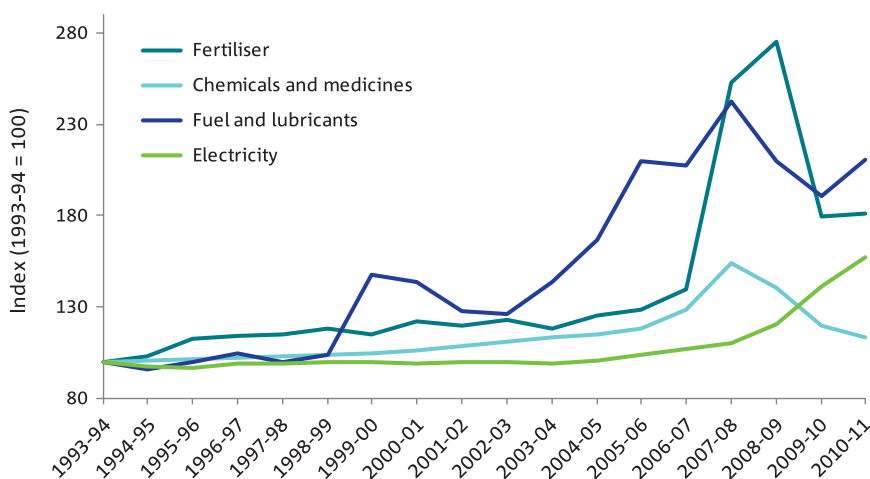
Nutrition transition. Globalisation and increased spending power is changing dietary preferences (Frost & Sullivan, 2012a). In developing countries, the most popular source of protein, for example, is from plants whereas in developed countries, protein is mainly derived from animal protein (Grigg, 1995) and high-income societies generally have a diet high in total fat, cholesterol, sugar and other refined carbohydrates and low in polyunsaturated fatty acids and fibre (Popkin, 2012). An estimated two billion people are expected to have joined the

middle income class by 2030 (Wilson et al., 2008), drastically changing the types of food demanded.

Increases in key agricultural input prices. A key contributor to the rise in food prices has been the rise in the prices of inputs to agriculture. This includes fuel, chemicals and fertilisers in particular (Stoeckel, 2008; World Bank, 2012b). Rising energy prices are also driving food price increases, particularly that energy is an input itself to the farming process and an input into the production of other inputs such as fertilisers (World Bank, 2008). During the 12 months prior to 2008, the World Bank (as cited in Stoeckel, 2008) attributed approximately 15 percent of the rise in food prices to the effect of higher energy prices on agricultural inputs. The cross price elasticity from energy to agriculture is approximately 2.0, so a 10 percent increase in energy prices would result in a 2 percent increase in food prices (Baffes, 2007; IEA, 2011b). Other short term drivers of price volatility include weather events, trade barriers in response to rising food prices and speculation by investors trading in the food commodities derivatives markets (Frost & Sullivan, 2012a).

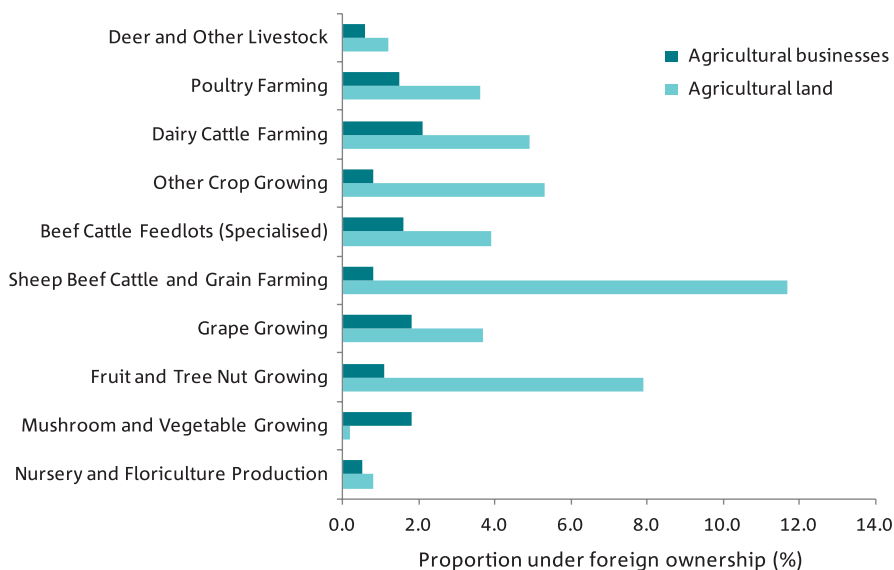
Foreign ownership of Australian agricultural land. Higher international food prices are driving global interest in investment in agriculture (Moir, 2011). Of Australia's 398 million hectares of agricultural land, 11.3 percent is under some level of foreign ownership (ABS, 2011a). Only 1 percent of agricultural businesses in Australia had some level of foreign ownership (ABS, 2011a). Although official data is limited, anecdotal evidence suggests that interest in investing in Australian agriculture is coming mainly from investors from Europe, North America, the Gulf States and Asia including China (Moir, 2011). Although Australian agricultural land is expensive relative to similar land in developing countries such as Africa, Brazil, Pakistan, Cambodia and Kazakhstan, Australian investment offers advantages over these countries (Moir, 2011). Australia already has existing trade links with some Asian countries, there are well developed markets for farm inputs and transport and communications, skilled labour is readily available and sovereign risks are low under a stable government (Moir, 2011). Such aspects make Australia more attractive to investors compared to other countries with similar land resources (Figure 21).

Figure 20. Index of prices paid by farmers for selected inputs in Australia



Source: Australian Bureau of Agricultural Resource Economics and Sciences (ABARES, 2011)

Figure 21. Foreign ownership of Australian agricultural land and agricultural businesses in 2010



Source: Australian Bureau of Statistics (ABS, 2011a)

Growing demand in the fertiliser industry. Australian agricultural productivity is already thought to be slowing (T. Ryan, 2010) and is likely to be worsened by valuing greenhouse gas emissions, rising irrigation prices and decreasing irrigation availability (Keating et al., 2010). As the world becomes richer, bigger and hungrier, fertilisers will play a key role in ensuring productivity and sustainability of the industry (IBISWorld, 2012d; T. Ryan, 2010). Without fertiliser, it is estimated that agricultural production in Australia would decline by approximately 20 percent in the broad acre cropping industries and by two thirds in the grazing industries (T. Ryan, 2010). By increasing crop productivity, fertilisers help reduce the need for land-use change which is a major contributor to greenhouse gas emissions (ICCA, 2009). Approximately five to six million tonnes of mineral fertiliser is used each year, approximately half of which is imported (IBISWorld, 2012d). Fertilisers are essentially a global commodity and given Australia's heavy reliance on imports, any global price changes will have a significant and far-reaching effect (IBISWorld, 2012d).

Alternative sources of fertiliser inputs. While fertiliser use is increasing, reserves are being progressively depleted. This is particularly problematic for phosphorous. Diets are trending towards more phosphorous-intensive

meat and dairy based foods, however world reserves are being progressively depleted and production costs are increasing (AIHW, 2012a). Phosphorous can, however, be captured from waste streams and recycled as a form of renewable fertilisers as this element does not decompose (AIHW, 2012a). As demand keeps rising and reserves are depleted, it is likely that alternative sources of fertilisers will need to be exploited to meet demand.

Need for increased efficiency of fertilisers. Although fertiliser is able to increase productivity and crop yield, there is scope to improve the efficiency of fertilisers, both in the manufacturing process and the take up rate by the plants. The manufacturing process is energy-intensive and if fertilisers are not used by plants, they can convert to greenhouse gases (SRI International, 2011). Such nutrient use efficiency is problematic particularly for nitrogen fertiliser as 50 to 70 percent of the applied nitrogen may not be taken up by the plant (OECD & FAO, 2012) and can convert into nitrous oxide (SRI International, 2011). Approximately 70 to 75 percent of phosphate fertiliser is not immediately available to the plant as it becomes bound in the soil and is gradually absorbed by the plant over time (OECD & FAO, 2012).

Opportunities in crop protection. Crop protection also plays a significant role in increasing crop production. Crop protection encompasses the use of herbicides, insecticides and fungicides. Between 26 to 40 percent of the world's potential crop production is lost to weeds, pest and diseases but this is half the expected loss if no form of crop protection was used (OECD & FAO, 2012). This industry faces conflicting pressures, on the one hand to increase agricultural productivity but on the other hand downstream users are facing growing environmental pressures to reduce the use of chemicals (Frost & Sullivan, 2009b; IBISWorld, 2012e). Despite this, the market for crop protection is expected to grow as it is a key enabler of increased crop productivity in light of increasing food demand (Frost & Sullivan, 2009b; IBISWorld, 2012e).

Continued growth in packaged food. As world trade expands food transportation is also on the rise. The global packaging industry is expected to grow from US\$670 billion in 2010 to US\$820 billion by 2016 (Smithers Pira, 2012). Looking forward, food, along with healthcare, is expected to continue to be the largest end user of global packaging (Smithers Pira, 2012). Plastics and chemicals play a key role in the food industry via packaging. Over 50 percent of food goods are protected by plastic packaging (PACIA, 2008). By extending the shelf-life of perishables, plastics and chemicals contribute to net savings of product, materials and resources (PACIA, 2008). Plastic packaging also has a significantly lower weight compared to other packaging materials, resulting in a lower overall carbon footprint even though it has a higher production footprint per kilogram of material (ICCA, 2009).

Increasing consumer awareness.

Consumers are becoming increasingly aware of the packaging that comes with the food product. Packaging must balance food protection with energy and material costs, heightened social and environmental consciousness and regulations on pollutants and disposal of waste (Marsh et al., 2007). A survey of Australian consumers highlighted the consumer preference for a decrease in the amount of packaging used in the food industry due to environmental concerns (Lea et al., 2008). These environmental concerns have are influencing producers to reduce the amount of packaging by using lightweight materials (WPO, 2008). There is also a growing focus on recycling and better waste management of these packaging products (Hopewell et al., 2009) in addition to exploring biodegradable packaging options (Mahalik et al., 2010).

Consumer preferences. Changing consumer tastes are also altering the types of goods bought. For example, there has been a rise in the sales of bottled water, fruit juice and milk drinks as consumers become more health conscience (WPO, 2008). The rising incidence of smaller households is expected to lead to increasing demand for convenience sized meal with smaller pack sizes (WPO, 2008). So while environmental concerns are influencing the packaging sector, an increasing amount of food sold in groceries is packaged. Changing and conflicting consumer preferences, whether based on sound facts or otherwise, will continue to be a challenge for the chemicals and plastics industry.



3.4 Responsible Industry

The boundary of the contemporary business has expanded. There are increasing legal requirements and social expectations that business now accounts for its impact on society and the environment. Investors are requesting triple bottom line information and companies are reporting on their social and environmental impacts more than ever before. These trends could be viewed as additional cost or liability to business. Alternatively, the rise of green chemistry and options to differentiate based on a product's green credentials could be viewed as an opportunity to add strategic value. Regardless, the forecast increased investment in cleantech, green chemistry and biorefineries has the potential to drive a paradigm shift in the chemicals and plastics industry. This will present opportunities for the industry to develop new services and products in an increasingly responsible and green industry.



The low carbon economy. The widespread acceptance of anthropogenic climate change has led to worldwide development and implementation of policy initiatives, roadmaps and market based mechanisms to address carbon emissions. Europe has been particularly active in promoting investment in cleantech and the European Commission is currently developing a roadmap for the transition to a low carbon economy in 2050 (Foxon et al., 2010) (European Commission, 2011). In particular, Germany has demonstrated

global leadership in investing in clean technologies, with plans to increase its reliance on renewable energy as it phases out nuclear generation. In addition to driving energy efficiency and the transition to a low carbon economy, it will also contribute to the German economy and generate new jobs (Lee, 2012; Nicola, 2012). From 1 July 2012, the Australian Government implemented a price on carbon. To assist Australia's transition to a low carbon future, the Government has implemented a clean energy plan. This provides \$1.2 billion to support energy efficiency for manufacturers and \$13 billion for renewable energy (Australian Government, 2012).

Investment in cleantech continues to grow at a rapid rate. The global cleantech market in solar photovoltaics (PV) was valued at \$2.5 billion in 2000 and \$71.2 billion in 2010 (Chowdhary,

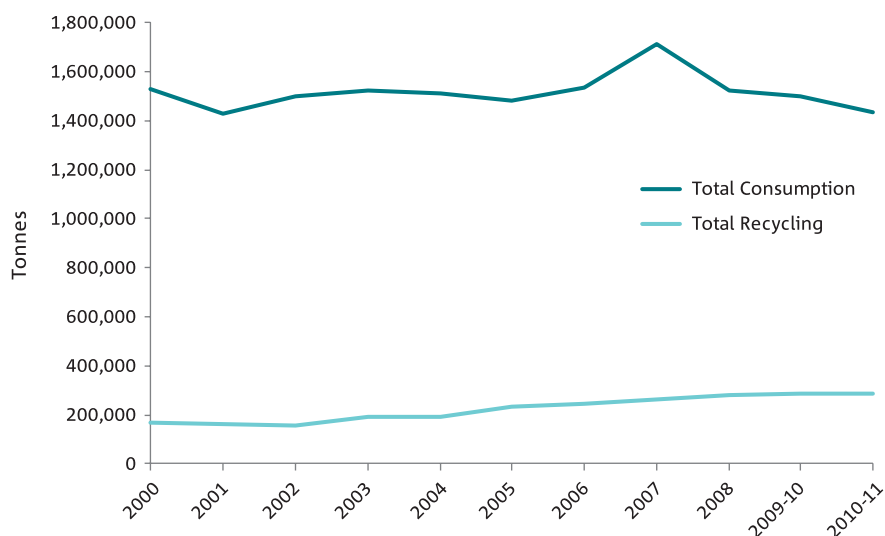
2012). The market for solar PV, wind and biofuels is forecast to double from \$188.1 billion in 2010 to \$349.2 billion in 2020 (Chowdhary, 2012). In addition, Ernst & Young's annual global survey (over 300 corporations, across all sectors) shows an expected increase in cleantech R&D investment. At least three quarters of the large international corporations plan to significantly increase their budgets between 2012 to 2014 (Ernst & Young, 2011).

The chemicals and plastics industry is energy intensive. For example; plastics SME's operate in a trade exposed market with tight margins using electricity equating to between 2 to 18 percent of input costs (PACIA, 2008). Traditionally, part of Australia's competitive advantage has been underpinned by access to low cost energy (PACIA, 2008). Increases in energy costs and resources will impact on business profitability.

Potential to reduce greenhouse gas emissions. While the chemical industry might be energy intensive, it is also an important producer of products and services that work to reduce greenhouse gas emissions (PACIA, 2011c). It has been estimated that for every unit of greenhouse gas emitted through chemical industry production, the resulting products enable savings of 2 to 3 units (ICCA, 2009). The biggest levers that enable these savings include insulation materials, chemical fertilisers and crop protection and advanced lighting solutions (ICCA, 2009). This places the chemicals industry in a unique position, as the products it enables and produces are an important part of contributing to a low carbon economy.

Room for greater recycling of plastics. Plastic waste is a global problem. While up to 10 percent of human solid waste is plastic, plastic comprises up to 80 percent of the waste that accumulates on land, shoreline, the ocean surface or seabed (D. K. Barnes et al., 2009; Joyce et al., 2012). Furthermore, plastic is estimated to persist in the environment for hundreds or thousands of years and while the size of plastic waste is decreasing, the impact of microscopic sized plastic waste on organisms and our environment is largely unknown (D. K. Barnes et al., 2009). In recent years, Australian plastic consumption has dropped slightly while recycling rates have increased (Figure 22). Around half of the plastics collected are processed in Australia, to make new products, with the remaining half exported for reprocessing (Sustainable Resource Use Pty Ltd, 2011).

Figure 22. Australia's plastic consumption and recycling rates, 2000-2011



Source: Sustainable Resource Use Pty Ltd (2011)

Regulation and information on chemical pollutants. In developed countries the chemical industry is highly regulated. In the USA and Australia, chemical pollutants and emissions are made publically available. The USA has a Toxics Release Inventory (TRI) program which has been running since 1998 (ACC, 2012). It contains information on around 650 toxic chemicals from US facilities. Australia has a similar program to the US TRI, the National Pollutant Inventory, which tracks 93 substances that may negatively impact human health and the environment. This information is made publically available through the Department of Sustainability, Environment, Water, Population and Communities.

In California, Proposition 65 has been law since 1986. Its goal is to protect drinking water and consumers from toxic chemicals that are known to cause cancer or reproductive and birth defects (OEHHA, 2007). Proposition 65 requires that products containing chemicals listed under the proposition, to be appropriately labelled. The list of chemicals is updated annually and currently contains around 800 chemicals. The Californian law does not prohibit the sale of goods containing listed chemicals, it ensures they are at safe levels and that products are clearly labelled. Since its enactment, this law is credited with driving the reformulation of consumer products to eliminate toxic chemicals, in addition to changes in toxic emissions.

In 2007 the European Commission introduced the Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH). It requires

manufacturers and importers to provide information on the properties of their chemicals (European Commission, 2012). The UK Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) impacts electronic product manufacturers, who need to comply with restrictions or bans of dangerous chemicals in their products (Hatti-Kaul et al., 2007). Many countries have since implemented their own RoHS; China, Japan, Korea & Norway. All of these regulations demonstrate the demand for increased transparency of chemicals in products, information regarding their impact on human health and the environment, and information on chemical facility releases.

An imperative for effective governance.

The significance of the chemicals and plastics industry to the economy poses challenges and creates a need for effective governance. On a global and local scale, inefficient regulation can have costly implications for the environment, human health, government budgets and the growth of this industry (OECD, 2010). Different regulatory approaches and requirements across countries have the potential to create significant costs, create barriers to trade and distort decisions in downstream industries (OECD, 2010). Such ramifications create an imperative for effective governance. For example, in the case of greenhouse gas abatement, approximately two thirds of the industry's abatement potential is in the developing world (ICCA, 2009). To realise these emission savings potential though, regulations need to place industry participants on a level playing field while still recognising the regional

strengths and differences of industry players (ICCA, 2009).

A new platform for consumer communication. Information sharing via social media has enabled individual consumers to harness a new and powerful communication ability (Mangold et al., 2009). By providing an open and accessible tool for communication, consumer expectations can be more clearly communicated (Heinonen, 2011). This is enabling consumers to collectively influence how industry operates both positively and negatively. As a result, consumer expectations are likely to be a more significant driver of how companies and industry operate given this emerging platform.

Impact of operations on the environment. The importance of the environment to government and the public is increasing. This places pressure on the chemicals and plastics industry. It has been estimated that the environmental impact of the chemicals sector in 2010 was US\$43 billion, accounting for 43 percent of sector earnings (KPMG, 2012). KPMG (2012) also suggests there is likely to be increasing pressure over the next 20 years for the price of resources, products and services to reflect the full cost of their production including environmental impacts. The cost of environmental degradation is high; hence the attraction of green growth. This trend will generate increased investment in green chemistry and green engineering technologies, to assist in reducing the impact of the sector on the environment, in turn addressing social licence to operate.

Pricing ecosystem services. Ecosystem services are the benefits provided by ecosystems such as watershed protection, habitat provision, pest and disease regulation, climatic regulation and hazard protection (Kinzig et al., 2011). Although highly valued by society, these benefits are not often priced into decisions and as a result, markets may not reflect the full social cost of production (Kinzig et al., 2011). However, markets that value these ecosystem services are beginning to emerge. In New South Wales, for example, irrigation farmers pay the state government for access rights to the water and revenue is used for upstream reforestation to reduce water salinity (Kumar, 2005). Given the impact

on the environment, it is likely that the chemicals and plastics industry will have to increasingly factor the impact on ecosystem services into their pricing and investment decisions to reflect the true cost of production.

Public perception of the industry. Information on the UK public opinion of the chemical industry shows a net unfavourable shift year on year between 1979 to 2002 (Johnston, 2012). Historic chemical disasters have contributed to the poor public perception of the industry. One of the most significant was in 1984 in India, Bhopal. At least 3,000 people died and over 500,000 people were injured as a result of a toxic gas leak from a Union Carbide India Ltd pesticide plant (Allen, 2000). In Niagara Falls, the 1978 Love Canal incident forced an entire neighbourhood to be abandoned as a result of toxic chemicals; buried between 1942 and 1953 and subsequently rising to the surface (Hoffman, 1995). Continued media coverage of smaller incidents such as facility leaks, as opposed to the positive contributions of the sector, continues to reinforce the negative public perception of the industry.

A negative public perception ensures that the positive contributions made by the industry to society, remain invisible. That the chemicals industry has a role to play in securing and boosting food production with pesticides and fertilisers, and products that reduce carbon emissions is often lost on the public consciousness (Johnston, 2012).

Social licence to operate. In response to significant global incidents and negative public perception, the chemicals industry has made significant progress on implementing voluntary codes of practice or guidelines for the industry. Responsible Care is an initiative of the international chemical industry to continuously improve the health, safety and environmental performance of the industry and to increase community involvement and awareness of the industry. The USA has the American Chemistry Council's Responsible Care® Program (ACC, 2012) and Australia was the third country to adopt Responsible Care® in 1989 (ICCA, 2012). Responsible Care® is a key program under PACIA's Sustainability Leadership Framework, which focuses on assisting the industry to meet its goals in a range of priority areas including Health and Safety, Community and

Stakeholders, Workforce, Wastes and Security. Voluntary industry standards complement regulation and assist business to adapt to technological and social change (Mallet et al., 2012).

Environmental certification and consumer demand. There has been a proliferation of green certification and labelling over the last 20 years. There is evidence to suggest businesses profit as a result of engaging in standards or certification. This is due to increased market share or more efficient supply chains (Mallet et al., 2012). Consumer demand for ecolabels is growing and according to a 2010 study, more than one-third of US consumers say they are willing to pay more for an environmentally friendly product (Big Room and WRI, 2010). A 2005 survey found evidence to suggest that one-third of consumers favoured environmental packaging as the most important criteria of their packaging selection (Rokka et al., 2008). Some of the noted trends for green certification to 2020 are:

- ◆ concerns about the number of certifications and that certification doesn't guarantee a measurable reduction in impacts;
- ◆ a shift from practice to performance;
- ◆ harmonisation across some standards;
- ◆ governments becoming more involved in certification;
- ◆ many programs moving from niche to mainstream; and
- ◆ China developing its own certification standards and certifications that address large scale issues such as water (Mallet et al., 2012).

Increased transparency from TBL reporting. Company engagement with corporate sustainability and the triple bottom line (TBL) has shifted from being of moral importance, to one that is necessary for companies operating in the 21st century. In 2011, KPMG's survey on corporate responsibility reporting found 95 percent of the top 250 global companies now report on their environmental and social activities (KPMG, 2011c). However, Asia Pacific companies trail behind this global trend with less than half of them disclosing information to the market. KPMG's sector based information found chemicals and synthetics to be reporting at 68 per cent, and pharmaceuticals to have the greatest increase in reporting between 2008 and 2011 (KPMG, 2011c).

Green chemistry is defined as “design of chemical products and processes to reduce or eliminate the use and generation of hazardous substances”

Increased corporate engagement with international sustainability initiatives.

The rise of international, voluntary initiatives and non-government organisations has helped to drive the engagement with social, ethical and environmental standards for businesses. For instance, the UN Global Compact is one of the world’s largest corporate citizenship and sustainability initiatives. Since its launch in 2000, it has grown to over 6000 business participants, from 135 countries around the world (UNGC, 2011).

Reporting on sustainability performance has risen dramatically.

since the first Global Reporting Initiative guideline was released in 2000 (Brown et al., 2009). Thousands of companies now report using the Global Reporting Initiative framework. Many choose to upload their reports to the Sustainability Disclosure Database which currently hosts 11,140 reports from 4,327 organisations from around the world (GRI, 2012b).

Investor interest in social and environmental credentials.

The Dow Jones Sustainability Index was launched in 1999 (RobecoSAM, 2012). It only lists companies that fulfil sustainability criteria and it is highly competitive to be either included in or remain in the index. The Australasian Investor Relations Association latest investor survey, conducted in May 2012, found that investors are requesting more information on a company’s operational impacts and governance (GRI, 2012a). Social and environmental impacts are important considerations for investors and analysts which in turn drives demand for sustainability reporting.

Increased global connectivity and industry collaboration.

The trend of increased global networks, transnational coalitions and global supply chains suggests our future world will be more interconnected. The risks of a more interconnected world are that of international crisis; social and political disruption, and significant climatic disasters. It also leads to a greater awareness of global responsibility (RBSC, 2012). Collaborative R&D is on the rise as companies seek to “do more with less” and leverage their innovation investment (ACC, 2012). Consulting firm ATKearney recently published their 2012 survey of chemical industry executives from USA, Europe and China, split into chemical manufacturers and

the customers that purchase from them. The survey found the majority of respondents expect collaboration across the supply chain to increase over the next five years (ATKearney, 2012).

The growing importance of green chemistry.

The concept of green chemistry was formulated in 1991. This scientific field aims to demonstrate next generation products and processes can be profitable while also being good for human health and without adverse environmental impacts (Anastas et al., 2010). Since then, many scientific programs, research centres and increased government investment have assisted the growth of the discipline. This includes the recently announced \$73 million Australian Green Chemical Futures Centre for research, innovation and collaboration with national and international partners including Monash University, CSIRO, PACIA, the Victorian Environmental Protection Authority with Federal funding from DIISRTE. The Centre, based at Monash University, is due for completion in 2014 (Monash University, 2010).

Green chemistry is defined as “design of chemical products and processes to reduce or eliminate the use and generation of hazardous substances” (Anastas et al., 2010). The most important concept of green chemistry is design, this is reflected in the internationally accepted Twelve Principles of Green Chemistry, such as the prevention of waste and design for energy efficiency (Sanderson, 2011).

Taking green chemistry from research to industry adoption remains a challenge. Industrial utilisation of greener technologies currently represents only a small fraction of worldwide production (Clark, 2006). There still remain technical barriers to overcome, such as identifying efficient green solvent substitutes for chlorinated solvents, eliminating the need to use toxic dosages of metals as catalysts and efficient renewable feedstocks for the development of bulk chemicals (Sanderson, 2011). To overcome these barriers, a facilitated approach is required in order to better connect industry and research. The Cooperative Research Centre for Polymers is the first example of connecting industry with research. It was established in 1992 under the Australian Government’s Cooperative Research Centres program and facilitates collaborative research

between companies, university, and government research organisations (CRC for Polymers, 2013).

The Victorian Centre for Sustainable Chemical Manufacturing (VCSCM) is another example of the connection between industry and research. VCSCM was established in 2012 and is a joint government, research and industry partnership between Monash University, CSIRO, PACIA and Victorian Environmental Protection Authority with funding from the Victorian Government Department of Business and Innovation (PACIA, 2012c). The partnership aims to support ties between manufacturers and researchers and assist industry to evaluate and deploy more sustainable manufacturing processes in order to capture the benefits of green chemistry (Monash University, 2012).

Alternative feedstocks and biorefineries. Increasing prices of raw materials and petrochemical feedstocks serve to encourage industry to investigate alternative feedstocks. For example, phenol's price tripled in 2004, largely due to rising oil prices and industry expansion in Asia (Clark, 2006). Alternative bio feedstocks include agricultural or forestry products or waste residues (Hatti-Kaul et al., 2007). The move from petrochemical to bio feedstocks is a paradigm shift for the chemicals industry and industrial biotechnology is one of the key technologies needed to process bio-based feedstocks into biofuels, bioenergy and biomaterials (Ragauskas et al., 2006). An example of an already economically viable process is the production of polylactic acid (used in food packaging and apparel) from corn dextrose in the USA, Europe and Japan (Ragauskas et al., 2006). A report by Pike Research (2012) forecasts global investment of \$170 billion in biorefineries between 2012 to 2022. Future investment will predominantly be in USA, Europe and Brazil.

3.5 Health and Wellbeing

Fuelled by an ageing population and changing consumer preferences healthcare expenditure is rising rapidly and is set to continue rising over coming decades. There is also an Australian and worldwide increase in the rates of chronic and lifestyle-related illness. This will have mostly demand side implications for the chemicals and plastics industry as a supplier of inputs into the health industry. There may emerge opportunities to supply products into niche sectors of the healthcare and pharmaceutical industry in both domestic and global markets.



Ageing population. Fourteen percent of the Australian population is currently over 65 years of age (ABS, 2012a). This is forecast to reach between 22 and 24 percent by the year 2050 (ABS, 2008).

New opportunities with an ageing population. Ageing has many biological changes which present both opportunities and challenges for the chemicals and plastics industry. Recovering from injuries and illness occurs more slowly, toxins are metabolised at a slower rate and general resilience decreases (Carstensen et al., 2012). Traditionally, medical science has focused on cures for acute diseases rather than the prevention of chronic diseases that develop over years (Carstensen et al., 2012). As a key input into the pharmaceutical industry, the chemicals industry faces new opportunities and challenges to

maintain the quality of life of an ageing population.

Longer lifespans. Life expectancy for Australians continues to rise (ABS, 2008). In 1900 males lived for 51 years and females lived for 55 years on average. By 2006, life expectancy at birth was 79 and 84 years respectively. Government projections forecast these life expectancies increasing to 84.5 and 87.8 years by 2030 and 87.7 and 90.5 years by 2050 (Australian Treasury, 2010). Increasing lifespans will see an increase in the number of surgical procedures (Frost & Sullivan, 2012b) and thus an increase in a range of surgical and medicinal inputs on behalf of the chemicals industry.

Maintaining quality of life. As lifespans increase, so will the demand to retain a high quality of life for prolonged years. As such, focus is shifting away from treatment towards preventative expenditure (Frost & Sullivan, 2012b) as the population becomes increasingly focused on maintaining quality of life. Demand for nutricosmetics, nutritional supplements for the function and structure of the skin, is increasing as the ageing population seeks to maintain good health (Frost & Sullivan, 2012b). Some of the chemicals used in these products include collagen, vitamins, omega-3 and carotenoids (Frost & Sullivan, 2012b). Joint replacements and treatment for other degenerative conditions is likely to increase and drive demand for the chemical inputs in these surgeries (Frost & Sullivan, 2012b).

Increased government health expenditure. The ageing population means that a larger proportion of people will fall into the older age groups that are the most frequent users of the health system. From 2009-10 to 2049-50, real health spending is expected to increase by around seven-fold for the over 65 age group and by about twelve-fold for the over 85 age group (Australian Treasury, 2010). As a result, Australian Government health spending as a percentage of GDP is expected to rise from 4 percent in 2009-10 to 7.1 percent in 2049-50 (Australian Treasury, 2010).

Increasing demand for pharmaceuticals. The consumption of pharmaceuticals is increasing across OECD countries (OECD, 2011). The demand for pharmaceuticals varies directly with the age of population (IBISWorld, 2012f). However the rise in consumption is also occurring in countries with younger populations, suggesting physicians' prescription habits are also changing (OECD, 2011). As prescriptions increase, there are concerns surrounding the interaction of prescribed medications. A study in the United States revealed that 17 to 19 percent of adults took at least 10 medications per week in 2006 (Sloane Epidemiology Center, 2006). This raises concerns regarding the potential interaction of multiple medications and the potential adverse side-effects (D. Ryan et al., 2012). Australia is a net importer of pharmaceutical products (IBISWorld, 2012b).

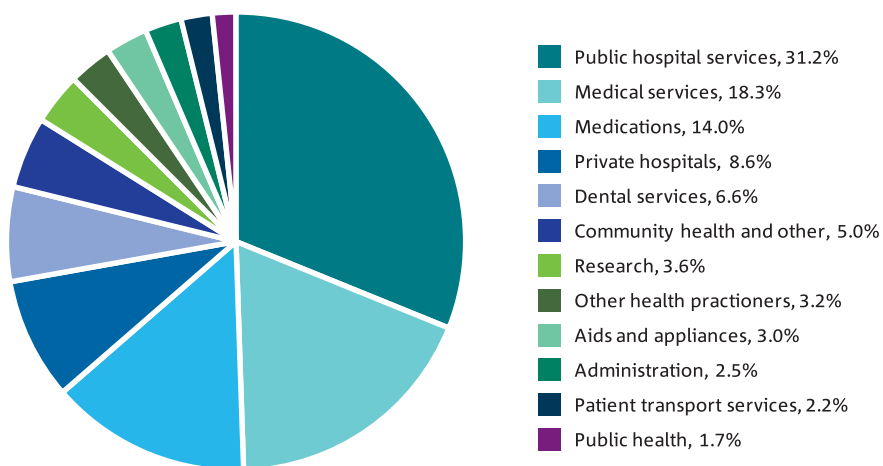
Increasing expenditure on medication.

The number of prescriptions has increased by 51.1 percent from 1996 to 2010 (AIHW, 2012b). The most commonly supplied medicines were for reducing blood cholesterol, lowering stomach acid, lowering blood pressure and antibiotics (AIHW, 2012b). Expenditure on medications accounted for 14 percent of total spending on health goods and services in 2009-10 (Figure 23). As the chemicals industry is a major upstream industry of pharmaceuticals, the rise in medications is likely to be a key driver of demand.

Health R&D expenditure. In 2008, Australian health R&D expenditure was estimated to be 1.1 percent of the global expenditure on health R&D (Access Economics, 2008). However, the global world health returns attributable to Australian R&D is estimated to be 3.04 percent (Access Economics, 2008), highlighting the contribution that Australia makes in this area.

Biofortification of crops. Biofortification aims to increase the density of minerals and vitamins in widely consumed food staples (Bouis et al., 2011). Over 50 percent of the world's population suffer from micronutrient deficiencies of iron, iodine, selenium, zinc, vitamin A and folic acid (Welch, 2005). Given that micronutrients assist in the normal bodily functions (Bhullar et al., 2012), reducing the incidence of micronutrient malnutrition can have significant health impacts. Although micronutrient malnutrition is more common in developing countries, developing countries are not exempt. The most common nutritional disorder worldwide, iron deficiency, affects approximately 2 billion people or 30 percent of the world's population (WHO, 2012). Biofortification has the potential to improve the nutritional content of staple crops and improve consumption of necessary micronutrients. To date, there has been limited adoption in Australia (AIHW, 2012a) however this does not discount a future potential role for Australia in research and development.

Figure 23. Spending on health goods and services in 2009-10



Source: Australian Institute of Health and Welfare (AIHW, 2011)

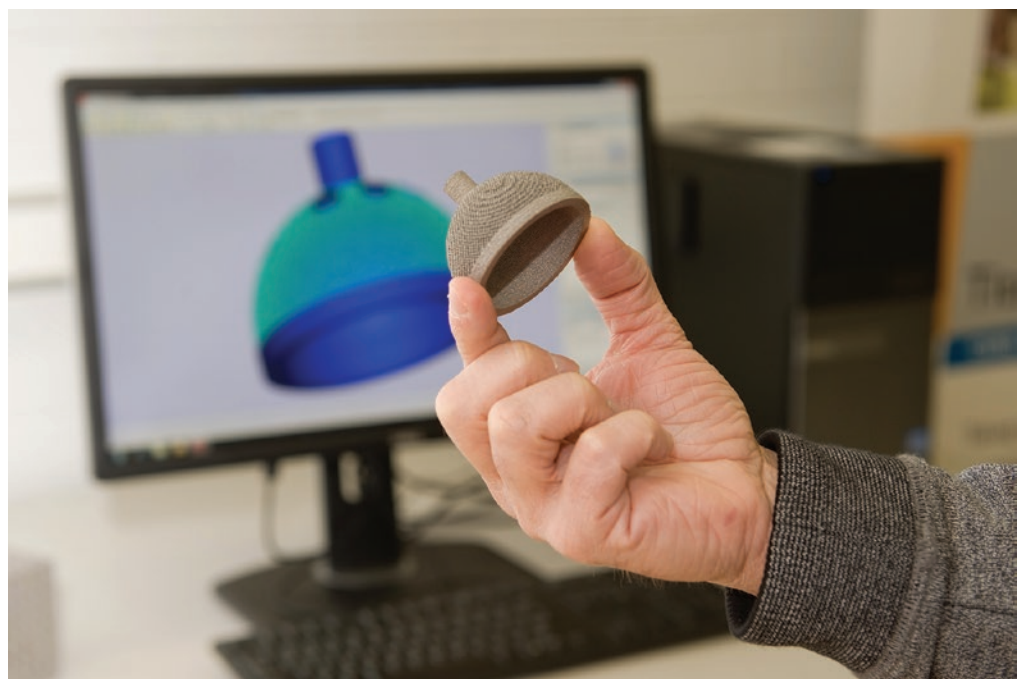
Growing opportunities in cosmetics. The cosmetics, perfume and toiletries manufacturing industry is relatively small, accounting for 3 percent of Australia's chemical manufacturing sector (IBISWorld, 2012c). A large number of cosmetic products are imported, reflecting the global nature of this industry (IBISWorld, 2012c). The push to reduce the carbon emissions has prompted a move towards the use of biodegradable packaging (IBISWorld, 2012c). On a global scale, healthcare packaging is expected to grow at 4.5 percent per year to reach \$34 billion in 2016 and cosmetics packaging is forecast to grow at 4.2 percent per year over the same time period (Smithers Pira, 2012).

A preference for the natural. Natural or organic products have been an area of recent development in the production of cosmetics, perfume and toiletries (IBISWorld, 2012c). A rise in ethical consumption has essentially made these 'green' products mainstream (IBISWorld, 2012c). Production processes are being altered to meet demand for products that are free from chemicals such as parabens, sulphates, GMOs, phthalates, and artificial preservatives (IBISWorld, 2012c). The demand for green products also extends to cleaning products and is influencing the chemicals inputs used in these products (IBISWorld, 2012a). This trend has been growing for the past five years and is affecting both inputs to the production processes and the production process itself towards more sustainable products and consumption (IBISWorld, 2012a). As a result of these environmental concerns, it is expected that growth opportunities will be based on green production (IBISWorld, 2012a).

3.6 Technological Advances

Disruptive technologies are, by definition, hard to see coming. Yet the disruptive technologies of the future will undoubtedly have a transformative effect on the way businesses operate and people live. According to a report published by the Economist Intelligence Unit (2012), the rate of technology disruption is likely to continue to increase over the coming decade. Many of the disruptive technologies will require innovative inputs from the chemicals and plastics industry. Additionally, disruptive technologies from outside the industry may facilitate more efficient processes and new business models within the industry.

In this section five emerging technologies are highlighted that are likely to present opportunities for the chemicals and plastics industry. By emerging technology we mean technologies that are emerging from the science base that are at a pre-commercial or early commercial stage that have the potential to be transformative. Most of these technologies have been known for some time, but still offer vast unexplored potential.



Part of a hip prosthesis made using the Arcam process, in front of a screen showing the computer-aided design for the implant

Electronic devices that can bend and fold. Flexible electronics refers to electronic devices on thin, flexible plastic substrates. Intense research into this technology has been driven by the possibility of creating light, robust, cheaply manufactured devices that can be used for a wide variety of applications. While rudimentary flexible electronic components have already made their way into simple applications such as toys, there is likely to be rapid growth as the application of this technology broadens. Indeed some analysts consider flexible electronics still to be at the embryonic stage, and forecast the global market to reach US\$25.9 billion by 2018 (GIA, 2012).

Flexible electronics in a variety of applications. The use of flexible electronic components has initially focused on thin film photovoltaics, organic LEDs and e-paper displays. Future growth is predicted for thin film transistor circuits, sensors and batteries (Das, 2011). Applications such as smart bandages that monitor vital signs, aerospace sensors, and large, foldable screens are being investigated (Nathan et al., 2012).

An opportunity for the chemicals and plastics industry. Flexible electronics require new functional and substrate materials that overcome the problems of poor air stability and low carrier mobility. Importantly, such materials

must be compatible with the low-cost production methods, such as low temperature deposition and solution printing methods, representing opportunities for innovative chemicals and plastics businesses.

Energy storage drivers. Whilst electricity storage technology has been the subject of research for over 150 years, a new wave of drivers has seen an escalation of activity in this area. These drivers include increasing demand for energy, technological advancements such as smart grids, deployment of renewable energy, and electric vehicle use. It is estimated that revenues earned by the large scale energy storage market will increase from US\$1.2 billion in 2010 to US\$2 billion by 2017 (Frost & Sullivan 2011). High energy density power systems were listed as one of the top ten emerging technologies for 2012 by World Economic Forum's Global Agenda Council on Emerging Technologies (World Economic Forum, 2012).

A range of technologies. In response to the variety of applications demanding energy storage technology, we are likely to see adoption of a variety of technologies. Electrochemical energy storage methods are strong candidates for grid applications due to their high energy density, flexibility, and scalability. Two main classes of battery are currently emerging as the most suitable candidates for electric grid applications: liquid electrolyte flow batteries and high-temperature batteries (Parkfomak, 2012). There have been grid demonstration projects involving both types of battery, however newer designs are still at much earlier stages of research and development. Additionally, research efforts are beginning to focus on nanostructured electrodes, solid electrolysis, and rapid-power delivery from novel supercapacitors based on carbon nanomaterials (Lu et al., 2012). The energy storage solutions that are part of our future world will require innovative anode, cathode, electrolyte, membrane and packaging materials from the chemicals and plastics industry.

Electric vehicles. The chemicals and plastics industry will have a role to play in powering new vehicles. Options being aggressively explored include the use of hydrogen in fuel cells to power electric motors or being cleanly burned in internal combustion engines, although this technology has not developed past demonstration models. Research

into nanostructured carbons and other nanomaterials which absorb molecular hydrogen, increasing the ease of transportation and storage, is promising (Gary, 2012).

Building objects layer by layer. Additive manufacturing, also known as 3D printing or direct digital manufacturing, is the process of building objects layer by layer from 3D model data. Although this technology has been in existence for more than a decade, its implications for large-scale manufacturing, where it is likely to complement existing manufacturing techniques, have only recently become apparent.

Coming years will see "...manufacture for design instead of design for manufacture" (Tim Gornet, University of Louisville). Additive manufacturing is suited to applications that have high design complexity. Problems such as manufacturing internal cavities and complex 3D contours can be overcome, allowing for weight reduction or efficient fluid flow (The Economist, 2012). Custom product applications, such as dental crowns or medical implants, may benefit from this technology as they could be produced economically in low volumes. Additive manufacturing also holds the promise of using less raw material, creating less waste and eliminating the need for re-tooling when compared with subtractive manufacturing technologies (Wohlers Associates, 2011).

Opportunities for chemicals and plastics manufacturers. There are a number of processes available for additive manufacturing including UV resin curing, inkjet technologies, fused deposition modelling, selective laser sintering, electron beam melting, powder based metal processes and laser engineered net shaping (Wong et al., 2012). Such a wide range of production methods support the use of a wide range of base materials including: polycarbonate (PC), acrylonitrile butadiene styrene (ABS), PC-ABS blends, and PC-ISO, which is a medical grade PC, polyphenylsulfone, acrylic styrene and polyamide, polyvinyl alcohol (Wong et al., 2012). Additional functionality and surface treatments can be added to additive manufactured parts – be they for inclusion in a jet or the human body.

Chemistry in a continuously flowing stream. Unlike batch production methods, flow chemistry involves a chemical reaction run in a continuously flowing stream. Large scale, continuous flow processes have been used by the chemicals industry for some time. However recent years have seen the development of laboratory scale flow chemistry equipment. This equipment may be of benefit to low volume – high value chemical producers, as well as to other manufacturers looking to establish processes in the lab and then scale up to commercial production without substantial alteration in reaction conditions (CSIRO, 2012).

Why go with the flow? Flow processing makes chemical production safer, more reproducible and scalable while offering reduced cost and low environmental impact (CSIRO, 2012). Hazardous substances can be contained; reaction parameters can be better controlled, resulting in secured reproducibility, and importantly can lead to significantly less waste; photochemical, microwave and ultrasonic processes can be incorporated; and multistep synthesis using linearly assembled flow devices can be achieved (J. Wegner et al., 2011a). A selection of commercial flow equipment has come on to the market, and it is believed that this enabling technology will gain a much broader use in the near future (J Wegner et al., 2011b). The chemical technology company Advanced Polymerik has implemented flow manufacturing methods and compared to traditional batch manufacturing processes, found this approach reduced the amount of waste generated by 91 percent, removed all chlorinated waste and doubled yields (PACIA, 2011b).

“Catalysts can make a previously impractical process economically feasible” (American Chemical Society, 2012). Catalysts are materials that improve the rate or selectivity of chemical reactions, and are of significance to the chemical industry: approximately one third of the gross chemical product material involves a catalytic process somewhere in the production chain (Dalai, 2012). Representing a major breakthrough in the catalysis domain, nanocatalysts utilize nanomaterials for homogenous and heterogeneous catalytic reactions. They frequently exhibit better performance than their conventional counterparts and facilitate new reaction pathways. It is estimated that the use of new nanocatalysts could result in cost reductions of up to 70 percent in some chemical manufacturing applications (Frost & Sullivan, 2008).

Nanocatalysts creating alternative feedstocks. There are some commercially well established nanocatalysts, such as industrial enzymes, zeolites and transition metal nanocatalysts. However, a technological shift driven by the need for new energy sources, water depletion, drug delivery and gene therapy has spurred further research into the nanoscale design of catalysts used in novel production processes. Recent research has had some success in demonstrating the creation of polymers from biomass using nanocatalysts - see, for example Torres Galvis et al. (2003) - although this research is at an early stage.

Nanocatalysts – chemicals for a better world. Current research suggests nanocatalysts have a significant role to play in a sustainable future. Scientists recently developed a mineral catalytic converter to remove emissions from diesel engines (Wang et al., 2012). Nanocatalysts have also been demonstrated in water treatment, air purification and disinfection applications (Palaez et al., 2012). Use of nanocatalysts in such applications, in addition to their broader ability to lower energy required for chemical production and in optimising production from existing energy sources, could see nanocatalysts turn out to be one of the most important technological developments for the chemicals and plastics industry in our time.

4 Our methods



To identify megatrends CSIRO Futures draws upon many qualitative and quantitative information sources. The aim is to combine analytic rigour with imagination to inform people's choices.

This study applied both qualitative and quantitative information and has been developed using evidence based research. The information sources include industry reports, academic papers and current affairs articles. Datasets held by the Australian Bureau of Statistics, the Organisation for Economic Cooperation and Development, the United Nations and the World Bank about economic, social and environmental matters have been examined. In addition to the published datasets information was drawn from 26 interviews with industry experts and stakeholders and a workshop with 29 persons in attendance.

4.1 Exploring the Future

The purpose of this study is to inform decisions about the Chemicals and Plastics industry by constructing a narrative about the future. However, the future is not known with certainty. In this study evidence and imagination are balanced to construct a narrative of the future that is both credible and insightful. To achieve this we use the concept of the ‘futures cone’ (Figure 24) to frame the study and identify megatrends.

The diameters of the circles in the futures cone can be considered inversely proportionate to the level of certainty about the future. At the current point in time the circle is a pinpoint because, if we can access accurate data, we have perfect certainty. As we project into the future we have three circles of increasing diameter and decreasing certainty.

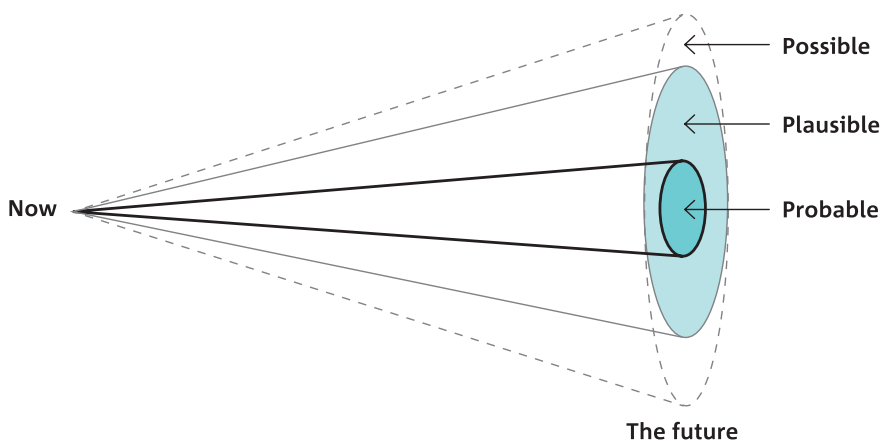
The smallest circle is referred to as the ‘probable’. This relates to future events that can be forecast using historical data series and statistical inference. Predictions of rainfall patterns, population growth and economic growth may fall into this category. Given the limited availability of historic time-series data on many important trends, and the limited ability for statistical forecasting of those data, the probable cone is unlikely to permit novel or insightful descriptions of futures.

The largest circle is referred to as the ‘possible’. This captures every event that could conceivably occur in the future. The problem with working in the possible space relates to credibility. If decision-makers cannot see a solid evidence base they are unlikely to use these narratives when making important choices.

In the centre of the futures cone is the ‘plausible’ space. This moves beyond the narrow, and empirically derived, outcomes in the probable space. However, it avoids the speculative and hard-to-substantiate nature of the ‘possible’ space. The plausible cone is a balance of evidence and imagination.

While probable, plausible and possible futures all have a valid role. This study aims to reside within the plausible space. It means that evidence already exists for each megatrend currently occurring. However, the megatrends are projected to play-out to a greater extent in future decades.

Figure 24. The futures cone



Source: Adapted from Voros (2003) and Hancock et al. (1994).

4.2 Stakeholder interviews

Interviews with key stakeholders were designed to help validate the megatrends. Key stakeholders were identified and contact details provided by the Plastics and Chemicals Industry Association. An email was sent to those identified, inviting them to contribute to the research. If the invitation was accepted, an interview was scheduled at a suitable time and date.

Thirty-eight key stakeholders were invited to participate in the research. Twenty-eight stakeholders agreed to participate, however two were unable to secure a suitable time for the interview. One invitee formally declined to be interviewed, believing their input would be captured from an interview with their colleague. A total of 26 interviews were completed, giving a response rate of 68 percent. Industry stakeholders were the predominant stakeholder group represented however interviews were also undertaken with representatives from government, NGO's and academics/researchers.

Background information was sent to interviewees prior to the interview and consisted of an Executive Summary of the Draft Megatrend Report, a Venn diagram illustrating the links between the proposed megatrends and an outline of the interview questions. Interviews were undertaken via telephone. Some interviews were one-on-one, others were undertaken using a lead interviewer, but with multiple project team members listening and on occasion asking additional clarifying questions.

The style of the interview was conversational, taking between 30 and 60 minutes to complete. Essentially the interviews sought to answer to the following questions for each megatrend and transition pathway:

- ◆ Do you agree that this is a mega-trend?
- ◆ Is there evidence that supports this mega-trend/pathway?
- ◆ Are there any trends not currently covered?

4.3 Workshop

The workshop was held at the Melbourne Museum from 9:30am until 4pm on Tuesday 13 November 2012. A total of 29 persons were in attendance including five CSIRO staff, two representatives from the Australian Government, three staff members from PACIA, two representatives from non-government organisations (NGOs) and the remaining 17 people from private companies. Of the industry representatives attending six people indicated their position as a chief executive officer and the bulk of other people were managing directors or above. The megatrends were largely endorsed at the workshop with important edits and improvements identified.

5 Conclusion

This report documents the current profile of the Australian chemicals and plastics industry and explores future megatrends – major shifts in the social, political and business landscape – over coming decades. The aim is to inform strategic choices about how best to position this vital industry for the future.

The industry profile reveals the critical role chemicals and plastics products fulfil within all industry supply chains and within our day to day lives. On the vast majority of days the vast majority of Australians use a chemicals and plastics product. Many people are unaware of the behind-the-scenes innovative processes and technologies used to ensure high quality products are routinely supplied with sound environmental, health, safety and social performance.

The need for chemicals and plastics products will continue into the future. As technology improves these products may play a greater role in building, construction, energy supply, energy storage and healthcare services. Research is continually identifying new ways that chemicals and plastics products can provide safer, cheaper and reliable functions with reduced carbon emissions and a smaller ecological footprint.

The megatrends presented in this report show that the Australian chemicals and plastics industry faces some major challenges and opportunities in the future. Competition for scarce feedstocks, especially from the energy sector, may push up production costs.

Rapid expansion and scientific research in plastics and chemicals production throughout Asia - and especially in China, India, Singapore and Korea – will make competition tougher in both global and domestic markets. The growth in production in these countries is being matched by fundamental science, research and technology development that will make the overseas industries yet more competitive in the future.

However, growth in Asian markets signals opportunity too. New niche markets may emerge which the Australian industry is well positioned to supply. The continued rise in healthcare expenditure - outstripping other areas of government and household expenditure - is likely to continue over coming decades. This may create opportunities to provide products for the pharmaceutical sector, hospitals and other healthcare services. The Australian industry may also be well placed to capitalise on technological advances such as flow chemistry and additive manufacturing.

Many other challenges and opportunities are described in the report. The next stage for this research involves the identification and description of strategic directions. These are high-level actions that help the industry transition into a desired future state.

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CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

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FOR FURTHER INFORMATION

CSIRO Futures
Stefan Hajkowicz
t +61 7 3833 5540
e Stefan.hajkowicz@csiro.au
w www.csiro.au/futures

CSIRO Materials Science and Engineering

Sarah King
t +61 3 5246 4747
e Sarah.King@csiro.au
w www.csiro.au/cmse