

Strategic Directions

Towards sustained growth of the Australian
chemicals and plastics industry

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ABOUT THIS REPORT

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Executive Summary

Chemicals and plastics play a vital role in society and are used to produce nearly everything we consume. The Australian chemicals and plastics industry is a critical part of most domestic supply chains and feeds essential products into almost every sector of the Australian economy including manufacturing, construction, mining, agriculture and healthcare (ABS, 2012b). Because it supplies so many downstream industries, innovations within the chemicals and plastics industry have the potential to have a very large multiplier effect across the broader Australian economy.

To continue to meet the needs of Australian consumers and industry, the chemicals and plastics industry must address a number of challenges and opportunities it currently faces. While the global chemicals and plastics industry is growing rapidly, the domestic industry is lagging behind. Since 2007, industry value added has been stagnant, the number of businesses operating domestically has decreased, and employment in the industry has declined.

Australian industry and consumers are becoming increasingly reliant on imports. The percentage of imported chemical and plastic products rose from 31 percent to 38 percent between 2005-06 and 2008-09 (ABS, 2013) (ABS, 2011b). Since 2005, Australia's trade deficit in chemical and plastic products has been increasing by 5 percent per year (ABS, 2013). A primary driver behind this is the increase in supply of cost-competitive imported chemical and plastic products, particularly from China, South Korea, Singapore and India.

At the same time, as identified in a prior CSIRO report entitled "Elements in Everything," shifts in global economic, social and environmental conditions will create new opportunities for the chemicals and plastics industry. Technological advances, changing environmental regulations, shifting consumer preferences and societal trends have the potential to open up new market growth areas for the industry:

Agriculture and Food – Global population growth and economic growth will fuel increased demand for food in the coming decades. This will create opportunities in fertilisers, herbicides, pesticides, and food additives that will improve yields

for domestic agriculture, as well as opportunities in new types of food packaging to reduce spoilage and waste.

Mining – Population and economic growth and increased urbanization in growth regions will increase demand for minerals into key economic and industrial sectors. Chemicals are used in the mining process to assist with the recovery and extraction of minerals and materials from ore. Given the expected gradual decline in ore grades in Australia (BREE, 2012d), mining chemicals will play a key role in increasing the profitability and efficiency of mining operations (Chadwick, 2012) and help Australian miners remain globally competitive.

Building and Construction – Increased domestic and global population and economic growth will increase demand for building and construction including housing, commercial and industrial buildings, government and educational institutions and other infrastructure. The construction industry is the second largest user of plastics in Australia and uses a range of chemical products. Owing to advances in technology, the

use of plastics in construction will expand into the future as they replace many existing materials (PACIA, 2012).

Materials Recycling – In a resource-constrained world, increased dependence on resource efficiency, including materials recycling, will open up new opportunities for the chemicals and plastics industry. Recycling uses a variety of chemicals depending on the product being recycled and the technique used.

Healthcare and Wellbeing – An ageing population, rise of chronic illnesses and changing consumer preferences will create demand-side opportunities for chemical and plastic products in medical devices, hospitals and other areas of the healthcare industry.

This report looks at ways the chemicals and plastics industry can address these challenges and take advantage of these market growth areas. It considers two possible scenarios for the future: the *current trajectory* and *sustainable growth*.

The Australian Chemicals and Plastics Industry today

Sustainable Growth

- Preserve everyday benefits
- Create jobs and economic growth
- Secure domestic supply chains
- Keep Australia a leader in global innovation

Current Trajectory

- Decreased output and jobs
- Increased reliance on imports
- Risk to supply chains
- Loss of means of production

The **Current Trajectory** scenario describes a likely outcome if no significant actions are taken. In this scenario, Australia stands to lose much:

- ♦ **Decreased output and jobs** – The domestic chemicals and plastics industry would continue to contract as it faces increased competition from imports, and offshoring of production would lead to a continued decrease in domestic employment.
- ♦ **Increased reliance on imports** – The decline in domestic production would lead to a continued increase in the trade imbalance for chemicals and plastics.
- ♦ **Risk to supply chains** – Unforeseen supply shocks in imported chemicals and plastics could cause major disruptions to downstream supply chains, potentially impacting the Australian macro economy and threatening food supplies and other essential items.
- ♦ **Loss of means of production** – The difficulty of rebuilding physical plant and training engineers and skilled labour could mean a nearly irreversible loss of domestic production capability and talent.

Alternatively, the **Sustainable Growth** scenario would see the industry return to a growth trajectory and remain a modern, sustainable industry using high-end technologies to adapt to the future. Under this scenario, the industry would contribute much to Australia:

- ♦ **Preserve everyday benefits** – These are benefits that many consumers take for granted, such as food security, hygiene and cleaning products, and water supply and treatment.
- ♦ **Create jobs and economic growth** – Because it supplies so many downstream industries, the chemicals and plastics industry has a large multiplier effect across the broader Australian economy. The sector has highly-skilled, highly-paid employees with high-leveraging economic outputs.
- ♦ **Secure domestic supply chains** – Maintaining a strong domestic supply chain makes downstream industries less susceptible to foreign supply shocks.
- ♦ **Keep Australia a leader in global innovation** – A healthy Australian chemicals and plastics industry would contribute valuable innovations to Australian industry and continue to produce products that are beneficial for Australia and global markets.

This report broadly considers a number of “Industry Enablers” that would help the industry move towards the sustainable growth scenario. Industry enablers are activities that take advantage of new opportunities (such as the market growth areas) or address major issues that may be holding back growth. Nine industry enablers were identified; of these, the most important are:

- ♦ **Feedstock development** – to maintain reliable access to feedstocks
- ♦ **Energy supply and efficiency** – to ensure access to affordable and reliable energy and utilities
- ♦ **Attracting capital** – by making Australia attractive for capital investment
- ♦ **Science, research and technology development** – to support innovation and strong intellectual property

The other industry enablers identified include: corporate social responsibility; market research and global market access; workforce skills and training; targeted education and awareness; and services and knowledge-based offerings. Investing in these industry enablers and focussing on the opportunities created in the market growth areas provide potential pathways for the chemicals and plastics industry to move away from the current trajectory and make progress towards sustainable growth.

This report takes a market-centric approach in exploring pathways forward for sustainable growth. The industry enablers are all actions that are harmonious with market forces. The market growth areas represent opportunities associated with natural supply and demand forces emerging over the coming two decades. It is beyond the scope of this report to make recommendations on specific policy actions or to outline detailed roadmaps for the industry enablers and market growth areas. The industry, in conjunction with key stakeholders in government, will continue to explore these possibilities.

1 Introduction

The Australian chemicals and plastics industry produces products that are part of nearly everything we consume. It is a vital input to the food we eat, the water we drink, the hygiene products we use and countless other goods that we take for granted on a daily basis.

The industry also plays a core role in Australia's supply chains. It is the second largest manufacturing industry in Australia, with a contribution of A\$11,651 million to gross domestic product in 2010-11 (ABS, 2012a). Food product manufacturing is the largest manufacturing sector and machinery and equipment manufacturing is

the third largest (ABS, 2012a). The chemicals and plastics industry produces goods and services that are essential for many other key industries: manufacturing, mining, agriculture, construction, healthcare, as well as many other important sectors. In fact, the chemicals and plastics industry supplies inputs to 109 of 111 industries in Australia (ABS, 2012b).

Without access to chemical and plastic products, the Australian economy would likely grind to a halt.

As with other industries, the chemicals and plastics industry faces major challenges and opportunities in the years ahead. Growth in Asia and the developing world presents an enormous opportunity to sell products into new global markets, but also presents the challenge of maintaining domestic capacity in the face of an increasing supply of cost-competitive imports.

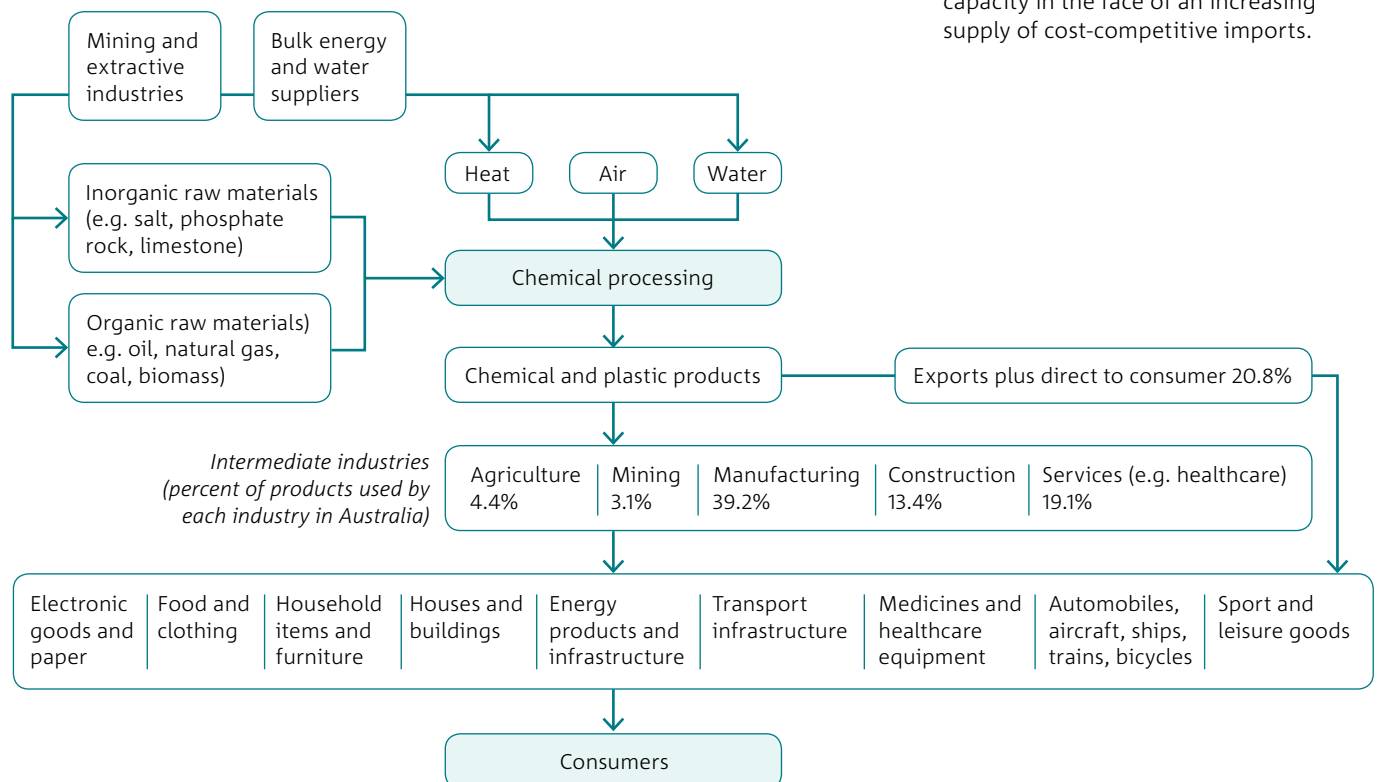


Figure 1. Generalised inputs and outputs from the Australian chemicals and plastics industry

Source: Estimates of intermediate industry usage from the Australian Bureau of Statistics (ABS, 2012b) and concepts drawn from the American Chemistry Council (ACC, 2012a)

Over the next several decades, the world will also see a number of social, economic, and environmental changes that could impact the industry. New environmental regulations and social pressures could present great opportunities for the chemicals and plastic industry to supply new, innovative environmentally-friendly, socially-conscious products to downstream industries. At the same time, a balanced regulatory environment will be necessary to support a flourishing industry.

These challenges and opportunities leave the chemicals and plastics industry at a crossroads, faced with the choice of continuing forward on the “current trajectory” or embarking on a path towards “sustainable growth.”

The remainder of this report explores these two scenarios in more detail and considers possibilities for creating sustainable growth in the industry. It includes the following sections:

The Current Trajectory – This section describes the current trajectory of the Australian chemicals and plastics industry. It considers the implications of minimal or no action being taken to address the opportunities and challenges it faces. In this scenario, the industry continues to contract, Australia becomes increasingly dependent on imported chemical and plastic products, jobs and production facilities are off-shored and Australia’s downstream supply chains are threatened.

Sustainable Growth – This section outlines an alternative scenario in which actions are taken towards addressing the key social, economic and environmental challenges and opportunities it faces in the upcoming decades. This leads to sustainable growth and a strong, vibrant and resilient chemicals and plastics industry that continues to contribute to the economy, creates Australian jobs and protects downstream supply chains. There are two main dimensions towards the sustainable growth scenario that are explored in this report: market growth areas and industry enablers.

Market Growth Areas – This section describes five market growth areas the chemicals and plastics industry should consider in its move towards sustainable growth. Market growth areas are demand-side opportunities in industries that rely on chemical and plastic products as inputs. This includes growth in demand in existing chemical and plastic products as well as business opportunities for new products created by social, environmental and economic changes in the decades ahead.

Industry Enablers – This section looks at nine key industry enablers that would potentially move the chemicals and plastics industry towards the sustainable growth scenario. Industry enablers are activities that create new opportunities or to address major issues that may be preventing future growth. These enablers are closely linked to the “nine fundamental needs” that PACIA have identified for the industry.

Charting a Way Forward – Although it is beyond the scope of this report to create a detailed roadmap for implementing the sustainable growth scenario, this concluding section briefly explores some possible pathways the industry may consider in the future.

This report builds upon the research and analysis of an earlier report commissioned by PACIA and the Australian Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE) and conducted by the CSIRO, entitled “Elements in Everything.”

The “Elements in Everything” report identified six global megatrends that could affect the chemicals and plastics industry over the next 20 years (Figure 2). 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 can have both supply side and demand side implications. They can be associated with the emergence of new markets, thereby creating opportunities to supply new products. They may also be associated with constraints to production processes and or changed operating costs.

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:

Emerging Markets – rapid income growth and technological advancement in Asia and the developing world will open up new markets for Australian chemical and plastic products.

Resource Scarcity – chemical and plastic products may be highly valuable in a resource-constrained world as substitutes for scarce mineral resources in construction, energy storage, and recycling.

Food for all – global population growth and economic growth will fuel increased demand for food in the coming decades, which could create opportunities in packaging, fertilisers, herbicides, pesticides, and food additives.

Responsible Industry – environmental and social credentials will be an increasingly important differentiator for consumer products and major corporate and government contracts.

Health and Wellbeing – an ageing population, rise of chronic illnesses and changing consumer preferences could create demand-side opportunities for chemical and plastic products in the pharmaceuticals, hospitals and other areas of the healthcare industry.

Technological Advances – emerging technologies such as additive manufacturing, smart materials, and flow chemistry could create new markets for chemical and plastic products.

While the “Elements in Everything” report identifies and describes change in the decades ahead (i.e. what is likely to happen), this report identifies and describes potential strategic directions for industry (i.e. what we can do about it). Although it is beyond the scope of this report to recommend or prescribe specific courses of action, it aims to build a strong body of evidence to inform choices being made by others.

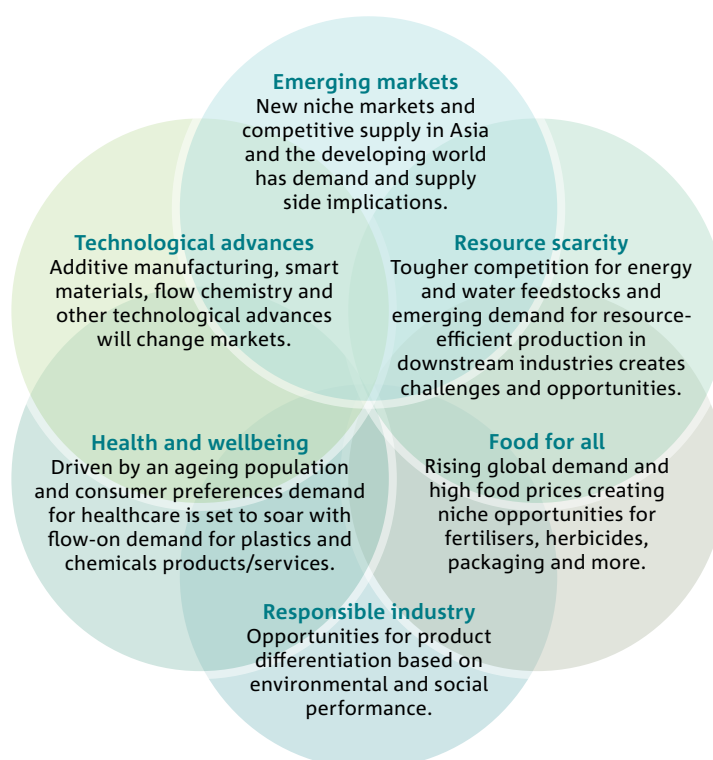


Figure 2. Megatrends for the chemicals and plastics industry identified in the accompanying CSIRO report “Elements in Everything”

② The Current Trajectory



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In the evaluation of policy or investment options, economists typically define the business as usual or “do nothing” option. This provides a reference point from which to assess all proposed actions.

In this section the consequences and impact on the economy of taking no major action and allowing the industry to continue on its current trajectory are explored. The current trends in the domestic chemicals and plastics industry are explored and contrasted with the global chemicals and plastics industry. Given the pivotal role that the chemicals and plastics industry plays, the impact of a contraction on downstream industries is also explored. This section concludes with an analysis of the strengths, weaknesses, opportunities and threats (SWOT) for the industry in its current position.

2.1 Consequence of Contraction (What Australia Might Lose)

Even under the current trajectory, the chemicals and plastics industry will continue to play an important role in Australia's economy over the next twenty years. However, it is likely that it will be much smaller and less diversified than the current or historic industry profile. Cost competitive imports will lead to the off-shoring of production facilities and jobs. Supply chains will depend on overseas producers to a greater extent, raising concerns about economic and geopolitical security. The decrease in manufacturing capability will also have ramifications for innovation and R&D capabilities. In summary the consequences of continuing on the current trajectory include:

Decreased Output and Loss of Jobs in Both the Chemicals and Plastics Industry and Downstream Industries

— In 2008 Australia had 6,015 companies in this industry. By 2011 Australia had 5,557 companies (ABS, 2012e). Given that employment and revenue are also decreasing in real terms it is unlikely that the loss of smaller companies is being offset by the growth of larger companies. The reality is many businesses are moving offshore. The trend is likely to continue in coming decades. This means Australia will lose its capability to make a diverse range of essential chemical and plastic products.

Between 2002 and 2012, employment in the industry decreased (Figure 4) (ABS, 2012f). The expectation would be for continued job losses at a similar rate in the decades ahead. This has an impact on the living standards of Australians employed within the industry and represents a significant loss of skills that will not easily be rebuilt. The loss of jobs within the industry is likely to impact jobs in downstream and upstream industries. These trends are explored in more detail in Section 2.2.

Increased Reliance on Imports of Chemical and Plastic Products –

Imports made up 38 percent of chemical and plastic products consumed in Australia in 2008/09 compared to 31 percent in 2005/06 (ABS, 2013) (ABS, 2011b). Since 2005 Australia's trade deficit in chemical and plastic products has been increasing by 5 percent per year (ABS, 2013). The contraction of domestic production relative to global growth is detailed in Section 2.3.

Risk to Domestic Supply Chains –

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, 2012b). A supply chain breakdown could rapidly lead to major economic and social

impacts. As Australia increasingly sources chemical and plastic products from offshore, downstream supply chains become exposed to increased geopolitical, engineering and natural risks which are beyond the control of individual governments. In times of global conflict and instability, reliance on offshore supply chains to support Australian industry and the defence forces becomes a source of security risk. This has been heavily investigated in the case of oil and energy dependence to achieve improved national security in the United States (Greene, 2010). The impact of the chemicals and plastics industry on downstream industries is highlighted in Section 2.4.

Loss of Means of Production –

The chemicals and plastics industry in Australia was built up over a century. The infrastructure, skills and know-how were gradually created over many decades of sustained investment. If the industry contracts or disappears from Australia, it will take considerable time to rebuild. If future geopolitical instability or changed global market conditions were to create a renewed requirement for a large Australian chemicals and plastics industry, it would not be possible to rebuild quickly. A thriving chemicals and plastics industry is fundamental for Australia to be able to design and produce essential products.

2.2 Current Trends in the Industry

Since 2007-08, the total number of businesses in the chemicals and plastics industry has been decreasing (ABS, 2012e). Although the industry is considered cyclical and the largest decrease in 2007-08 may be partly attributable to short term economic conditions (Euromonitor International, 2011), the long term continuing decline is likely to be more indicative of a struggling industry (Figure 3). As the number of businesses has declined, employment in the industry has also declined (Figure 4) (ABS, 2012f).

Industry value added (the contribution by business to GDP) jumped 12 percent from A\$10.6 billion in 2006-07 to A\$11.8 billion in 2007-08. However, growth stalled in the following three years. From 2007-08 to 2009-10 the industry value add contracted from A\$11.8 billion to A\$11.4 billion with negative growth of 4 percent (ABS, 2011c).

Since the year 2005, Australia's trade deficit in chemical and plastic products has been increasing by 5 percent per year. This is mainly due to cost-competitive supply of imported products mostly from Asian regions. As developing Asia continues to build advanced and modern infrastructure and continues to increase production and exports this trend is likely to continue (ACC, 2012a). Over the 10 year period from 2002 to 2011 China increased exports of chemical and plastic products from US\$2,944 million/year to US\$13,270 million/year. 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/year to US\$6,381

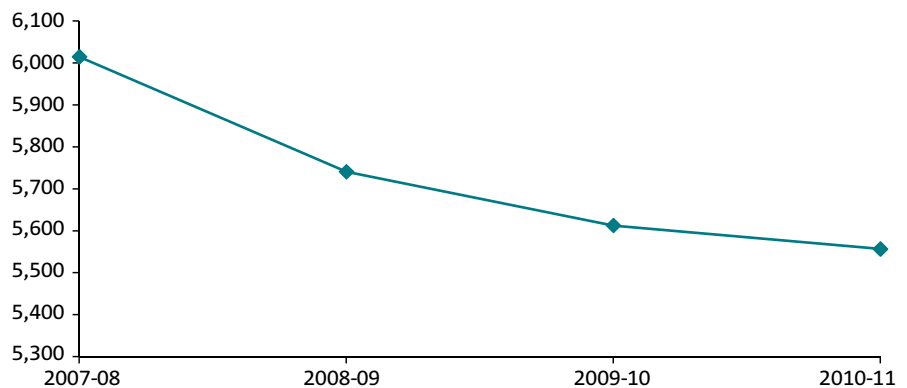


Figure 3. Number of businesses operating at the end of the financial year

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

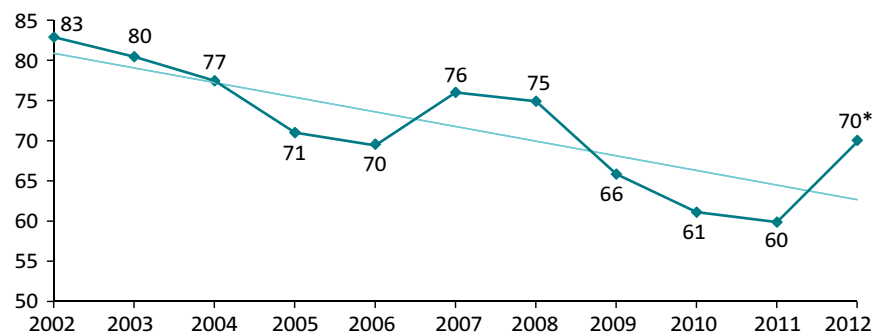


Figure 4. Employment in the chemicals and plastics industry, 2002 – 2012 (with linear trendline)

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

Note 1: 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.

***Note 2:** The increase in employment from 2011 to 2012 was driven by unexpected spikes in the “cleaning compound and toiletry preparation manufacturing” and “polymer product manufacturing” subsectors of the chemicals and plastics industry. Our consultation with industry leaders identified a potential discrepancy. Based on their knowledge of the industry, they felt employment within these sectors was most likely decreasing between the two time periods. Further consultation with ABS revealed that this dataset uses a small sample size and is subject to sampling error. Their methodology also introduces possible industry code misclassifications. Additional investigation would be required to determine the accuracy of the 2012 data point.

million/year (140 percent increase) and Singapore increased exports from US\$1,448 million/year to US\$4,206 million/year (190 percent increase). Indian exports rose from US\$757 million/year to US\$4,393 million/year (480 percent increase). This compares to growth in exports of 98 percent in Australia from US\$1,490 million/year to US\$2,955 million/year. Australia has a trade deficit in chemicals and plastics which has been continually worsening from 2005 and is expected to worsen further under the current trajectory as imports make up an increasing proportion of Australia's chemicals and plastics consumption (Figure 5).

A growing proportion of chemical and plastic products used in the Australian economy are already imported. In 2005-06 imports comprised 31 percent of chemical and plastic products consumed in Australia. In 2008-09 this grew to 38 percent (Figure 6). This means Australian industry and society is becoming increasingly dependent on offshore supply chains for essential products and inputs into many domestically produced goods.

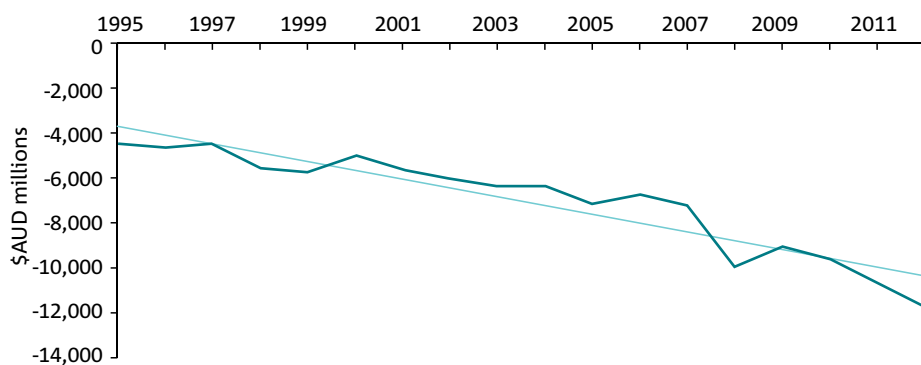


Figure 5. Australia's chemicals and plastics annual trade balance (exports less imports), 1995 – 2012 (with linear trend line)

Source: Australian Bureau of Statistics (ABS, 2013)

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.

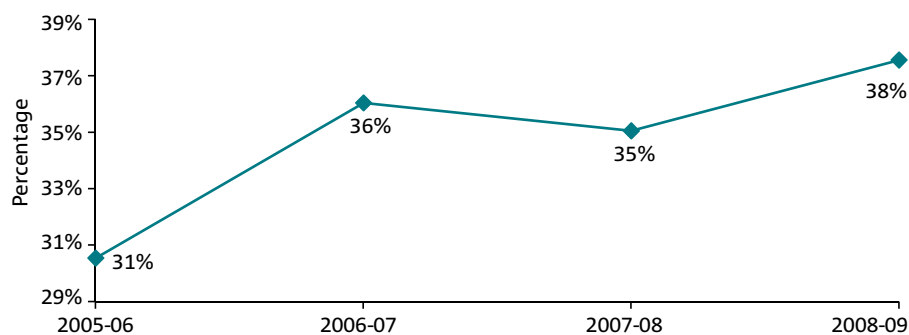


Figure 6. Percentage of chemicals and plastics consumed in Australia from overseas producers

Source: Australian Bureau of Statistics (ABS, 2013) (ABS, 2011b).

Note: Consumption is estimated as domestic production less exports plus imports.

2.3 Domestic Contraction in the Context of Global Growth

Given that the chemicals and plastics industry is cyclical and sensitive to economic conditions (Euromonitor International, 2011), the extent of growth in the industry is difficult to estimate. By examining forecast economic growth rates, some deductions can be drawn regarding the growth prospects. It is forecast that for OECD countries at least, economic conditions will generally improve in the coming decade compared to the last decade (Figure 7). However, in the short term the improvement is expected to be slow in advanced economies while relatively solid in developing economies (IMF, 2012b).

The growth in developing countries is expected to be driven by the Chinese economy. Although GDP growth has slowed recently (Figure 8), China's GDP is expected to strengthen and grow at 8.25 percent in 2013 and continue to grow at similar levels out to 2017 (IMF, 2012b). It is unlikely that this recovery will be strong enough for China to return to double digit growth in GDP in the near to medium term (IMF, 2012b), but China is still likely to be a driving force in the global economy.

The trend in the chemicals and plastics industry has reflected these global conditions, namely the growth in the industry and the strength of emerging markets. While the global chemicals industry has doubled since 1999, the compound annual growth rate of industry sales has slowed significantly in the last five years

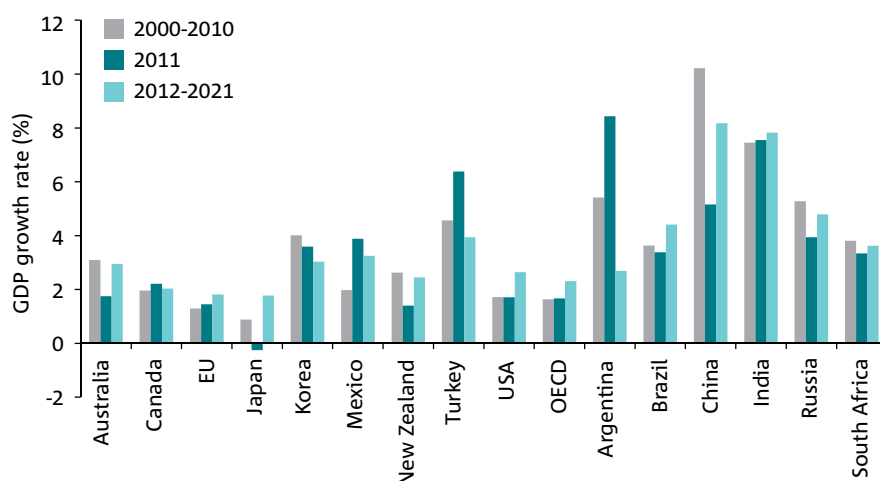


Figure 7. Actual and forecast GDP growth in selected economies

Source: Organisation for Economic Development and the Food and Agriculture Organization (OECD & FAO, 2012)

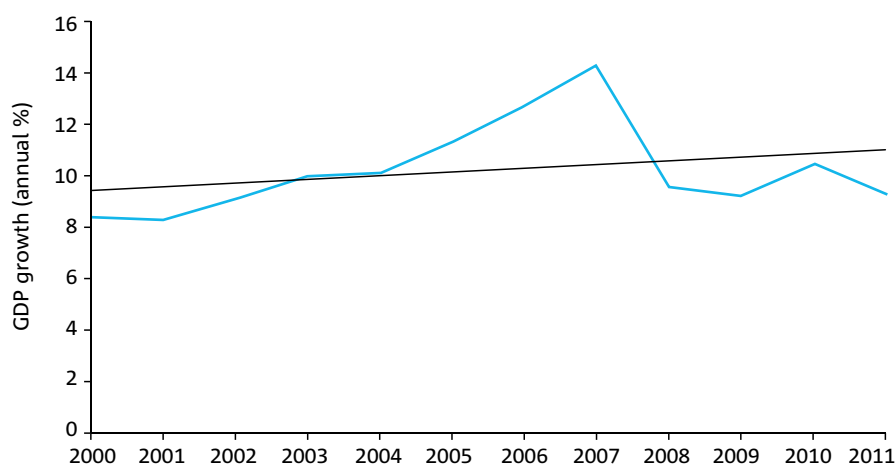


Figure 8. China's GDP growth, 2000-2011 (with linear trendline)

Source: The World Bank Database (World Bank, 2012)

(Figure 9). The chemicals and plastics industry has continued to grow but the growth rate has been slowing. Additionally, in the past 25 years to 2010, the majority of growth in the chemicals industry has been driven by Asia (ATKearney, 2012a). Since 1989, China's production of chemicals has increased rapidly in comparison to other countries (Figure 10).

Looking forward, the global chemicals and plastics industry is expected to grow, albeit at a slower rate. Global markets for the chemicals industry are expected to grow by an average of 3 percent in the next 20 years (ATKearney, 2012a). While it is expected that North America and Western Europe will continue to make substantial contributions to global production, China is expected to be the main player, with Brazil, and Eastern and Central Europe also making sizable contributions to growth (ACC, 2012a). Indeed it is expected that China will become a net exporter of chemicals between 2018 and 2025 if the current trends in growth continue (ATKearney, 2012a). In addition to China's growth, Asian players are expected to own approximately two-thirds of the market by 2030 (ATKearney, 2012a).

It is expected that the chemicals and plastics industry will face challenging domestic operating conditions in the future. However these challenges can also present opportunities. It has been suggested that current domestic economic conditions are indicative of a structural adjustment occurring in the Australian economy (Mitchell, 2012). The RBA Governor has identified the high terms of trade and a persistent high exchange rate as being significant drivers of this shift (Mitchell, 2012). As the adjustment takes place, productive resources will shift towards the more productive sectors while less productive sectors will shrink (Mitchell, 2012). A growth gap could result if other industries, such as manufacturing or service industries, are slow to fill the gap left as mining activity declines (Mitchell, 2012).

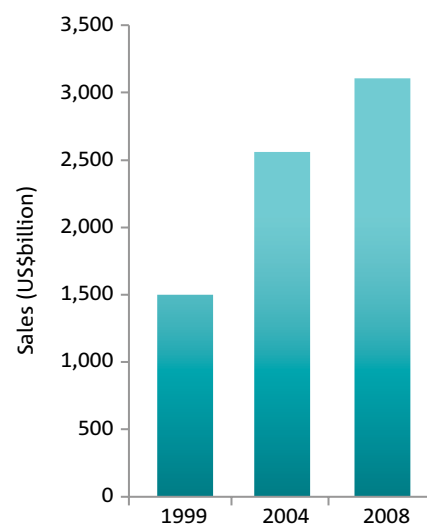


Figure 9. Global chemical industry revenue growth, 1999-2008

Source: Deloitte (2009)

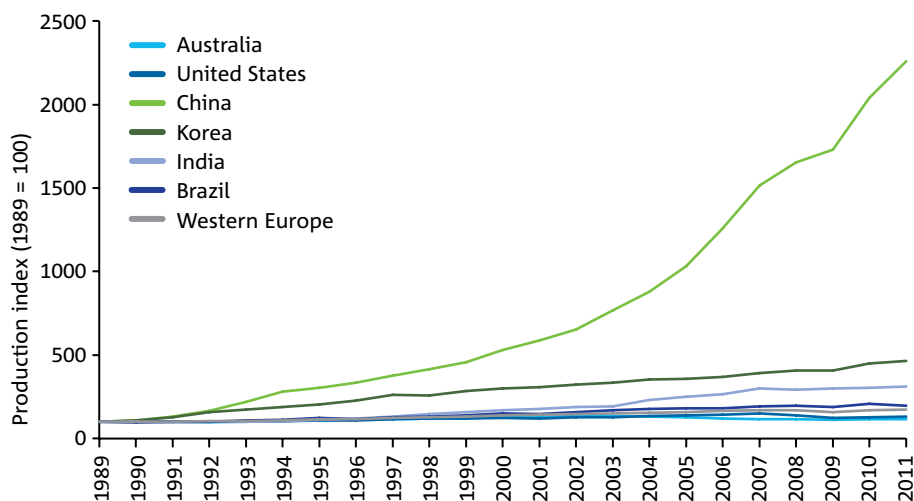


Figure 10. ACC Global Chemical Production Regional Index, 1989-2011

Source: American Chemistry Council (ACC, 2012a)

2.4 Impact on other Industries

Traditionally the domestic industry has been well regarded in niche areas such as explosives and agricultural chemicals, reflecting the broader economy's strengths in agriculture and mining (Upstill et al., 2006). The Australian chemicals and plastics industry is also integrated into the global industry through trade and the domestic presence of multinational companies (Upstill et al., 2006). It is therefore unlikely that the chemicals and plastics industry will cease to exist on Australian shores if no major action is taken. However the current trajectory of the industry points towards contraction of domestic production and domestic demand being satisfied by imports.

This contraction in the chemicals and plastics industry could have an impact on downstream industries. The majority of outputs from the chemicals and plastics industry are used as inputs into manufacturing (valued at \$19,346 million), construction (\$6,639 million), agriculture (\$2,916 million), mining (\$1,724 million) and health care and social assistance (\$1,352 million) (Figure 11) (ABS, 2012b). Within manufacturing, the largest users are basic chemical manufacturing, polymer product manufacturing, printing, motor vehicles and parts, cleaning compounds and toiletry preparation manufacturing and dairy product manufacturing (ABS, 2012b). A decrease in domestic production will result in these industries having to source a greater proportion of inputs offshore.

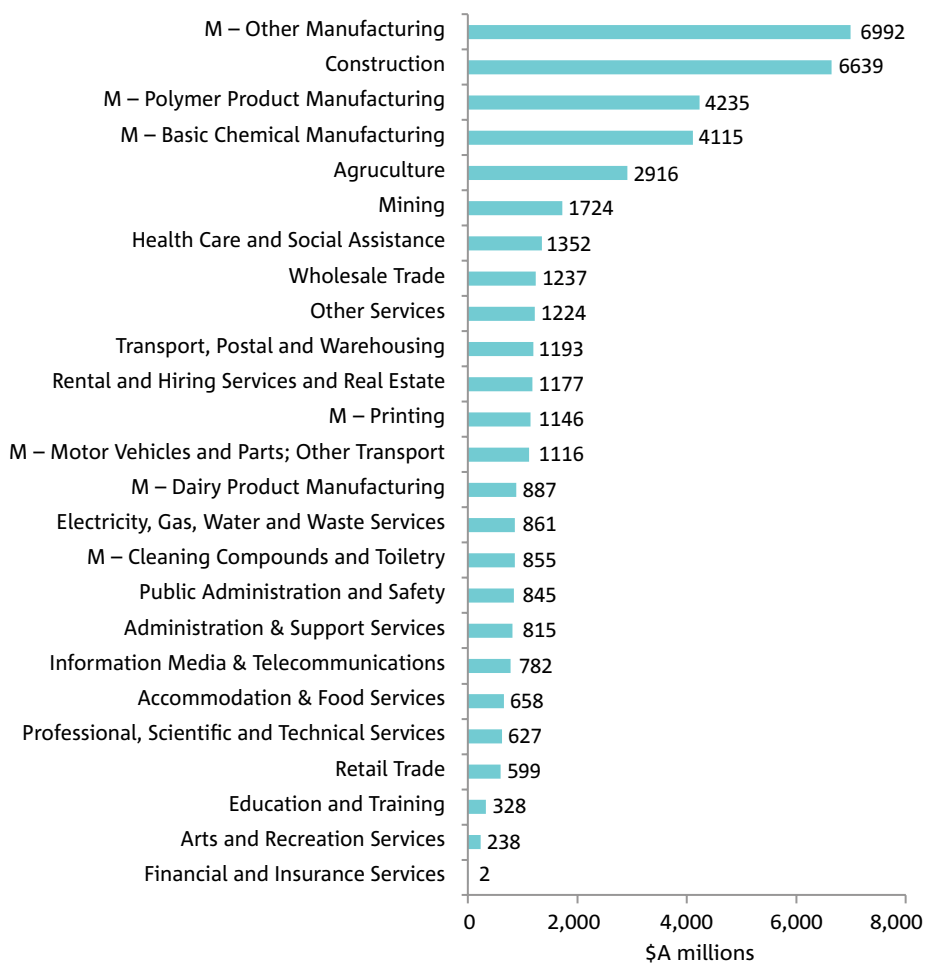


Figure 11. Value of inputs supplied to the Australian economy by the chemicals and plastics industry

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

Note: Categories denoted 'M' are part of the manufacturing sector. The manufacturing sector as a whole consumes A\$19,346 million worth of inputs from the chemicals and plastics industry.

2.5 SWOT Analysis

The following table presents a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the industry's current position based on the current trajectory. The domestic industry still has a strong presence under the current trajectory by 2030 but its size and structure will change, with implications for Australia's economy, society and environment. Action is required if the industry is to reverse the likely contraction of the industry and grow sustainably to support other domestic and international industries.

TABLE 1. SWOT ANALYSIS

Strengths (S)	Weaknesses (W)
<ul style="list-style-type: none"> • Stable government and political environment • Good industry safety & environmental performance • Strong health sector • Good access to R&D capabilities • High skills base • Good access to education • Proximity of feedstocks • Proximity to Asian markets 	<ul style="list-style-type: none"> • Ageing infrastructure • Significant use of water & energy for manufacturing • Mismatch between public benefit and recognition
Opportunities (O)	Threats (T)
<ul style="list-style-type: none"> • Mining industry • Agrifood sector • Medical devices • Corporate Responsibility • Develop services • Emerging markets, in particular China & India 	<ul style="list-style-type: none"> • Loss of domestic oil refineries • Access to feedstocks • Access to competitively priced energy • Business investment in R&D is lower than other developed countries. • Ageing population • Terms of trade and volatility of Australian dollar

③ Sustainable Growth



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The previous section, outlining the current trajectory scenario, paints a picture of industry contraction. This section describes an alternative scenario – one of “sustainable growth” leading to the development of a strong, vibrant and resilient chemicals and plastics industry over the next two decades.

3.1 The Benefits of Sustainable Growth (What Australia Could Gain)

The chemicals and plastics industry is part of the Australian manufacturing sector. Manufacturing is an important part of the economy and makes disproportionately large contributions to Australian exports and research and development (Australian Government, 2012c). Manufacturing is also an important part of Australia's future economic prosperity, for while it only comprises eight percent of Australia's GDP, it delivers many direct and indirect benefits to other industries.

PACIA's vision for the industry is "a vibrant and sustainable industry in Australia, providing the building blocks of a modern economy and central to the country's economic, environmental and social well-being."

This vision reflects the important role of Australian manufactured chemical and plastic products evidenced by the diverse industries its products support. In 2008, the chemicals and plastics industry articulated its goals for the future through the "Sustainability Leadership Framework" which outlines priorities for the industry at a micro-level (PACIA, 2008b).

Building upon the PACIA vision and the industry framework, this section explores the benefits of sustainable growth in more detail, including economic growth and job creation, secure supply chains, and innovation. This section also identifies key industry metrics that could help measure progress towards achieving the sustainable growth scenario.

3.1.1 Economic Growth and Job Creation

Manufacturing industries are generally considered important in terms of contributions to total employment (Valadkhani, 2003). Under a hypothetical industry shutdown scenario, it has been estimated that the chemicals industry has the ninth largest impact on total employment and rubber and plastics products the fourteenth largest impact if these industries were to cease to exist¹ (Valadkhani, 2003). The manufacturing industry as a whole has an employment elasticity of 0.242 meaning that a ten percent change in final demand in the manufacturing industry can lead to a 2.42 percent change in aggregate employment in the economy (Valadkhani, 2003). Hence a growing chemicals and plastics industry will have positive flow-on effects to employment.

The degree of connection between the chemicals and plastics industry and the rest of the economy has been quantified via an economic multiplier. The Australian Industry Group (2006) has estimated that, as a general rule, every \$1 generated from the manufacturing sector flows through to an additional \$1.25 expenditure in the rest of the economy. In the Pilbara region of Western Australia, additional manufacturing jobs have the largest impact on employment of all other sectors (Pilbara Development Commission, 2012). One manufacturing job results in 1.04 new jobs in the Pilbara regional economy (Pilbara Development Commission, 2012). In the United States, approximately one in six jobs in the private sector are dependent on the manufacturing base (The Manufacturing Institute, 2009). In addition, in the United States it has been estimated that every dollar of final sales for manufactured products generates \$1.48 in economic activity in other parts of society (The Aspen Institute, 2013).

3.1.2 Secure Domestic Supply Chains

The chemicals and plastics industry is deeply embedded within countless supply chains that provide the products we consume on a day-to-day basis. One of many examples is food production. The food value chain depends on chemical and plastic products in nearly every stage: production, storage, processing, transportation, retail and final consumption (Figure 12).

A continued contraction of the chemicals and plastics industry would result in a larger proportion of inputs being imported from overseas, creating a greater reliance on overseas supply chains, thereby increasing Australia's exposure to international supply chain risks. The impact of a contraction would vary according to the amount of inputs supplied domestically and the degree of substitutability between domestic and overseas inputs. It is expected that the manufacturing, construction, agriculture, mining and health care and social assistance sectors would realise the greatest impact as these are the largest downstream users of the domestic chemicals and plastics industry (ABS, 2012b).

A strong reliance on global suppliers is often associated with increased uncertainty and poorer transparency and visibility (Wagner et al., 2006). This can manifest in many different ways, such as longer lead times, a loss of flexibility and increased risk of external disruptions. In response to challenging economic conditions, companies are already examining their supply chains to identify cost cutting measures and improve their ability to respond quickly to changes in demand (KPMG, 2012).

¹Based on data from 1996-97 ABS Input-Output Tables.

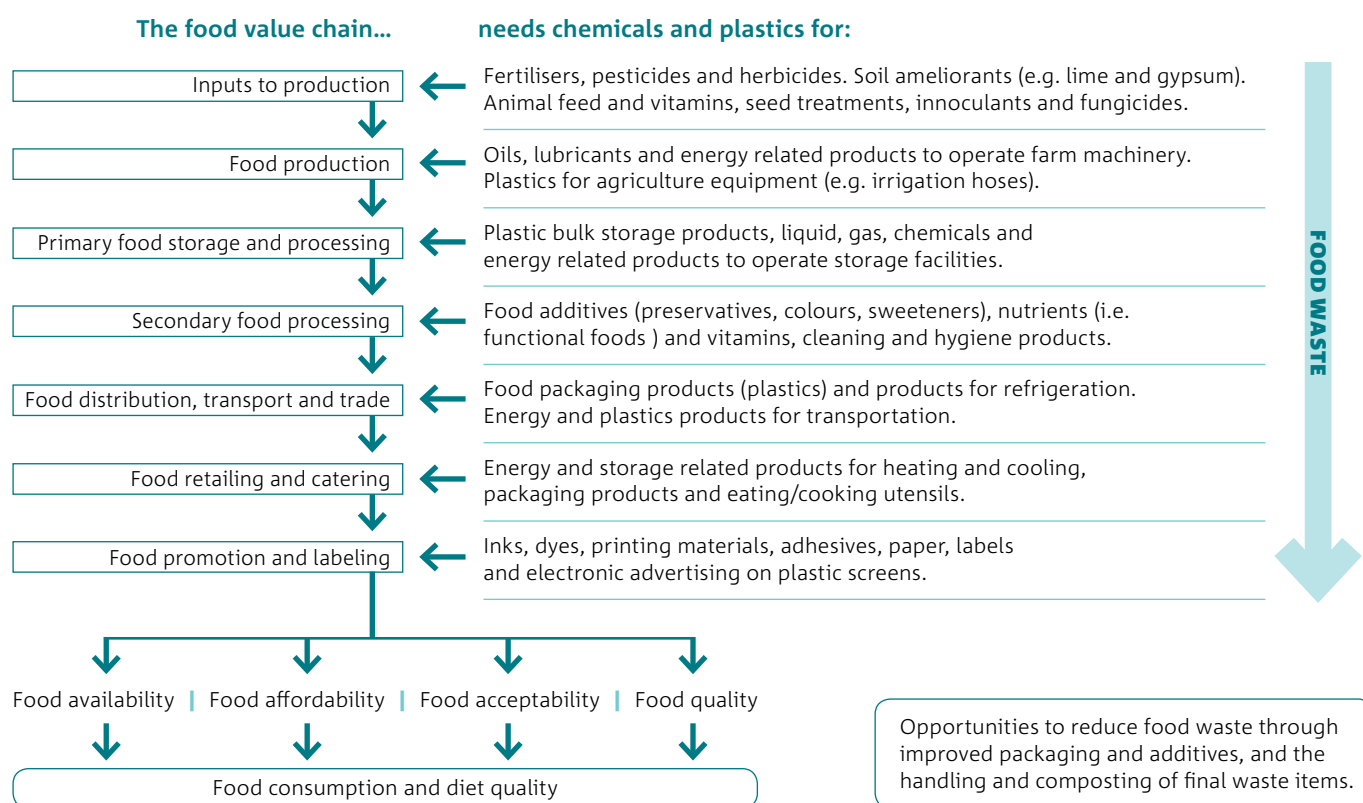


Figure 12. Chemicals and plastics inputs to the food value chain

Source: Adapted from Hawkes (2009) and Hawkes et al. (2011)

Although this has resulted in overseas contracts being awarded in the past to meet domestic needs (KPMG, 2012), Australian industry is best positioned to improve an Australian companies' ability to respond to changes quickly given the proximity to market.

Introducing an overseas component in the supply chain can increase exposure to the risk of supply chain disruption (CFO Research Services, 2009). Supply chain disruptions are negatively viewed by the market and can have substantial ramifications down the supply chain. It has been estimated that supply chain disruptions can decrease shareholder value by 10.28 percent under certain conditions (Hendricks et al., 2003). Global supply chains are also subject to the variability and uncertainty of

exchange rate fluctuations (Meixell et al., 2005; Wagner et al., 2006), adding another element of risk. Increasing the degree of overseas exposure is likely to increase this risk of supply chain disruption and opens the supply chain to new risks.

A thriving chemicals and plastics industry will also facilitate development in downstream industries. Importantly, service activities tend to rely more heavily on the manufacturing industry than the manufacturing industry relies on service activities (Park et al, 1989). The manufacturing industry can play a key foundational role if Australia wishes to develop the service component of its economy (Park et al., 1989). These industries will be able to source chemical and plastics inputs domestically

and will not have to account for the longer lead times associated with sourcing inputs overseas.

Another aspect of supply chain security relates to national defence. The ability to source vital energy, chemical and plastic products within the boundaries of Australia is considered by many important to ensuring the capacity of the military and industry to operate effectively in times of conflict and instability. The extent of this risk may be debated. However, the academic literature and policy sphere – particularly in the United States – gives the issue much attention (Greene, 2010). Much of the debate centres on the costs of achieving domestic supply relative to the national security benefits.

3.1.3 Keep Australia a Leader in Global Innovation

In Australia, the majority of expenditure on R&D is concentrated in large businesses and in sectors such as manufacturing, mining and financial and insurance services (DIISR, 2011a). Both the Aspen Institute (2013) and the Boston Consulting Group (2009) highlight the importance of manufacturing for innovation and R&D capabilities and identify that process and product innovation occurs in and around manufacturing plants. Thus when factories close or move offshore, the country loses a major source of innovation. It has been estimated that Australian businesses that innovate are twice as likely to experience increased productivity compared to businesses that do not and are 40 percent more likely to report increased profitability (Australian Government, 2012a). If Australia loses its R&D capabilities this is likely to have flow on effects regarding Australia's competitiveness in innovation (Australian Government, 2012a). The strong association between manufacturing and R&D capability (Rao et al., 2012) raises concerns about the implications and ramification of the loss of Australia's manufacturing base. A contraction in the chemicals and plastics industry is likely to have greater ramifications than simply a decrease in production of goods.

Such innovation activity and R&D that is part of the manufacturing industry contributes to economic growth (KPMG, 2012). The impact on economic growth is not only limited to the growth occurring inside the manufacturing industry. The use of innovation in the chemicals and plastics industry is not restricted to this industry alone, but is likely to apply to the wider manufacturing industry and can translate across into other industry sectors (Future Manufacturing Council, 2011). The chemicals and

plastics industry is noted for playing a significant role in introducing new technologies that can reduce production costs or improve product characteristics in non-chemical industries to improve productivity and growth opportunities (NIEIR, 2006). It has been estimated that innovation in the chemical industry in the United States contributes approximately 0.2 percent to long-term GDP growth (ACC, 2012a). This occurs via technological innovation as evidenced by a constant stream of new products and production processes (ACC, 2012a). A contraction in the chemicals and plastics industry is likely to negatively impact on the innovation and R&D capabilities of the domestic economy.

Not only will a contraction in the manufacturing base impact innovation and R&D, there are also ramifications for the job opportunities and the future skills base of the economy. In response to increased competition from low cost imports, the high Australian dollar and cheaper offshore manufacturing costs, there has been a flow of foreign direct investment in manufacturing from developed to developing countries. This has been a well-established trend since the 1990s (Rao et al., 2012). The loss of domestic manufacturing capability is likely to result in a loss of Australian job opportunities for highly skilled tradespeople and engineers. Highly skilled scientists, engineers and researchers are likely to pursue opportunities in other market sectors or exit the domestic innovation system. This is likely to further compound the immediate loss in innovation and R&D capabilities following a contraction in the chemicals and plastics industry.

A sustainable and healthy chemicals and plastics industry will continue to create Australian innovations that deliver benefits both domestically and globally. Some examples include:

- ♦ **Polymer Banknotes** – The industry, in conjunction with CSIRO, developed a non-fibrous and non-porous plastic film for banknotes. This substrate gives high tear initiation resistance, good fold characteristics and a longer lifetime than paper. As well as being more secure, the banknote is four times more durable than rag paper notes. Currently there are over thirty different denominations totalling some 3 billion polymer notes in service in 22 countries worldwide (CSIRO, 2011).
- ♦ **Integrated Packaging** – Round bale silage wrapped in polyethylene film has revolutionised animal feeding and pasture management. Invented in Australia and exported worldwide, this innovation of specialised films and application equipment has become the global industry standard extending milk yields and availability, improving herd, pasture and crop management and eliminating the effluents associated with previous silage systems (IP, n.d.).
- ♦ **Plantic** – A biodegradable organic food packaging alternative made from corn starch. This product was developed in Australia to minimise waste, improve production processes and achieve increased productivity. The product was developed by the Cooperative Research Centre (CRC) for International Food Manufacture and Packaging Science. (PACIA, 2013b).
- ♦ **Marplex** – Australian motor vehicles are made from 8.5 percent plastic on average. Australia also disposes of large quantities of used carpets. Marplex developed a product and process to catch old carpets before they enter landfill and recycle them into plastics suitable for car manufacturing. They believe 500 tonnes of waste nylon and 250 tonnes of waste polypropylene could be diverted annually (PACIA, 2013a).

3.2 Measuring sustainable growth – Industry metrics

The key industry metrics proposed here aim to monitor progress against a sustainable industry vision (considering economic, social and environmental impacts). These metrics facilitate a global comparison of the Australian chemicals and plastics industry.

3.2.1 Industry Revenue

Industry revenue is reported by the Australian Bureau of Statistics as sales and service income. This includes the sales of goods regardless if they are produced by the business or not, income from services and rent, leasing and hiring income (ABS, 2012a). This excludes interest income, any funding from government for operational costs and other income (ABS, 2012a). In 2010-11, the industry reported A\$38,631 million in sales and services income (ABS, 2012a).

3.2.2 Employment

Employment is measured at the end of each financial year and refers to the number of persons working for businesses in the industry during the last pay period of the financial year (ABS, 2011c). It represents part of the social contribution of the industry to the economy and the industries' contribution to human capital.

Employment cannot be interpreted as a measure of efficiency however as a higher employment rate does not necessarily mean a more efficient process (Azapagic et al., 2000). Rather, employment has been included as a metric to indicate the industry's social contribution to the economy.

3.2.3 Industry Value Added

Industry value added (IVA) measures the contribution made by businesses in an industry, to GDP (ABS, 2011c). It is equivalent to the value added to the intermediate inputs used by the industry in the production process (ABS, 2011c). It is a measure of economic activity rather than operating profit (ABS, 2011c) and is used to calculate the relative size of the industry compared to other industries.

Industry value added is calculated by the Australian Bureau of Statistics. The IVA for the chemicals and plastics industry in 2010-11 was A\$11, 651 million (ABS, 2012a).

3.2.4 Trade Balance

The Australian Bureau of Statistics collects monthly trade data for each industry. The trade balance can provide information about the degree of integration of the domestic industry into the global chemicals and plastics economy. It is also an indicator of the contribution of the domestic industry to global output. A trade surplus would result if the domestic industry exported a greater value than it imported, thus indicating that the domestic production is produced competitively domestically compared to overseas.

In 2012, the domestic chemicals and plastics industry had a trade deficit of A\$11, 719 million (ABS, 2013), calculated as exports minus imports.

3.2.5 Safety performance – Lost Time Injury Frequency Rate (LTIFR)

Australia has a high health safety and environmental management record and ranks amongst the best performing countries in the world (Productivity Commission, 2010). One of the standard health and safety metrics collected and reported in Australia is Lost Time Injury Frequency Rate (LTIFR).

A lost-time injury is defined by Standards Australia as an occurrence that resulted in a fatality, permanent disability or time lost from work of one day/shift or more (Safe Work Australia, 2013). The LTIFR is per million hours worked and is calculated as below:

$$\text{LTIFR} = \frac{(\text{Number of lost-time injuries} \times 1,000,000)}{\text{Total hours worked in accounting period}}$$

The LTIFR is a standard measurement reported by Safe Work Australia for serious claims (the loss of at least one working week or more) and this safety metric has been decreasing in the chemicals and plastics industry, reaching the point where it is at or below the manufacturing sector industry average (Figure 13).

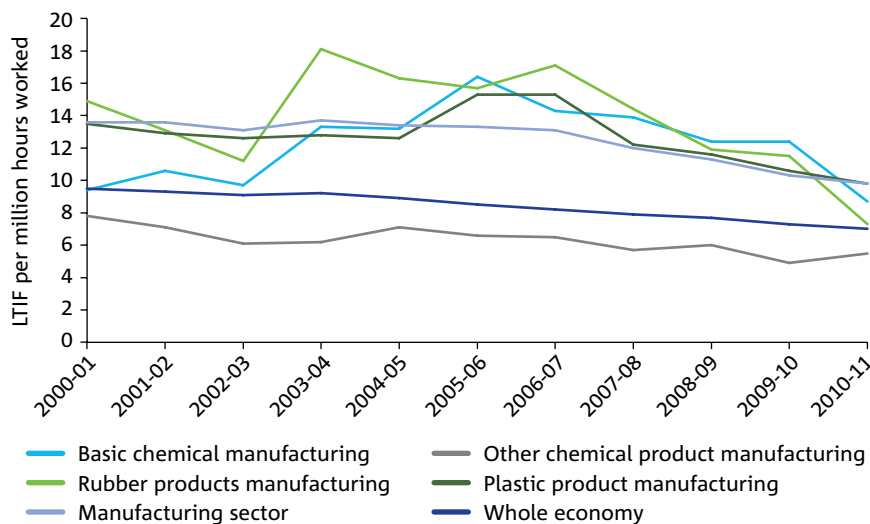


Figure 13. Australian lost time injury frequency rates, by industry

Source: Safe Work Australia (2013)

3.2.6 Supply Chain Stability – Lost Production/Shareholder Value Resulting From Supply Chain Disruption

All supply chains are subject to some degree of risk. A supply chain disruption occurs when an unanticipated event disrupts ‘the normal flow of goods and materials within a supply chain’ (Craighead et al., 2007). They can be categorised into two different groups; disruptions and delays. As a result, there is operational and financial impact to companies within the supply chain (Craighead et al., 2007). For example, supply chain disruptions have been

estimated to decrease shareholder value by 10.28 percent (Hendricks et al., 2003).

There is no single metric in Australia that currently quantifies supply chain disruption. Total \$AUD of lost production value and either total \$AUD or percentage of lost shareholder value due to supply chain breakdowns could provide a benchmark in quantifying the stability and reliability of industry supply chains in Australia. These metrics are not without their difficulties. Clear guidelines are needed for what classifies as a disruption or delay and in turn the directly attributable production value decrease as a consequence of a disruption. Jointly, these two metrics would demonstrate the importance of supply chain linkages between the chemicals and plastic industry and downstream industries.

3.2.7 Clean Industry – Number of Facilities Reporting Chemical Spills and Incidents

Industry is required to measure and report the emission of toxic and hazardous substances. Information pertaining to chemical spills and incidents is captured in Australia’s National Pollutant Inventory (NPI) and data from NPI is publicly available through the Department of Sustainability, Environment, Water, Population and Communities. Emissions to air, land and water are included in the NPI and it tracks over 93 substances (Australian Government, 2013a). Chemicals and plastics facilities are required to report once certain criteria have been met. Over the previous five years, the number of chemicals and plastics facilities reporting to the NPI has remained relatively constant (Figure 14). Each facility reports on the substance type and quantity emitted.

The number of facilities reporting incidents is part of the summary NPI data readily available for the Basic Chemical and Chemical Product Manufacturing sector and Polymer Product and Rubber Product Manufacturing sector. The quantity of substance emissions could also be used as a metric in lieu of the number of facilities reporting to the NPI database. A metric relating to chemical emissions is important as the general public are interested in industry emissions and facility safety. In addition the data is already publicly available and a decrease in the number of facilities reporting to the NPI indicates increased control over potentially hazardous emissions.

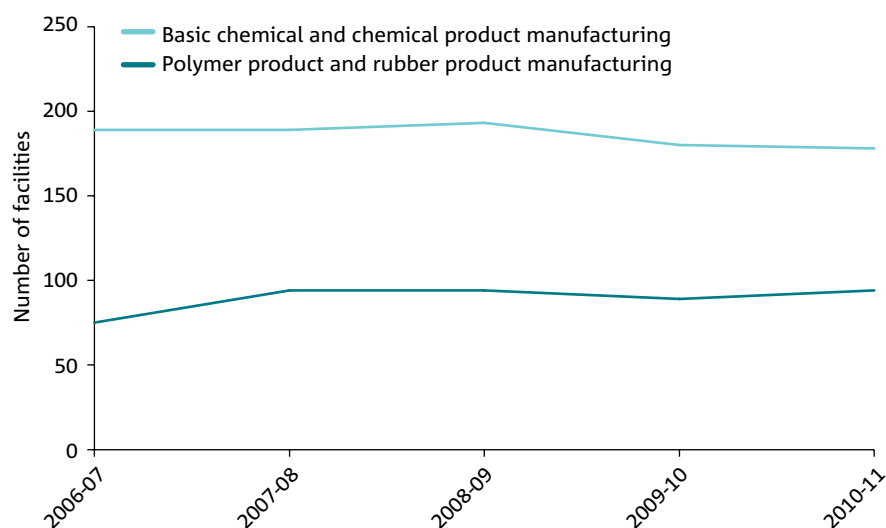


Figure 14. Number of National Pollutant Inventory facilities reporting in the chemicals and plastics industry

Source: Australian Government (2013a)

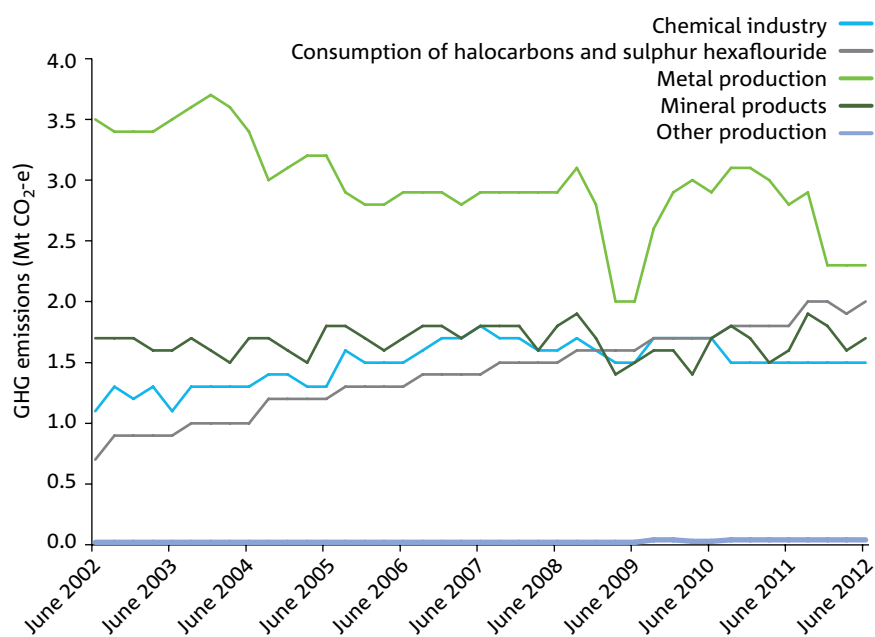


Figure 15. Quarterly emissions from industrial processes, 2002-2012

Source: Australian Government (2012a)

3.2.8 Greenhouse Gas Emissions

The chemicals industry has a dual effect on greenhouse gas (GHG) emissions. Although it produces emissions during manufacturing, the products it creates also help to reduce GHG emissions.

The International Council of Chemical Associations (ICCA) commissioned a study that forecast global chemicals industry GHG emissions to 2030. It forecast GHG production emissions to almost double from 2005 to 6.5 GtCO₂e +/-35 percent in 2030, accounting for increases in production.

However, the study also found that the products the chemicals and plastics industry enables have the potential to decrease GHG emissions by a factor of 4:1 (ICCA, 2009) – meaning that for every unit of emissions generated in production, four units of emissions are saved through the use of the product. According to the ICCA study, the three products with the most potential for GHG emissions savings are:

- Insulation materials, which can make buildings more efficient and decrease the need for heating and cooling;
- Fertilisers and crop protection, which increase agricultural efficiency; and
- Advanced lighting solutions (such as compact fluorescent lights) which are more energy efficient than incandescent bulbs.

The Australian Government has committed to reducing carbon emissions to at least 80 percent below 2000 levels by 2050 and, as an intermediary target, aims to reduce emissions by between 5 and 15 percent below 2000 levels by 2020 (Future Manufacturing Council, 2011). This will impact on the manufacturing industry as a producer of greenhouse gas emissions. The industry accounted for over 28 percent of greenhouse gas emissions in 2005 (Future Manufacturing Council, 2011).

The latest release of Australia's national greenhouse accounts shows a steady increase in quarterly emissions from the chemicals industry from 1.1 to 1.5 megatonnes of carbon dioxide equivalent (MtCO₂-e) (Figure 15). Since 1990, the chemicals industry's emissions have grown 188 percent to 5.9 MtCO₂-e (Australian Government, 2012d).

3.2.9 Energy Efficiency

Energy efficiency is an important metric as it is linked with productivity improvements that go beyond reduced energy costs and reduced GHG emissions. Examples of non-energy benefits resulting from energy efficient processes or technologies are reduced waste and emissions, improved operating environment, improved working environment and material reduction (Worrell et al., 2003).

Recognition by the Australian Government of the importance of energy efficiency for the future competitiveness and productivity of the Australian manufacturing sector is evident in the Clean Energy Future Fund. The Clean Technology Investment Program and the Clean Technology Food and Foundries Program were allocated \$800 million and \$200 million respectively (Australian Government, 2012b). These funds support manufacturers to invest in energy efficient technologies.

④ Market Growth Areas



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Market growth areas describe industries or subsectors that are currently or are expected to experience significant growth. These industries all rely on inputs from the chemicals and plastics industry and therefore present future opportunities. The market growth areas described in this section have both domestic and global dimensions. The focus of this report is on both domestic and global opportunities. Global trends will have far-reaching impacts on domestic markets and open up opportunities for exports.

The market growth areas explored include:

1. Agriculture and Food
2. Mining
3. Building and Construction
4. Materials Recycling
5. Healthcare and Wellbeing

Each market growth area relates to one or more of the megatrends identified in CSIRO report “Elements in Everything.” 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. These megatrends point to possible risks and opportunities that will impact future growth in the chemicals and plastics industry.

Before examining the growth areas in detail it is worth noting the overall growth in human population (fuelling the demand for chemical and plastic products) and the macro-economy. The specific areas of growth fall against a backdrop of domestic and global population and economic growth:

- ♦ Australia’s population is forecast to grow from its current level of 23 million persons to between 31 to 43 million persons by the year 2056 (ABS, 2008). The world population is forecast to grow from its current level of 7 billion persons to 9.5 billion persons by the year 2056 (United Nations, 2011); and

- ♦ Over the period 2012 to 2017 Australian economic output is forecast to grow from A\$1.376 trillion currently to A\$1.633 trillion, developing Asia economic output is forecast to grow from US\$12 trillion in 2012 to US\$20 trillion and world economic output is forecast to grow from US\$72 trillion in 2012 to US\$94 trillion (IMF, 2012a).

This background population and economic growth will fuel increased demand for chemical and plastic products because they are fundamental to people’s day-to-day lifestyles and the needs of all industry sectors. The following sections examine the specific growth areas in detail. At the end of each growth area are exploratory questions about the possible opportunity that might exist for industry.

4.1 Agriculture and Food

Major growth prospects exist in the agricultural sector driven by global food demand growth in coming decades. As identified in the megatrend ‘Food for All’, the two primary drivers are population growth and economic growth in developing countries. In recent years supply and demand forces have caused global food prices to reach their highest levels on record (Figure 16). Forecasts suggest that food prices will remain high over the next ten years.

Supplying sufficient food to balance supply and demand will be an ongoing global challenge, underpinning strong prospects for the Australian agrifood industry over the long term. The chemicals and plastics industry supplies many products to this industry, including fertilisers, herbicides, pesticides, food

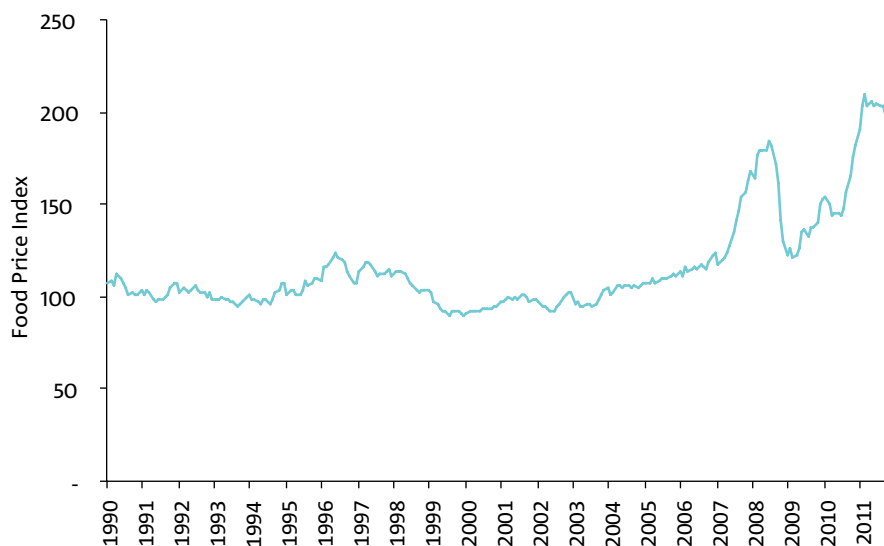


Figure 16. United Nations Food and Agriculture Organisation (FAO) Global Food Price Index

Source: Food and Agriculture Organisation of the United Nations, Food Price Index.

additives, food preservatives and packaging for food transportation.

Based on assumptions about population growth, changing diets and agricultural systems the United Nations Food and Agriculture Organisation (FAO) forecast that food production must increase by 60 percent by the year 2050 (Alexandratos et al., 2012).

Whilst demand is growing, supply is constrained. Every year the world loses around 12 million hectares of productive agricultural land which, if kept in production, would have produced around 20 million tonnes of grain (UNCCD, 2011). The amount of agricultural land being added is relatively small.

The essential gains in production will predominately occur through yield and productivity gains – not the expansion of agricultural land (OECD & FAO, 2012). Regions that will see the most rapid growth in agricultural production are sub-Saharan Africa, South Asia and the Near East/North Africa (Alexandratos et al., 2012).

Fertilisers and other agrochemicals represent methods to achieve yield/productivity growth relevant to the chemicals and plastics industry. They have proven to significantly increase farming productivity in developed and developing countries in the past. Looking to the future, chemistry will again underpin many of the innovations required if world food demand is to be met. Much of the growth in fertiliser consumption will occur in the developing world. The International Fertilizer Association (IFA, 2011) estimates that world fertiliser consumption in 2011 was 175.3 megatonnes of nutrients (nitrogen, phosphorus and potassium). The IFA (2011) forecasts annual growth of 2.2 percent reaching consumption of 189.9 megatonnes by the year 2015.

In addition to demanding more food people's 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, 2011c; OECD & FAO, 2012). An estimated two billion people are expected to have joined the middle income class by 2030 (Wilson et al., 2008), significantly changing the types of food demand. As people become wealthier, they tend to express a preference for higher protein-content foods. People in developing countries are, on average, increasing meat consumption at the rate of 5 percent per year (FAO, 2003).

Another issue of growing importance is food wastage. The chemicals and plastics industry has a critical role to play in reducing food waste via the provision of innovative packaging solutions and food preservatives to improve shelf life. A recent study finds that one-third of food produced for human consumption, or around 1.3 billion tonnes, is never actually eaten (FAO,

2011b). The wastage occurs throughout the supply during initial production, transportation and storage (OECD & FAO, 2012). Food wastage is higher in the developed world. It is estimated that in wealthy countries people dispose of 95 to 115 kilograms of food per year while in Sub-Saharan Africa and South/Southeast Asia the amount is 6 to 11 kilograms per year (FAO, 2011b).

An important characteristic of global food production will be the expansion of agricultural supply chains. People are increasingly dependent on global markets for their daily energy intake. Over the past half-century people have increased consumption of imported cereals from 26 kilograms per person per year in 1961 to over 46 kilograms per person per year in 2009, a 77 percent increase (FAO, 2011a; Hajkowicz et al., 2012). More food is moving around the world today than ever before and people are more reliant on global supply chains. This creates an opportunity for the chemicals and plastics industry to supply products essential for the efficient operation of food supply chains (see Figure 12).

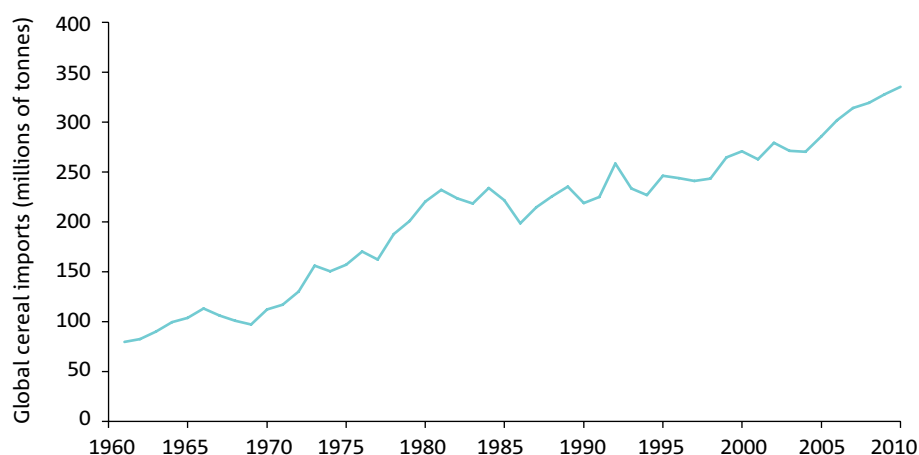


Figure 17. Worldwide imports of cereals, 1960-2010

Source: United Nations Food and Agriculture Organisation, FAOSTAT

Supplying sufficient food to balance supply and demand will be an ongoing global challenge, underpinning strong prospects for the Australian agrifood industry over the long term. In 2010-11 the value of farm and fisheries food production (including food manufacturing) was \$40.7 billion (DAFF, 2012). The Australian agrifood 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, 2012). The outlook for the domestic agrifood industry is positive: the Australian Bureau of Agricultural and Resource Economics and Sciences 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). The Australian agrifood industry is likely to remain a relatively strong exporting industry and a stable domestic consumer of chemical and plastic products and services. The need for the development of technologies appropriate for the Australian environment, many of which may be based on chemical and plastic products, will continue.

Whilst demand is set to grow, the agricultural sector will be challenged due to supply volatility. It is well established that agricultural markets are intrinsically subject to greater price variation than other markets due to the occurrence of natural shocks, low short-run demand elasticity, and the low ability for supply to respond to changes in demand in the short term (FAO et al., 2011). This volatility could potentially impact chemicals and plastics manufacturers supplying the downstream agrifood industry in addition to upstream volatility challenges.

In a report on price volatility in food and agricultural markets, the FAO (2011c) note that whilst volatility in agricultural commodity prices has been higher than usual in the decade since 2000 compared to the previous two decades, it cannot yet be considered outside normal cycles seen in the industry over the long term. However, the FAO argues that a range of factors from increasing investment in financial derivatives markets for agricultural commodities to climatic factors increase the likelihood that higher food prices and volatility will not settle back into a business-as-usual scenario (which is itself relatively

volatile) but will instead continue over the coming decades. To be successful in supplying the agrifood sector therefore, chemicals and plastics manufacturing firms must have reliable processes and tools to respond flexibly and mitigate exposure to volatility in this market.

The ability to respond quickly to changes in customer requirements is one method that can be used by manufacturers to manage volatility (Christopher, 2000). This can be achieved in part by careful supply chain management, founded on close partnerships and collaboration between entities along the supply chain. In the case of chemicals and plastics supply into agrifood industry, firms must be capable of reading and responding to real demand which can be improved through developing relationships that allow information to be shared.

What has been referred to by some (NFF, 2012) as the forthcoming “Food and Fibre Boom” will create downstream opportunities for the chemicals and plastics industry. There will be a requirement to supply packaging, fertilisers, herbicides, food additives and innovative supply chain products.

Emerging Questions

1. What types of new fertilisers and crop protectors can Australia's chemicals and plastics industry create to help improve productivity and efficiency in the agriculture and food industry?

2. A significant proportion of produced food is never actually eaten. What opportunities are there in packaging to prevent this wastage, both at the consumer end and throughout the agricultural supply chain?

3. What barriers exist that might prevent the Australian chemicals and plastics industry from being a global leader in herbicides and pesticides?

4.2 Mining

The mining industry has been identified as a market growth area and encompasses the megatrends 'Emerging Markets' and 'Resource Scarcity'. Developing economies require mineral resources to grow and develop while the continued demand for these resources will place pressure on declining mineral reserves. More efficient and productive extractive techniques will be required as ore grades continue to decline.

The mining sector utilises only approximately 3 percent of the total output produced by the Australian chemicals and plastics industry compared to the manufacturing industry which utilises 39 percent of outputs (ABS, 2011b). However, as the mining sector accounts for a larger proportion of GDP, the mining sector has potential to become an increasingly important part of the future market for the Australian chemicals and plastics industry (Figure 18).

Chemicals are used in the mining process to assist with the recovery and extraction of minerals and materials from ore. Given the gradual expected

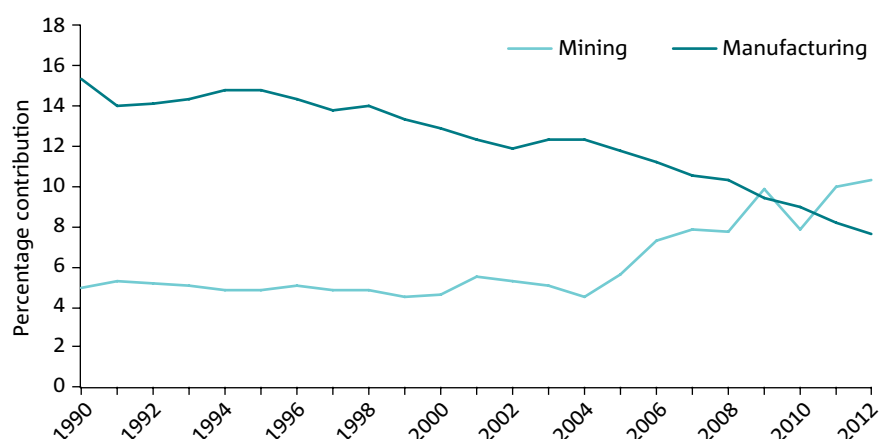


Figure 18. Percentage contribution to gross value add, by industry, 1990-2012

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

decline in ore grades (BREE, 2012d), mining chemicals can play a key role in increasing the profitability and efficiency of mining operations (Chadwick, 2012). Explosives and drilling application are the largest and most rapidly growing mining chemicals markets globally, largely driven by demand from the coal sector (Chadwick, 2012).

Polymeric chemicals, such as polyurethane, phenolic and urea silica based resins, are used throughout the mining and construction industries for a number of applications (DEEDI, 2010). Most common is its use in underground coal mining where common applications involve cavity filling, formation of temporary plug seals, strata binding of fractured or unstable roof and flat-proofing (DEEDI, 2010). A number of chemicals are used in the hydraulic fracking process in the extraction of gas. Typical chemicals used in this process include acids, sodium chloride, polyacrylamide, ethylene glycol, borate salts, sodium/potassium carbonate and citric acid among others (Department of Mines and Energy, 2013).

Chemicals are also used in the mineral processing of precious metals such as copper and gold. Cyanide is typically used in the mining industry to extract gold. The Australian mining industry utilises around 80 percent of the domestic cyanide production (DRET, 2008). It is a highly toxic chemical, however in Australia there have been no attributable deaths to cyanide poisoning in the previous 100 years (DRET, 2008).



Australia has a strong and well established mining sector. The country is currently the largest exporter of iron ore and black coal with demand driven largely by emerging Asian economies (BREE, 2012a). Australia is expected to maintain its dominance in iron ore exports and remain a strong competitor in the coal industry (BREE, 2012a). Current production of LNG makes Australia the fourth largest exporter in the world and, based on available resources, is expected to remain a major exporter in coming decades (BREE, 2012a).

The outlook for the Australian mining sector is uncertain however, owing to declining commodity prices ending a ten year boom in Australian mining (Figure 19). Although it is expected that the demand for commodities will recover to a degree, commodity prices are expected to gradually decline from the historical highs as a result of the extra supply generated by high levels of mining investment in Australia (Kent, 2013). As a result of this decline, investment decisions are being delayed or re-considered (BREE, 2012c). Therefore, while mining investment in Australia is expected to remain high for some time, it is likely to peak at a lower level and earlier than expected given revised economic outlooks (Kent, 2013). This peak may occur within four years as the current growth in mining investment is fuelled largely due to decisions made in the past as opposed to new developments in the current economic environment (Deloitte Access Economics, 2012; RBA, 2013). This is subject to uncertainty however, and even when mining investment slows, the operational phase of mining will commence (Kent, 2013) ensuring continuing activity in the mining industry.

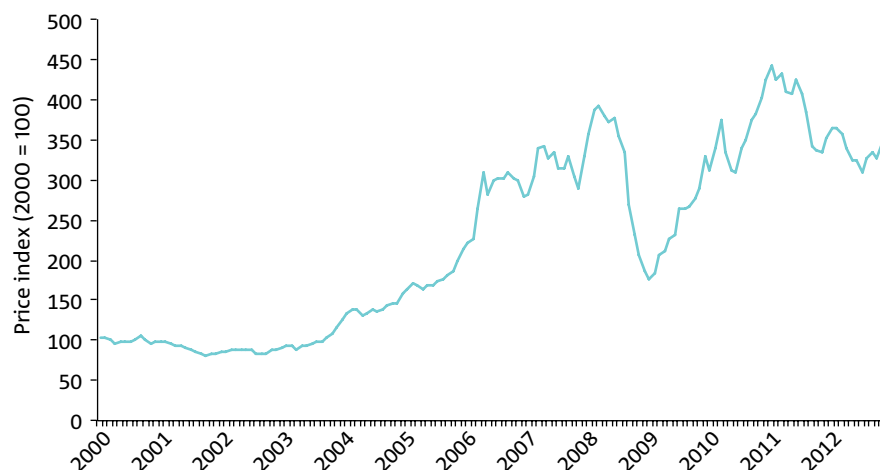


Figure 19. Minerals, Ores and Metals Commodity Price Index, 2000-2012

Source: United Nations Conference on Trade and Development (UNCTADstat, 2013)

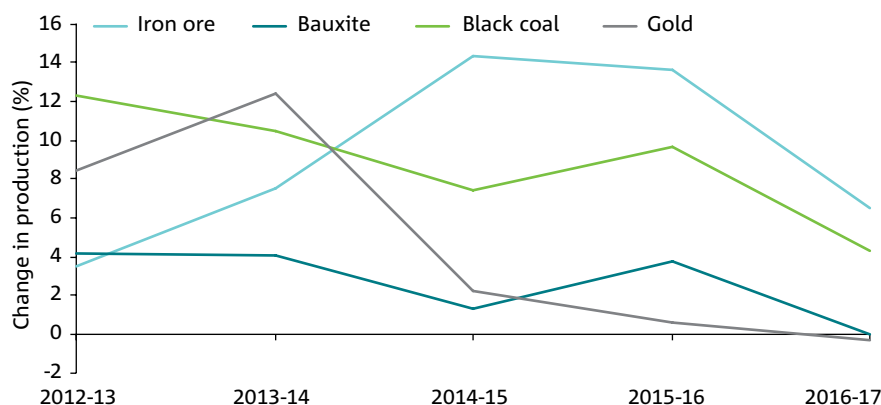


Figure 20. Forecast change in Australian production of selected minerals

Source: Deloitte Access Economics (2012)

Mineral exploration, a key indicator of future mining investment, has increased 252 percent from \$2 billion in 2001-02 to \$7.4 billion in 2011-12 (BREE, 2012c). Although petroleum exploration has been declining recently, expenditure on mineral commodity exploration increased by 32 percent to \$4.1 billion in 2011-12 from 2010-11 (BREE, 2012c). Expenditure in iron ore and coal exploration, as well as gold and base metals, were the main drivers of that increase (BREE, 2012c). A substantial proportion of Australia's investment is devoted to LNG projects however (BREE, 2012c), an area of growing interest and potential. Although these projects will be conducted in a tighter operating environment and slower economic conditions, there is considerable potential in this market which will continue to drive mining growth. Growth in minerals mining is expected to slow as illustrated in Figure 20. By comparison however, natural gas production is expected to grow at an average annual rate of 5.5 percent out to 2034-35 (Geoscience Australia and

BREE, 2012). The magnitude of already committed LNG projects is expected to sustain high mining investment for a couple of years (RBA, 2013).

The tighter operating environment creates an opportunity for the use of mining chemicals. The decline from peak prices has placed increasing pressure on mining companies to reduce costs and improve productivity (Booz & Co., 2012). There is high potential for innovative chemical and plastic products to cut costs in the mining sector.

As a result of this growth in Australia's mining industry the accompanying mining services sector has emerged and has become a major exporter in itself. Australian export sales revenue in mining services have grown at approximately 25 percent over recent years (Tedesco et al., 2010). In 2008-09 it was estimated that sales revenue from the mining technology services and engineering sector was A\$8.7 billion, equal to 0.7 percent GDP, with export of \$A2.5 billion and employment of 31,000 people (Tedesco et al., 2010).

The mining industry globally has been influenced by the European debt crisis and a general slowdown of global growth. The future is likely to continue to be volatile, with tight supply and continued strong demand driven by developing countries, China, Brazil and India (PwC, 2012b). China continues to show strong demand for steel exports from Australia as they restock inventories (RBA, 2013). The United States have recently increased coal exports as domestic energy demand shifts towards natural gas, which has contributed to a decline in the price of coal (RBA, 2013). This is compounded by reduced demand for coal in Asia and Europe, however global demand is expected to show some signs of recovery as global economic conditions improve (RBA, 2013). Despite the ensuing global uncertainty, the OECD (2012b) expects the Australian mining industry to continue to grow with export growth gathering pace as a result of the expansion in mining capacities and the expected improvement in economic conditions in 2014.

Emerging Questions

1. What mining chemicals could be developed to help the Australian mining industry extract maximum benefit for declining ore grades in the future?

2. Mining investment in Australia is currently being driven by LNG projects. What inputs can the chemicals and plastics industry supply in the gas extraction process?

3. The Australian mining services sector is highly advanced in areas such as explosive and mineral ore processing. Are there opportunities to sell this know-how to other countries in the process of building up their mining sectors?

4.3 Building and Construction

This market growth area relates to the 'Emerging Markets' megatrend and the expected urbanisation of developing countries, although the growth in building and construction is also expected to encompass developed economies.

The construction industry covers businesses engaged in building residential, industrial, commercial and engineering structures including public and private sector infrastructure. The construction industry accounts for some 7 percent of Australia's gross domestic product and employs some 9 percent of the Australian workforce. It is the fourth largest contributor to Australia's economic output (ABS, 2010b). The construction industry holds a similar place in most other advanced western economies.

In Australia the construction industry has grown substantially over the last decade. Based on current trends there would be an expectation for continued growth in the near term. During the year 2000 the total value of public

and private sector construction was A\$55.8 billion. This grew to an amount of A\$163 billion by the year 2010 representing annual average increases of 19 percent (Figure 21)(ABS, 2012d).

After packaging, the construction industry is the second largest user of plastics in Australia. Owing to advances in technology the use of plastics in construction is likely to expand into the future as they replace many existing materials (PACIA, 2012). A few examples of plastics products used in building would include decking, kitchen/bathroom fixtures and skylights.

In addition to plastics the construction industry consumes a large quantity of chemical products. Construction chemicals are used in all forms of residential and non-residential structures. For example, construction chemicals include additives that enhance concrete performance, paints, adhesives and sealants (Frost & Sullivan, 2012b). Modern construction techniques depend on chemistry.

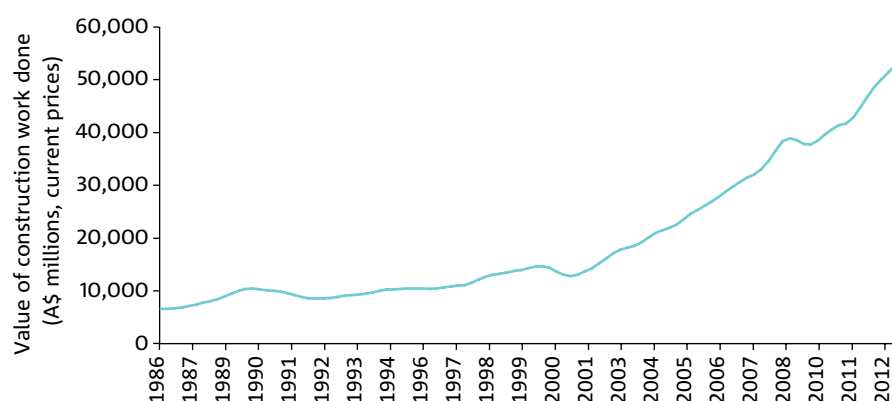


Figure 21. Time series trend in the value of monthly construction work done in Australia, 1986-2012

Source: Australian Bureau of Statistics, Current Prices, Trend Series (ABS, 2012d)

Examples of Chemicals and Plastics for Residential Construction

Source: American Chemistry Council (ACC, 2012b) and the Plastics and Chemicals Industries Association (PACIA, 2012)

Roofing – Roofing membranes made of vinyl or thermoplastic olefin can reflect light, keep buildings cool and save energy.

Insulation – Polystyrene foams can save on heating and cooling costs and are relatively easy to install.

Wall Coverings – Vinyl wall coverings are easy to clean and used in hospitals. They can be produced at lower energy cost to paper alternatives.

Windows – Vinyl windows are rivalling traditional materials as they are shatter resistant and lightweight.

Piping – Polyvinyl chloride (PVC) pipes are lightweight, easy to connect and avoid corrosion.

Decks, Fencing and Railings – Plastic wood is a long-lasting and low maintenance alternative to traditional materials.

Other Chemicals – Paints, carpet backing, sealants, concrete additives, strip roll steel coatings, cable insulation, adhesives for laminated timbers.

Other Plastics – Decking, kitchen/bathroom fixtures and skylights, EPS waffle pods, pipes, guttering electrical insulation, water tanks and irrigation systems.

Whilst the Australian construction sector as a whole has experienced growth, so too has the construction chemicals sector. Frost and Sullivan (2012b) estimate the construction chemicals industry had revenue of A\$550 million in the year 2006 and they forecast this will grow to A\$758 million by the year 2016 (Figure 22). The industry is forecast to have a compound annual growth rate (CAGR) – a smoothed measure of annualised growth – of 2.8 percent per year over the period 2008 to 2016 (Frost & Sullivan, 2012b).

Growth in the global construction industry is also likely to be strong largely due to the rapid urbanisation of the developing Asia region. According to a report sponsored by Price Waterhouse Coopers, global construction will grow by almost 70 percent from US\$7.2 trillion today to \$12 trillion by the year 2020 (Global Construction Perspectives and Oxford Economics, 2011).

The United Nations forecasts that the world's urban population will grow from its current 3.63 billion people to 6.25 billion people by the year 2050. This represents average annual growth of 1.7 percent during the twenty-year period from 2011 to 2030. Most of the growth will occur in the developing world. The developing world will have annual growth of 2 percent over this same time period and will add an additional 1.16 billion people to its urban population (United Nations, 2012). The rates of urbanisation are particularly pronounced in developing Asia and especially in India and China (Figure 23).

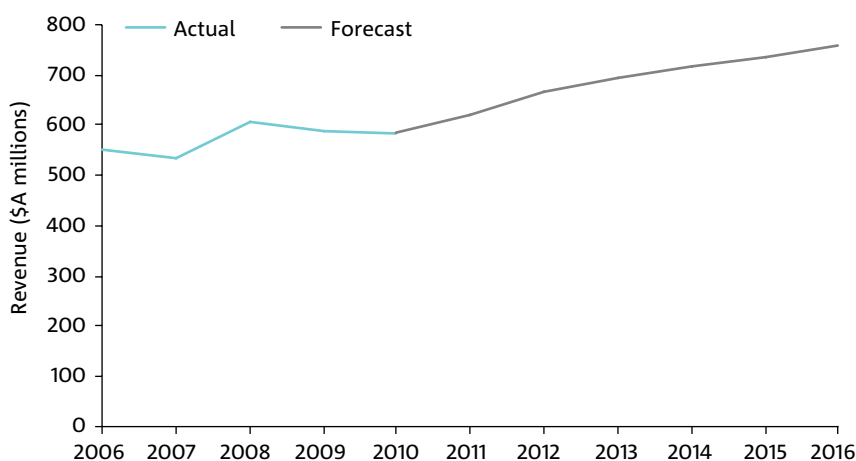


Figure 22. Revenue in the Australian construction chemicals industry, actual and forecast

Source: Frost & Sullivan (2012b)

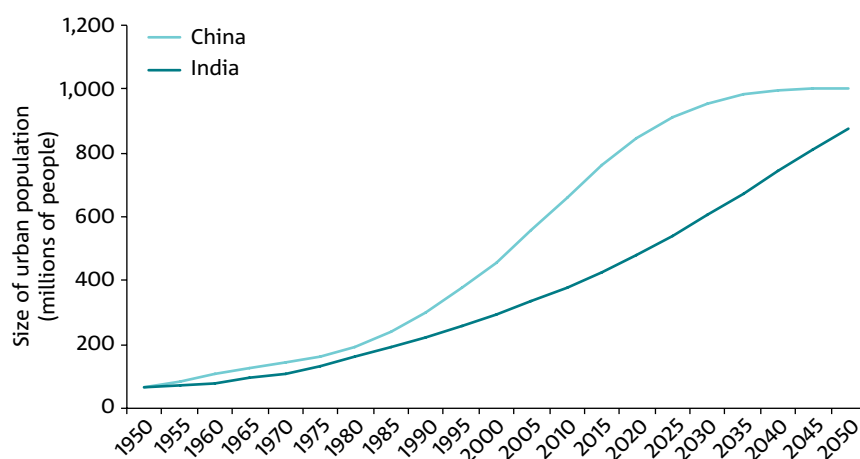


Figure 23. Historical and forecast urban population of India and China

Source: United Nations Economic and Social Affairs, World Urbanization Prospects (United Nations, 2012)

4.4 Materials Recycling

In summary future growth in the building and construction sector, both within Australia and overseas, will fuel demand for products in the chemicals and plastics industry. The underlying force of urbanisation is likely to sustain growth in the construction industry over the coming decade. As architects and builders have more specialised environment and performance design requirements innovation, especially in plastics production, will become more important.

Emerging Questions

1. Environmental and performance design requirements are becoming more specialised. How can the capacity for innovation that is inherent in the chemicals and plastics industry respond to these changes in demand?

2. Plastic has already gained attention as a building material. Is there potential for plastic to be further incorporated into building and construction and replace or complement traditional materials to a far greater extent than currently?

3. What developments are required in construction chemicals to increase the financial and environmental performance of traditional building materials?

The megatrend 'Resource Scarcity' illustrates the increasing pressure that population and economic growth will place on the world's limited supply of mineral, energy, water and agricultural resources. A resource-constrained future that needs to meet increased demand requires improved resource efficiency. One priority for resource efficiency is source reduction, where chemicals and plastics play important roles such as reducing component weight and improving thermal insulation.

In addition, recycling plays a key role in resource efficiency. Recycling enables limited resources to be used more than once and hence retrieve greater benefit. Recycling can be defined as 'a resource recovery method involving collection and processing of waste for use as a raw material in the manufacture of the same or similar non-waste product' (Environment Protection and Heritage Council, 2010, p. 361).

The main materials that are recycled in Australia include metals, organics, paper and cardboard, plastics, glass and masonry materials (DSEWPac,



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2012). Based on 2008-09 recycling rates, there is scope to increase the recycling rates across all of these categories (Figure 24) (DSEWPac, 2012).

Recycling uses a variety of chemicals depending on the product being recycled and the technique used. For example, acids are used as part of the steel recycling process (Yellishetty et al., 2011). Reagents such as alcohols, acids, glycols and amines are used in the recycling process of polyethylene terephthalate (PET) depending on

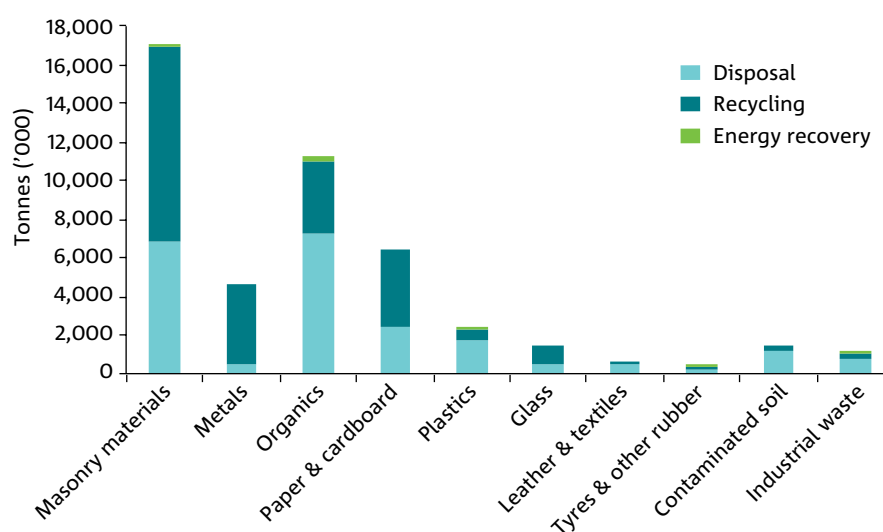


Figure 24. Australian recycling tonnage by material, 2008-09

Source: Hyder Consulting (2012)

which technique is used (Bartolome et al., 2012). Importantly, chemical recycling of PET is the only recycling method that conforms to sustainable development principles as it leads to the formation of the raw materials from which PET is originally made (Bartolome et al., 2012). Chemicals are also used as part of the recycling process for paper (Laurijssen et al., 2010). As the use of these materials continues to increase, there will continue to be opportunities for increased recycling and hence use of such chemicals.

Currently there are limited comprehensive data sources on waste generation and recycling in Australia (DSEWPac, 2012; Environment Protection and Heritage Council, 2010). Estimates show that the recycling and waste sector is valued at between A\$7 to A\$11.5 billion (Environment Protection and Heritage Council, 2010). In 2006-07, Australia generated 43,777,000 tonnes of waste², recycling 52 percent

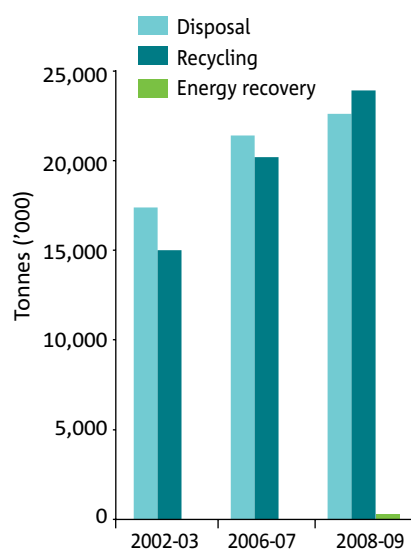


Figure 25. Total waste disposal, recycling and energy recovery, Australia

Source: Hyder Consulting (2012)

and sending 48 percent to landfill (Environment Protection and Heritage Council, 2010). This was a 35 percent increase from 2002-03. Forecasting out to 2020-21, under a medium growth scenario of 4.5 percent per annum, it is predicted that Australia will produce 81,072,593 tonnes of waste (Environment Protection and Heritage Council, 2010).

Sustained population growth, rising real per capita incomes and changes in the way people consume goods and services have created large increases in the volume and diversity of waste (ABS, 2010a; Environment Protection and Heritage Council, 2010). Environmental and cost pressures have, however, prompted more effective waste management in response to growth in waste resulting in increased recycling rates (Figure 25) (ABS, 2010a). A key objective of resource efficiency is waste elimination and chemical and plastic products can help reduce waste generation as well as its management. Where more and more waste is produced, recycling enables a more efficient use of resources.

It has been suggested that there is significant scope to take advantage of this opportunity and increase the use of waste as a resource (Environment Protection and Heritage Council, 2010). Making use of plastic waste is largely an unrealised market in Australia with as yet unexplored opportunity for what is a growing resource. The recycling of plastic in Australia has been experiencing small but consistent growth over the previous ten years, with a slight decrease in 2010-11 while plastics consumption has remained reasonably constant (Figure 26). Around half of the plastics collected are processed in Australia to make new products, with the remaining half exported for reprocessing (PACIA, 2011a). With a mechanical recycling rate of 20 percent Australia has the opportunity to recover and derive value from a greater amount of plastic waste. Recycled plastic is even being evaluated for its potential for addition to concrete (Siddique et al., 2008). The use of integrated waste management systems and technologies can make the best use of the mix of plastic materials and available markets.

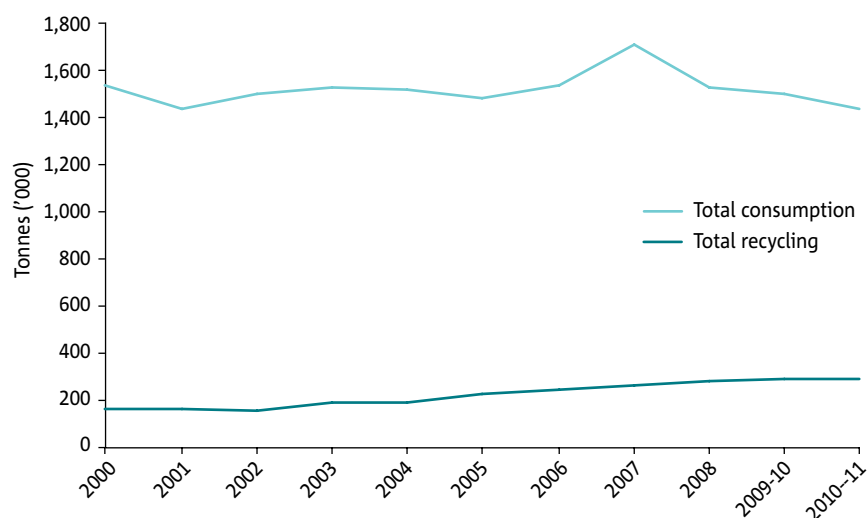


Figure 26. Australia's consumption and recycling tonnage, 2000-2011

Source: Plastics and Chemicals Industries Association (PACIA, 2011a)

²This includes municipal solid waste, commercial and industrial waste and construction and demolition waste. Hazardous waste is excluded from this estimate.

Globally, the United Nations Environment Programme estimates world production of plastics has increased by 5 percent per year over the previous 20 years. In 2010, 265 million tonnes of plastic was produced, up 15 million tonnes from 2009 (UNEP, 2013). Of these quantities of plastics produced, it is estimated that 50 percent of plastic produced is for a single use disposable application (European Commission, 2011) and up to 10 percent of human solid waste is plastic (Barnes et al., 2009; Joyce et al., 2012).

Recovery and recycling of this plastic waste is one option within the traditional waste hierarchy (prevention, reduction, re-use, recycle, recover energy, disposal/landfill) (PACIA, 2011b).

In the case of steel, it has been argued that it is always cheaper to recycle than to go through the mining and processing to produce new steel (Muller et al., 2006). Steel and many other metals are infinitely recyclable with no detrimental effects on the properties such as strength, ductility or formability (Yellishetty et al., 2011). Not only can steel be recycled for future use, but recycling can reduce the use of other resources in that are used when processing virgin materials. The World Steel Association (2009) estimated that over 1,200 kilograms of iron ore, 7 kilograms of coal and 51 kilograms of limestone are saved for every tonne of steel scrap used. In Australia, it has been estimated that recycling saves over 241,000,000 GJ of energy each year, equivalent to the energy consumption of 5 million homes (DSEWPaC, 2012).

Waste is increasingly being viewed as resource-rich 'non-waste' from which commodities can be 'mined' (Pongrácz

et al., 2004). In 2006, global electronic waste production was estimated to be between 20 to 50 million tonnes per year (Robinson, 2009). It is suggested that increased economic wealth in developing countries will correspond to increased amounts of e-waste generated (Robinson, 2009). The electronic waste resource is rich in precious metals such as gold, copper and silver. The recycling of e-waste may present unique opportunities for the application chemicals.

Not only is there a role for the chemicals and plastics industry through the provision of inputs into the recycling process, but end of life recycling schemes have seen manufacturers play a greater role in recycling (DSEWPaC, 2012). An innovative example of one company who has explored this market is the Australian plastics manufacturing company Tapex. This company has successfully introduced the 'Plasback' program. The program is a product stewardship solution targeting the recycling of all farm plastics, not just those manufactured by Tapex. This approach has created a market for plastic waste and the program aims to be self-funding. The plastic captured through the program is remanufactured into new farm products, such as a tile, board and compost bin – all made from recycled plastic. This closed loop, award winning solution has provided Tapex with opportunities to engage with stakeholders, develop their market and introduce new products such as their range of Tuffboard products (Tapex, 2012). The chemicals and plastics industry can play a role in further developing solutions and opportunities in the recycling market.



Emerging Questions

1. How can the use of chemicals in recycling be made more effective to increase the yield of the recycling process for certain materials and goods such as electronics equipment?

2. What product stewardship initiatives can be developed to increase the role of manufacturers throughout the lifecycle of the product?

4.5 Healthcare and Wellbeing

The megatrend ‘Health and Wellbeing’ illustrates the expected increased focus on health that will drive growth in the healthcare markets. Healthcare expenditure has already risen significantly over the past decade. The health-to-GDP ratio, measuring a country’s spending on health as a percentage of its spending on all goods and services, rose from 7.9 percent in 1999-00 to 9.4 percent in 2009-10 in Australia (AIHW, 2012). Over this period, health spending grew at an average annual rate of 5.3 percent compared to average annual GDP growth of 3.1 percent (AIHW, 2012). Health spending by the Australian Government is projected to grow from 4 percent of GDP in 2009-10 to 7.1 percent of GDP in 2049-50 (Australian Treasury, 2010). Over the medium term there will be growth in spending in all areas of healthcare (Figure 27).

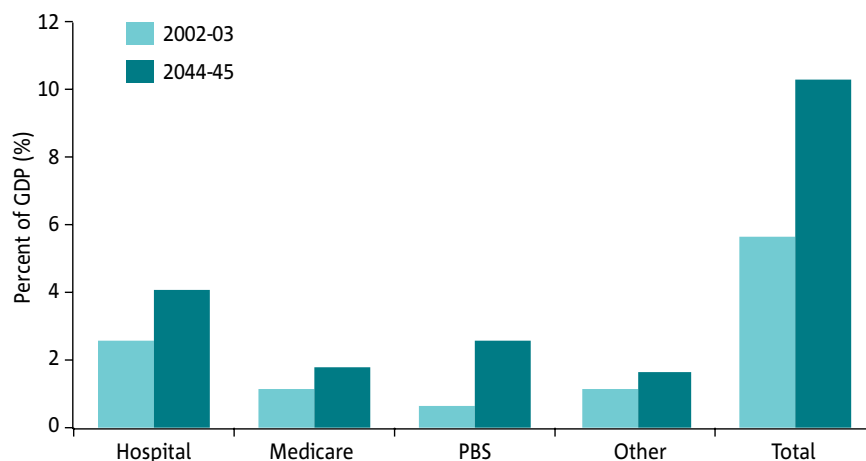


Figure 27. Projected government health expenditure as a proportion of GDP, 2002-03 to 2044-45

Note: ‘Other’ expenditure includes other health professionals, aids and appliances, community and public health, dental, ambulance services and research and administration.

Source: Productivity Commission (2005)



The ageing population is a key driver of growing healthcare expenditure. Demographic forecasts by the Australian Bureau of Statistics reveal the extent of change in the nation’s age profile. In 2011, 14 percent of the Australian population was aged 65 years and over (ABS, 2011a). By 2056, this proportion is predicted to have risen to between 23 and 25 percent (ABS, 2008). This growth in the older age brackets is expected to have significant implications for the health sector. It is estimated that health expenditure on those aged over 65 is around four times more than expenditure on those aged under 65 (Productivity Commission, 2005).

Given these demographic changes, Australia’s health landscape is likely to be characterised by a dramatic decline in infectious disease and a steady increase in diseases of the

affluent such as cancer, diabetes and heart disease (Australian Government, 2009). The types of diseases that the population is susceptible to are likely to change as the demographic profile shifts. A global analysis finds that the portion of deaths from non-communicable diseases, including cancer and cardiovascular diseases, will increase from 59 percent of total deaths in 2002 to 69 percent of total deaths in 2030 (Mathers et al., 2006).

Chemicals and plastics are a key input into the healthcare sector. As this industry continues to grow, there is opportunity for the chemicals and plastics industry to explore arising opportunities. For example, increasing demand for healthcare services combined with rising treatment costs in healthcare facilities are likely to result in an increase in home-based treatments (Frost & Sullivan, 2012a; IBISWorld, 2012). This will drive the demand for items such as dialysis kits and devices for diabetics which will consequently lead to increased consumption of medical plastics (Frost & Sullivan, 2012a). This may require adaptation of the equipment currently used in hospitals. As a key provider of the equipment for home-based treatments, the chemicals and plastics industry can play a role in developing equipment tailored to home-based care, focusing on convenience and ease of use.

This growth in the healthcare sector is not unique to Australia. Overseas economies face similar demographic changes and are facing the same associated healthcare challenges. Specifically, pharmaceutical markets in developed countries are expected to slow and be overtaken by the markets in India, China, Brazil and Russia (McKinsey and Company, n.d.-b). China's pharmaceutical market is the fifth largest in the world and, based on

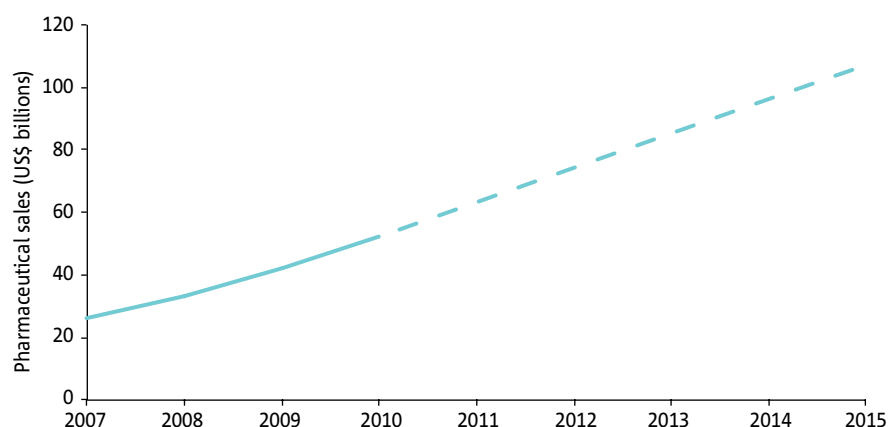


Figure 28. Pharmaceutical sales in China, 2007-2015, actual (2007-2010) and forecast (2011-2015)

Source: Deloitte (2011)

forecast levels of growth, is expected to become the second largest by 2015 (Figure 28) (KPMG, 2011a). In the 12th Five Year Plan (2011-2015), China aims to streamline drug distribution and bring pharmaceutical production and sales closer together, thereby reducing medicine prices (KPMG, 2011a).

The Indian healthcare market is being driven by increasing affordability, shifting disease patterns and modest healthcare reforms (McKinsey and Company, n.d.-a). Assuming the economy continues on its high growth path, the Indian pharmaceuticals market is forecast to grow at a compounded annual growth rate of 12.3 percent to reach US\$20 billion by 2015 and hence move into the world's top 10 pharmaceutical markets (McKinsey and Company, n.d.-a).

Modern medicine and newer therapies are expected to become more accepted by consumers in India and China due to an increased acceptance of biologics and preventative medicine in addition to

the greater propensity to self-medicate (McKinsey and Company, n.d.-b). It is expected that increased acceptability of pharmaceuticals in general will account for 25 percent of the growth in the Chinese pharmaceuticals market (McKinsey and Company, n.d.-b).

Like China, India is also expected to experience a rise in lifestyle diseases and already has the largest diabetic population in the world (McKinsey and Company, n.d.-a). Rapid urbanisation is likely to increase the prevalence of major risk factors for chronic diseases such as the consumption of processed foods and higher fat intake combined with a more sedentary lifestyle (KPMG, 2011a). The over-the-counter medicine market is a driver of pharmaceutical sales and is forecast to continue to grow given the cultural tendency to self-medicate and bypass doctors (KPMG, 2011a). Over-the-counter sales are led by cough, cold and other respiratory remedies and vitamins, minerals and nutritional supplements and pain relievers

(KPMG, 2011a). In China, this tendency, combined with a push to upgrade the nation's healthcare, will drive to secure pharmaceutical inputs in the supply chain (KPMG, 2011a). This is likely to be a key area for Australia's chemicals and plastics industry to explore.

These two economies represent major growth opportunities for Australia if the chemicals and plastics industry can position itself to take advantage of the overseas growth. By drawing on existing relationships with expanding overseas pharmaceuticals markets and identifying the unique local demands, the Australian chemicals and plastics industry can position itself as local market partners. This strategy draws upon the trend for local markets to deliver global products as a result of the rise of multinational companies (AEGIS, 2002). The chemicals and plastics industry can draw upon its crucial role in the supply chain to integrate itself into overseas supply chains.

Another dimension of the healthcare market, nutraceuticals, is also emerging as a growth market. Nutraceuticals, or functional foods, can be described as 'food engineered or supplemented to provide health benefits' (Moreno et al., 2006). The incidence of lifestyle diseases, an increase in life expectancy and inadequate nutrition intakes are all drivers of this growth such that nutraceuticals are becoming an increasingly important part of the consumer's diet (Frost & Sullivan, 2011). Consumers are becoming increasingly aware of the link between diet and health which is driving growth in nutraceuticals (Australian Government, 2004). In 2010, the global nutraceutical market was estimated to be worth US\$140.1 billion and, while interest has been growing since the 1990's,

the market has shown strong growth since the recession (Figure 29) (Frost & Sullivan, 2011). Future growth is expected to be driven by demand in India, China and Brazil (Frost & Sullivan, 2011).

The nutraceuticals market is linked to the chemicals and plastics industry via the input of food additives (ACC, 2012a). For example, bio-chemical ingredients extracted from meat-based products can be used in the treatment of arthritis (Australian Government, 2004). Research into milk proteins has shown their potential to be used in health promoting foods for diet related diseases such as cardiovascular diseases, type two diabetes and obesity (Korhonen, 2009). There are opportunities in dairy, meat, plant and grain based products (Australian Government, 2004). Developing countries such as Latin America, Asia and Eastern Europe have

been identified as areas of expected high growth where the key drivers are likely to be economic growth and increased disposable income (Australian Government, 2004). Growth in more developed economies is likely to be driven by the ageing population, rising healthcare costs and concern for food safety and environmental impacts (Australian Government, 2004). The expected growth in nutraceuticals, in addition to the wider healthcare sector, presents opportunities for the chemicals and plastics industry.

Emerging Questions

1. What food additives can be used to combat lifestyle disease such as obesity and diabetes?

2. How can the chemicals and plastics industry contribute to innovations in medical devices – e.g., through novel new plastics?

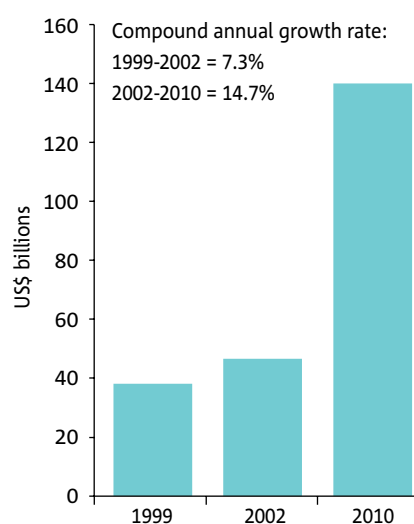
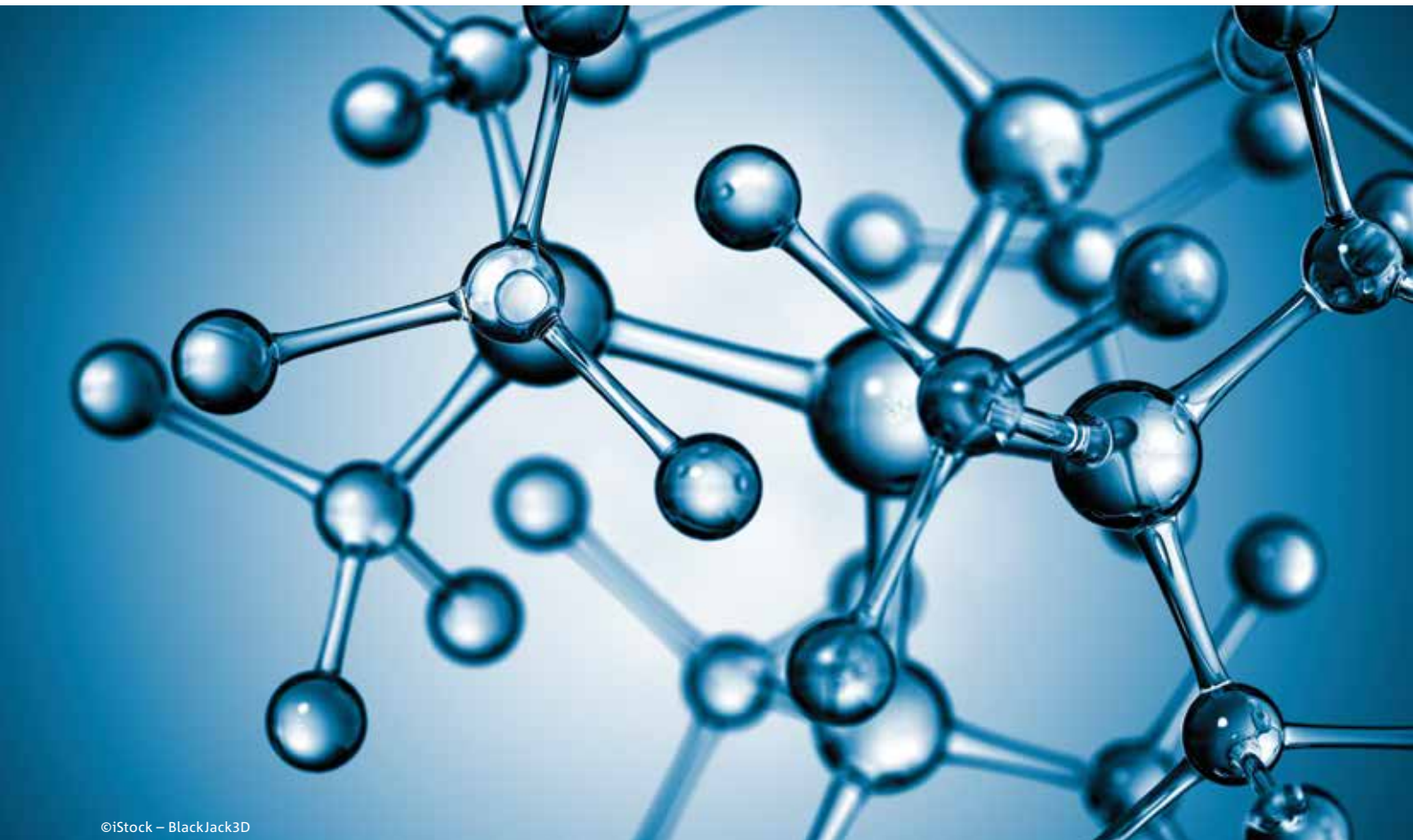


Figure 29. Growth in the global nutraceuticals market, 1999-2010

Source: Frost & Sullivan (2011)

⑤ Industry Enablers



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5.1 Nine Fundamental Needs – A View from within the Industry

In conjunction with this report, PACIA worked with key stakeholders from industry, government, non-governmental organisations and the research community and identified nine fundamental needs for the industry to achieve sustainable growth. In PACIA's words, these nine needs are:

- 1. Feedstocks** – *To operate in Australia chemicals and plastics producers need access to natural gas feedstocks. While 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.*
- 2. 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.*
- 3. 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.*
- 4. 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.*
- 5. 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 chemical and plastic products are used in our everyday lives and are essential for almost all other industry sectors, the industry has low visibility.*
- 6. Innovation and strong intellectual property** – *Australia's chemicals and plastics industry has developed many highly innovative products and advanced manufacturing systems. The industry has a need to build upon and expand the strong IP base to ensure innovation into new spaces which opens new market opportunities.*
- 7. 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 chemical and plastic 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.*
- 8. 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.*
- 9. 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.*

5.2 From Fundamental Needs to Industry Enablers

Based on the fundamental industry needs identified by PACIA and additional independent research, nine industry enablers have been identified.

Industry enablers are defined as short and/or long term actions that are available to the industry by which it can create opportunities for future growth. The enablers are outlined at a high level so they can be adapted to an industry-level action or company-level action, be it the Australian branch of a multinational enterprise or a small to medium sized enterprise operating in the domestic market. The Industry Enablers explored include:

Industry enabler	...which builds upon the industry's fundamental need for:
Feedstock development	Feedstocks
Energy supply and efficiency	Energy and utilities
Attracting capital	Competitive capital
Science, research and technology development	Innovation and strong intellectual property
Corporate social responsibility	Social license to operate
Market research and global market access	Strong customer base
Workforce skills and training	Skilled and productive talent
Targeted education and awareness	Social license to operate
Services and knowledge-based offerings	Strong customer base



The following sections describe each Industry Enabler with high-level strategic actions for each. These actions present an opportunity to disrupt the current trajectory and may involve individual businesses, industry organisations, research agencies, Federal, State and Local Governments and community groups. Identifying strategic actions helps industry garner the support and involvement of all relevant players to achieve successful implementation. The strategic actions can be implemented through investments, divestments, changes to policy, regulations and legislation and education and awareness raising activities.

5.3 Feedstock Development

Access to feedstock at competitive prices is a critical challenge for the chemicals industry. In fact, access to a competitively priced, secure domestic supply of natural gas was considered the most urgent issue facing the industry based on stakeholder input. This issue is complex and involves a great variety of stakeholders across Australia. Managing short-term needs for feedback while planning for a sustainable future is a key challenge for the chemicals and plastics industry in Australia.

5.3.1 Short Term – Natural Gas Feedstock

Gas is a critical feedstock for chemicals and plastics production. It is forecast that consumption of Australia's natural gas and coal seam gas will grow at 3.4 percent per year over the coming two decades (Syed et al., 2010). The electricity generation sector and exports of liquefied natural gas to overseas markets are primary drivers of this growth and strong demand for gas is likely to continue into the future (Syed et al., 2010).

A report by the National Institute of Economic and Industry Research (NIEIR) for the Australian Industry Group and the Plastics and Chemicals Industries Association has examined the consequences of large scale gas exports. The report estimates that for every \$1 gained in exports, \$21 to \$24 is forgone in domestic industrial output. High domestic gas prices, resulting from the linkage to the highest priced export market in the world, have made it difficult for the traditional domestic users of natural gas to secure long term gas contracts (NIEIR, 2012).

There is evidence that gas prices have hindered investment in new value-added chemical processing (Prime Minister's Manufacturing Taskforce, 2012). The NIEIR report highlights the need for recognition of the economy wide impacts of natural gas exports and proposes continued debate on how negative impacts might be prevented or alleviated (NIEIR, 2012).

The Australian Government has acknowledged interest in making gas reserves available for the domestic market. 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' (DRET, 2012, p. xiv). Furthermore, the 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' (DRET, 2012).

Australia's position contrasts with that of the United States where access to cheap natural gas, driven by the shale gas boom, is providing a boost to manufacturers and in particular, the chemicals industry. The United States has a policy of prioritising domestic gas supply.

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 very modest (Leonard et al. as cited in DomGas Alliance, 2012). Comparatively, the eastern states do not have a reservation policy for domestic use.

It is worth noting that reservations are but one of many policy instruments used to address the issue of access to natural gas. A wide range of policies and actions are available to both industry and government. These include providing better market information, reducing transaction costs, removing artificial barriers to market entry and/or other policy instruments designed to address market failure.

The comparatively low U.S. gas price is providing resurgence to the chemicals industry and the downstream users of chemical products. The low gas price is stimulating new investment from companies such as Dow Chemical who have committed USD\$4 billion to expand their production, including opening a new plant, and Formosa Plastics who are investing USD\$1.5 billion in a new ethylene plant. Both investments are partly due to access to shale gas (PwC, 2011b). However consensus from within the U.S. gas sector is that the current low prices will rise in the future to between \$4.5 and \$6 per MMBtu by 2020 (Black & Veatch, 2012). Based on the analysis undertaken by PwC, employment for the U.S. manufacturing sector is predicted to grow by at least 1 million employees to 2025. In addition, American manufacturers are forecast to save energy costs and benefit from the increased demand for products to extract the gas (PwC, 2011b).

5.3.2 Long Term – Bio-Based Feedstocks

The development of bio-based feedstocks is part of a broader global shift towards green growth. Developing a bioindustry addresses three main problems for Australia including climate change, future energy security and rural development (Cherubini, 2010). In addition, bio-based industries could create new jobs, additional export revenue, add value to existing industries such as agriculture, forestry and pulp and paper and chemicals and plastics (Bioscience, 2010; Parratt & Associates, 2010).

Bio-based feedstocks reduce pressure on fossil fuels. Australia's domestic oil consumption is continuing to rise while production is falling (Figure 30). Australia had eight refineries as recently as ten years ago. Australia has a total of five refineries in operation today (Vivoda, 2012).

Bio-based feedstocks help to reduce greenhouse gas emissions and save production costs. One scenario (Europe to 2050) predicted that the production of bio-based bulk chemicals could, under favourable conditions, result in 31 percent savings in the use of non-renewable energy, with similar

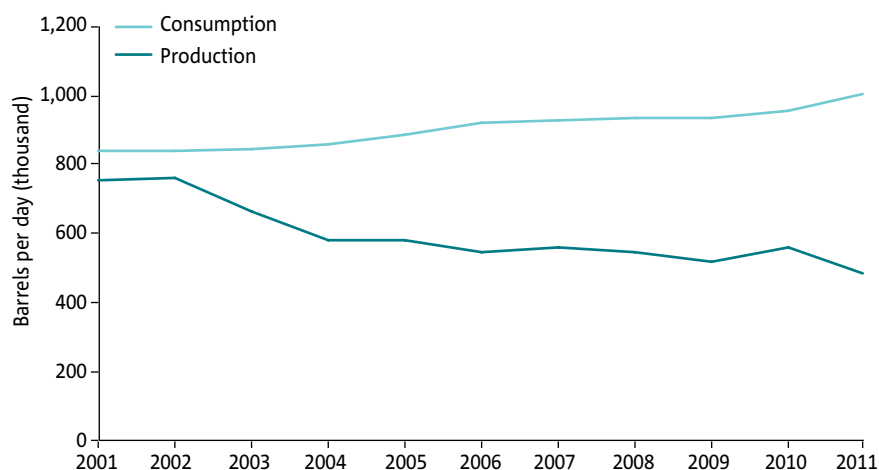


Figure 30. Australia's oil production and consumption, 2001-2011

Source: BP Energy Statistics (BP, 2012)

savings of greenhouse gas emissions. In addition, this scenario provided an estimated \$75 billion euro production costs savings (Dornburg et al., 2008).

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. Pike Research suggests that scale-up and bio-based production is no longer a question of "if", but "when". Global production of bio-based chemicals is on the rise and forecast to grow from 2 percent in 2008 up to 22 percent by 2025 and the market for bio-based chemicals could reach \$19.7 billion in 2016 (Bergeson et al., 2012). It is important to note that many international and Australian chemical companies currently utilise bio-based feedstocks. However, they are still the minority compared to existing petrochemical feedstocks. Global investments in bio-based feedstocks for the chemicals industry are comparatively low, and while they are growing, their key problem is for

the process to be cost competitive with existing fossil derived feedstocks.

Supportive policy and strategic thinking from both government and industry is necessary for the establishment of the bioeconomy to support the development of new technologies, overcome barriers to investment and assist projects compete with fossil derived technologies and established supply chains (Londo et al., 2010) (OECD, 2009). An example is the production of global biodiesel which increased from 0.8 megatonnes in 2000 to 9.1 megatonnes in 2009. Government legislation assisted this growth and 65 percent of the world's 2009 biodiesel production was from the European Union (Vlysidis et al., 2011). The Australian Government is in the process of updating its strategy for the bio-based economy and this is an important step in establishing policy that supports continued investment in bioderived feedstocks for Australian biorefineries. It is important that chemicals and plastics industry stakeholders are engaged as part of the process of developing this strategy.



Competitive access and distance to feedstocks is a key consideration for any new infrastructure investment. Investigation on potential feedstocks has already been undertaken for Australia by DIICCS RTE. The two publically available reports also include a high level account of the technology that is currently available. However, one report acknowledges that there is a lack of reliable state or national estimates of the availability and costs of biomass types (Parratt & Associates, 2010).

Bio-based feedstocks for Australian chemical and plastic products can add value to the economy. For example, high value or platform chemicals have an estimated value of US \$1,000 to \$10,000/tonne. The estimated average value of exported raw sugar between 2005 and 2010 is US \$289/tonne, however the price is known to fluctuate (Bioscience, 2010). There are estimates of an additional A\$20 billion per annum for the production of platform chemicals from forest and crop residues, in addition to bioenergy (Parratt & Associates, 2010). Both of these examples demonstrate the significant potential that the chemicals and plastics industry has to value add through the adoption of bioderived feedstocks and as part of a bioeconomy strategy.

However there are still significant costs associated with establishing a new biorefinery in Australia. Evidence suggests that multiple product biorefineries are the future of biomass refining as they have a better environmental performance compared with a single product ethanol plant (Luo et al., 2010). Australia faces competition from China, Thailand and Indonesia in attracting investment to build biorefineries (Bioscience, 2010). It is necessary to address and overcome any barriers for biorefinery investment into Australia.

As part of a strategy for developing bio-based feedstocks it is necessary to address public perception and the regulation of biobased chemicals. Regarding the former, there has been public outcry at the use of food crops for biofuels and the subsequent increases in prices (Joyce et al., 2012). Therefore any use of food crop derived biofeedstock will need to address these concerns. A similar concern could arise in competition for land use between

food and non-food crops given the trends of increasing population and high food prices. Experience suggests that clear guidelines for the regulation of bio-based chemicals are needed. In the US, there is some confusion over how the Toxic Substances Control Act should be applied to biochemicals. This results in commercial disruption and business uncertainty; both are deterrents to investing in bio-based chemicals and plastics (Bergeson et al., 2012).



CSIRO scientists are developing efficient and low-cost processes to value add to Australia's large natural gas reserve.

5.4 Energy Supply and Efficiency

The issues of feedstocks and energy for the chemicals and plastics industry are closely linked. Energy inputs required for the manufacture of chemicals, such as oil and natural gas, are also feedstocks to the chemical production process. The chemicals and plastics industry is energy intensive and PACIA have estimated that electricity costs for SME's equate to between 2 to 18 percent of input costs (PACIA, 2008a).

In 2009-10, the Australian manufacturing sector was the third largest consumer of electricity (1,261PJ), after electricity generation (1,793PJ) and transport (1,267PJ) (BREE, 2012b). According to the Bureau of Resources and Energy Economics, the dominant energy source for the chemicals industry is natural gas (Figure 31). Australia has substantial natural gas and LNG resources, with a forecast average annual growth rate in production of 5.5 percent between 2008-09 to 2034-35 (BREE, 2011). Increased domestic production, coupled with natural gas as an important energy source and feedstock, makes the issue of securing supply of natural gas at competitive prices of primary importance to the chemicals and plastic industry.

Given that energy is such a crucial resource in the chemicals and plastics industry, an important aspect is how the resource is used in the sector. Given a forecast rise in energy costs (KPMG, 2012), energy efficiency is likely to have a large impact on industry competitiveness. As identified by the Department of Resources, Energy and Tourism (DRET, 2011a), improving energy efficiency can have many benefits, such as:

- reduced expenditure on energy, permits, capital, maintenance and occupational health and safety costs;
- improved productivity, product quality and staff engagement;
- increased profits; closer alignment of energy procurement with actual energy needs;
- improved awareness of CO2 emissions from energy use and cost effective opportunities to reduce emissions;
- improved corporate reputation; and
- access to external funds for energy efficiency and greenhouse projects.

By becoming more efficient in the use of energy, the chemicals and plastics industry will be able to make better



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use of its available resources. Possible opportunities to improve the efficiency of energy usage include: optimise the use of existing equipment, maintain existing equipment, improve heat and power recovery, implement process innovation and equipment upgrade and design chemical and plastic products to enable energy efficiency (EEX, 2012). These opportunities range from simple actions to more complex strategies that deliver efficiencies in varying degrees of scope. For example, by implementing a simple procedure to switch off air conditioning systems overnight and on weekends at one plant, the Australian manufacturer Vinindex saved \$6,000 and 80 tonnes of CO2-equivalent per year (Smith et al., 2007). Genos realised a saving of \$30,000 per year in energy by monitoring and adjusting the pressure of boiler feed water pumps (DRET, 2011b).

The Clean Technology Investment Program is one avenue that may help facilitate investment to improve energy efficiency. The Program is a merits based grants program aimed to support Australian manufacturers to invest in energy efficient capital equipment and low emission technologies, processes and products (AusIndustry, 2013). In addition, the Significant Opportunities Register for Chemicals Manufacturing, maintained by the Department of Resources, Energy and Tourism is an opportunity for industry to collaborate and identify potential measures that other companies have implemented that may be beneficial to other companies in the industry.

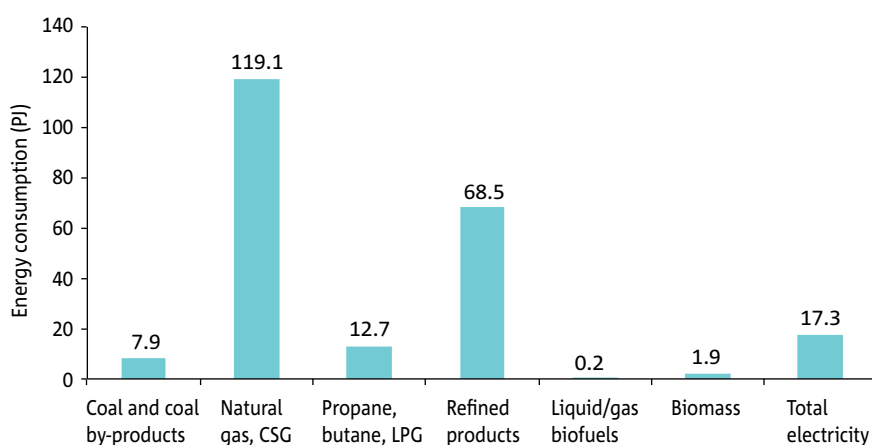


Figure 31. Energy consumption in the chemicals industry, by type, 2009-10

Source: Bureau of Resources and Energy Economics (BREE, 2012b)

5.5 Attracting Capital

Even though the global landscape is becoming increasingly competitive, Australia still has an attractive environment to support future investment in the chemicals and plastics industry.

The rise of China and India and the Asian century places Australia's strong economy at the centre of forecast growth in demand for energy, mineral resources and products and services for the rising middle class (Australian Government, 2012a).

Australia is well connected to Asian ports and has strong trade links with Asia. Australia's strong economic credentials are the envy of the world, outperforming other OECD countries in growth and resilience for many years (Australian Government, 2013b). Australia is democratically and politically stable, is effective at responding to economic challenges and has a transparent legal framework. This results in lower levels of corruption compared to the US, UK and Canada (Australian Government, 2013b).

Australia ranks 8th globally for its enforcement of intellectual property rights and its highly regulated banks are the 4th best in the world. The level of foreign direct investment has increased over the last 5 years at an average rate of 5.8 percent per year. Australia's

workforce is highly skilled, multilingual and educated, with 24 percent holding a tertiary qualification. Lastly, Australia's quality of life is excellent, ranked 6th out of 57 countries, ahead of the USA and UK (Australian Government, 2013b).

However, the cost of doing business in Australia remains high relative to other countries. Average hourly labour compensation costs in Australia's manufacturing industry in 2011 were US\$46.29, compared to US\$35.53 in the United States, US\$22.60 in Singapore and US\$18.91 in South Korea

(BLS, 2012). Australia also ranks 42nd globally in labour market efficiency, behind Singapore (2nd), Malaysia (24th), and even China (41st) (WEF, 2012). The business community cites labour regulations as being the most problematic factor for doing business, ahead of red tape (WEF, 2012).

These factors present a case for ongoing investment in the Australian economy and create a framework which can assist and sustain a growing chemicals and plastics industry.



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5.6 Science, Research and Technology Development

Innovation improves industry competitiveness and productivity. The ability to innovate relates to an ability to adapt to change, helping to create a resilient economy and society. Although investment in science, research, patents, technology development and acquisition is a subset of the broad definition of innovation, it has been shown that a company's investment in R&D is positively related to a company's innovative ability and productivity (Artz et al., 2010). Therefore investment in science, research and technology development is an important industry enabler to building competitiveness and resilience.

5.6.1 Articulate Industry Research, Development and Technology Priorities

Industry and academic leadership could be consulted to understand the short term industry research, development and technology priorities. Many industries already publish R&D priorities, in particular in the agriculture and medical sub-sectors. Prioritising R&D facilitates the efficient and transparent allocation of R&D resources. An example of where prioritisation has occurred is the US initiative to develop a technology vision to 2020 for the chemicals industry. This project was initiated by the US government who wanted an industry perspective on

how to improve the allocation of R&D funding to support the manufacturing sector. The US Government engaged with over 300 industry participants to reach consensus. This project established a vision and articulated the technical advances necessary to achieve the vision (American Chemistry Society, 1996). The industry interviews undertaken as part of this project strongly supported the proposed action to prioritise industry R&D needs and that strategic direction in this area was lacking.

Industry technology and R&D priority lists tend to encompass industry-wide challenges and may well fall within research areas such as waste management, water management, energy efficiency, urban planning, logistics and supply chain management, industrial process monitoring and control, international business etc. The industry's set of R&D and innovation priorities can then be disseminated to possible R&D and innovation partners. Through prioritising and promoting its research, development and technology priorities, the chemicals and plastics industry improves its chances for matching with appropriate partners in demand-driven R&D and innovation collaborations and ultimately improving productivity. It can also bring the benefits of providing clear signals to the industry, government and the research community around what the most pressing industry challenges are.

5.6.2 Selective Involvement in Research Hubs and Precincts

There is an increasing tendency for governments to facilitate collaborative R&D and innovation through specialised centres, hubs and precincts focussing on specific challenges. Some examples are:

- ♦ The recently announced Australian Research Council Industrial Transformation Research Hubs and Training Centres
- ♦ The Monash Green Chemical Futures and the Victorian Centre for Sustainable Chemical Manufacturing (VCSCM)
- ♦ The CSIRO Clayton Manufacturing and Materials Precinct
- ♦ The Manufacturing and Food Industry Innovation Precincts, as announced in the Industry and Innovation Statement
- ♦ Cooperative Research Centres (CRCs) such as the Advanced Manufacturing CRC and the CRC for Polymers

The consortia partners for both the Green Chemical Futures Facility on the Clayton site at Melbourne and the Victorian Centre for Sustainable Chemical Manufacturing (VCSCM) are Monash University, CSIRO, PACIA, EPA Victoria. For research to succeed chemicals and plastics industry players may also need to become involved in the centres, hubs and precincts relating to downstream industries. The chemicals and plastics industry may benefit by collaborating with R&D occurring in other industries.

5.6.3 Access State and Federal Funding to Support Technology and R&D

It may be questioned whether investment in chemicals and plastics research in Australia is sufficient to maintain global competitiveness (Ananda et al., 2008). In 2005, the Australian chemical industry was ranked eighth, in comparison to European union members with similar sized chemical industry (Ananda et al., 2008). As shown in Figure 32, chemicals and plastics industry investment in research and development dropped in around 2008 and declined further in 2009. The global financial crisis is likely to have influenced this trend. More recent data is needed to understand how Australian research investment compares with other countries or similar sized sectors.

There are many funding grants available to industry to support the access of new technologies, research and development. These grants change over time so it is important industry remains up to date with the funding programs relevant to them. Current examples are:

- The Clean Technology Investment Program which provides grants to manufacturers to support investments in energy efficient or low pollution technology, processes or products
- The Clean Technology Innovation Program supports manufacturers invest in renewable energy, low pollution technology and energy efficiency R&D
- Enterprise Connect Researcher in Business grant for SME's.

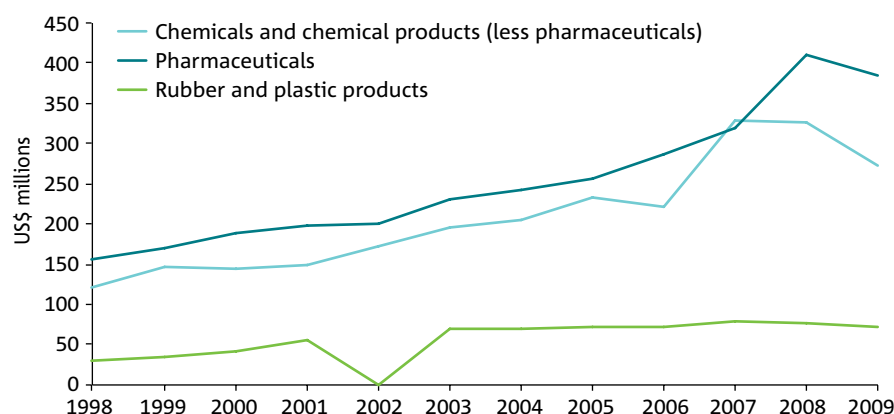


Figure 32. Australian chemicals, pharmaceuticals and plastics industry business expenditure on research and development (BERD) investment

Source: Organisation for Economic Cooperation and Development (OECD, 2012a)

5.6.4 Collaborate on Research and Development Projects

The benefits of collaboration are well documented, and collaboration has been empirically linked to the innovative performance of firms (Tomlinson, 2010). Sharing information and applying diverse expertise to understand and meet challenges can assist in delivering long-lasting competitive advantage. The workshops held as part of this project with government and industry representatives identified barriers to effective collaboration. Many stakeholders felt R&D collaboration was not occurring to a sufficient extent. Compared to other OECD countries, Australia does not perform strongly in the intensity of collaboration between industry and universities and other research organisations (DIISR, 2011b). However, it is recognised as an important issue. A.T. Kearney's 2012 Chemical Customer Connectivity Index

(C3X) found collaboration to be the key theme in future industry developments (ATKearney, 2012b). Efforts to enhance the efficiency and effectiveness of collaboration may be worth exploring.

5.6.5 Focus Research and Technology Innovation in Key Markets

This report identifies an opportunity for focused research in three key market segments: agrifood, pharmaceuticals and bio-based feedstocks.

First, there are opportunities in agrifood research. To become an exporter of agrifood innovations, investment in R&D is needed to bring new products, processes and services to market. Associated costs are large. A study commissioned by Crop Life America and the European Crop Protection Association found that the discovery and development costs associated with bringing a new crop protection chemical to market increased by

approximately 39 percent from US\$184 million in 2000 to US\$256 million in 2008 (Phillips McDougall, 2010). For development, the greatest rise was seen in the costs of field trials, which were shown to have risen by 116 percent from 2000 to US\$54 million in 2008. R&D by the chemicals and plastics industry to support the agrifood sector will continue to be undertaken across the globe; a question is whether the investment in R&D will occur in Australia. There is no doubt that there is a strong, albeit lagged, association between R&D spending and agricultural productivity improvements and that in the past Australia's strong agrifood R&D has been a competitive advantage for the agrifood industry and also the solution providing industries such as chemicals and plastics. For the chemicals and plastics industry to position itself as an agrifood solutions provider continued investment in collaborative R&D is vital.

Second, research opportunities exist in the pharmaceutical sector. The Australian pharmaceutical industry enables medical research to progress from discoveries to new medicines. The industry is a high-technology and knowledge-intensive sector, investing over \$1 billion in R&D annually (Research Australia, 2011). The majority of health R&D is conducted by the public sector and it appears that Australia is well-positioned in health R&D given levels of discovery, publications and citations

(Access Economics, 2008). It has been estimated that for the average dollar invested in Australian health R&D, \$2.17 in health benefits are returned, with a minimum of \$0.57 and a maximum of \$6.01 (Access Economics, 2008).

Australia has traditionally enjoyed a favourable reputation in clinical research in the pharmaceutical industry (Koryakovtseva et al., 2012). The largest challenge is Australia's comparatively high cost environment, however recent regulatory changes are a step in the right direction for Australia to retain its competitiveness (Koryakovtseva et al., 2012). Given the importance of pharmaceuticals in the future, R&D is an area in which the chemicals and plastics industry can expand.

Third, bio-based feedstocks provide another opportunity for targeted research. New bio-based chemical and plastic products are enabled through new technological breakthroughs and research and innovation in green chemistry. Similar to the forecast growth of new products and market growth, Pike Research forecast global growth in green chemistry from \$2.8 billion in 2011 to \$98.5 billion in 2020. Green chemistry is a driver for the design of chemical products that eliminate the need for use or generation of hazardous substances. Most of the short term growth is predicted to be in polymers as it is currently more advanced than

the speciality, fine and commodity chemical sectors (Pike Research, 2011). In summary, the benefits of developing bio-based products are to develop new products and market opportunities and address consumer demand. Global bioplastic and chemical markets are forecast to grow in coming years and the development of new bio-based products is dependent upon investment in research and development.

Developing large scale, biobased feedstocks are viewed by industry as a long term option for the chemicals and plastics industry and this was supported during the development of this report. The process of developing a bio-based technology, aligned with the current petrochemical industry could provide Australia with a smooth transition from oil to bio-based refineries (Sheldon, 2011). However, integrated biorefineries (producing both a biofuel and a bioproduct) are currently in their infancy (Sheldon, 2011). Technology that is integrated with a pulp and paper mill can provide commodity or value-added chemicals. It remains risky for a single company to 'go it alone' and invest in new biorefinery technology. Collaborative supply chain partnering, for example between a forestry, technology provider and chemical company, will help share risks, resources and benefits of developing a biorefinery business (Janssen, 2008).

5.7 Corporate Social Responsibility

Companies in the chemicals and plastics industry are likely to suffer from a reputation of the commons whereby a firm's reputation is tied to the reputation of other firms and reputation therefore becomes a common resource shared by all members of the industry (King et al., 2002). This is accepted to be the case in the chemicals and plastics industry (Barnett et al., 2008). The severity of the problem is worsened when companies are very similar or provide little information by which consumers can distinguish their relative performance and hence any individual firm will be judged by the public to be characteristic of all such firms (Barnett, 2006).

The notion of corporate social responsibility provides a method of communicating such information regarding the firms' relative performance. Corporate social responsibility incorporates the notion that companies have responsibilities to society beyond that of making profits for shareholders (Carroll et al., 2010). Corporate social responsibility reporting has essentially become mandatory for most multinational companies (KPMG, 2011b). The global chemicals and plastics industry has taken steps to address such reputational and ethical considerations and 68 percent of companies reported on corporate responsibility initiatives in 2011, up from 62 percent in 2008 (KPMG, 2011b).

Sustainability is also becoming increasingly important. The Global Reporting Initiative is an internationally accepted guideline to report on sustainability performance. KPMG (2011b) report that over 95 percent of the top 250 global companies report

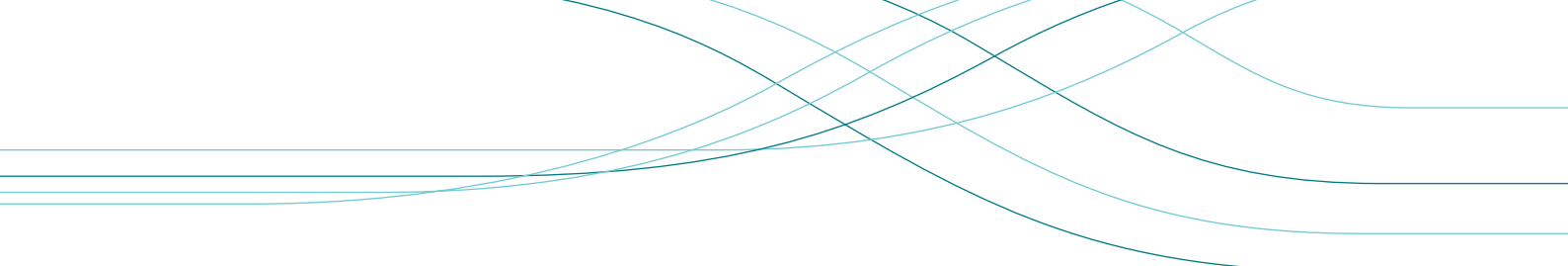
on their environmental and social activities. The benefits of reporting and engaging in corporate sustainability include reputation management, brand value, improved financial performance, customer and staff retention, improved access to capital, licence to operate, decreases in costs and risk management (Drews, 2010). Voluntary industry initiatives such as the Global Responsible Care program and PACIA's Sustainable Leadership Framework provide industry members with the tools to engage with social and environmental programs. PACIA has 40 companies who have signed onto the sustainability framework which is aimed at assisting companies with integrating sustainability into their business.

Proactively engaging in corporate sustainability can also deliver strategic opportunities that help improve company resilience in today's volatile markets. For example, evidence suggests that rather than oppose consumer demands and NGO pressure for companies to become more sustainable, companies that react positively can play a role in shaping and creating new markets (Iles et al., 2012).

Engagement in corporate social responsibility is able to increase shareholder value via improved health of employees, fewer leakages, fewer incidents and better risk management, these benefits being particularly apparent in SMEs (Martinuzzi et al., 2010). Some goals within corporate responsibility have become an industry standard rather than product differentiators, particularly health and safety indicators (Martinuzzi et al., 2010).



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Corporate social responsibility is sometimes seen to conflict with the factors of competitiveness, as many corporate social responsibility measures do not appear to be well connected to the main strategic decisions of a company or address its main societal and environmental impacts (Martinuzzi et al., 2010). This is not the case in the chemicals industry. Innovation, resource availability, trust and the social license to operate are core to a chemical companies economic success (Martinuzzi et al., 2010). It has therefore been suggested that corporate social responsibility in the chemicals and plastics industry should focus on supporting and promoting innovation, implementing health and safety standards and ensuring high (eco-) efficiency (Martinuzzi et al., 2010).

In addition, the industry can focus on the enforcement of lifecycle management of products. Product stewardship involves the responsible use and management of products during

the complete product lifestyle from discovery through to manufacturing and use to disposal (Carlton et al., 2009). Product stewardship is one initiative that can assist companies in meeting the expectations of external stakeholders in regards to sustainable development commitments (ICCA, 2007).

A lifecycle-based approach to product management improves transparency as it demands follow up on the product to downstream users (Martinuzzi et al., 2010). It also signals sustainability and helps establish the reputation of being a responsible company (Martinuzzi et al., 2010). The lifecycle approach links corporate social responsibility and competitiveness by tracing product and service improvement and by improving supply chain efficiency (Martinuzzi et al., 2010). To be effective, any product stewardship program requires close and sustained dialogue and working relationships with suppliers, customers and others in the value chain (ICCA, 2007). This ensures that information

can be shared in both directions – up and down the supply chain. The resulting evaluation and avoidance of risk reduces the potential harm and liability, making product stewardship a ‘value add’ proposition (ICCA, 2007).

Programs such as PACIA’s Sustainability Leadership Framework can be developed to cover all stages of the product lifecycle including production, consumption and end-of-life disposal (PACIA, 2008b). It is expected that producers of high value products and services will differentiate themselves on the basis of whole-of-life management (Future Manufacturing Council, 2011). Where SMEs are involved in product stewardship initiatives, the size of the program must be commensurate with the size of the company and may require action at an industry level to assist in the start-up and maintenance of such programs (ICCA, 2007).

5.8 Market Research and Global Market Access

Accurate, updated and comprehensive market information is a critical source of competitive advantage. Knowledge of both domestic and global markets is important. The growth of trade with developing Asia is opening a new set of markets which are comparatively unfamiliar to many Australian industries. In 2011-12, the largest value of exports in the chemical industry was destined for the United States (Figure 33). However, of Australia's top 12 export markets for goods and services in 2011, ten were located in the Asian region (Austrade, 2012a). Understanding the markets of these trading partners is crucial. Not only are emerging economies such as China and India playing an increasing role in terms of competition, they will also play a more important role as suppliers (Future Manufacturing Council, 2011). Integration into these global supply chains and partnering with overseas firms will enable the success of Australian manufacturers (Future Manufacturing Council, 2011). Australia already has established trade connections in the Asian region. Using these existing trade links, the chemicals and plastics industry can work to further develop these connections into industry specific linkages.

In the past, the expansion of a firm's ability to exploit overseas opportunities has been facilitated by an international orientation. Over the period from 1988 to 2008, the shift in the manufacturing industry towards a more export oriented, capital intensive and skills intensive sector helped it become more robust and respond to the challenges and opportunities

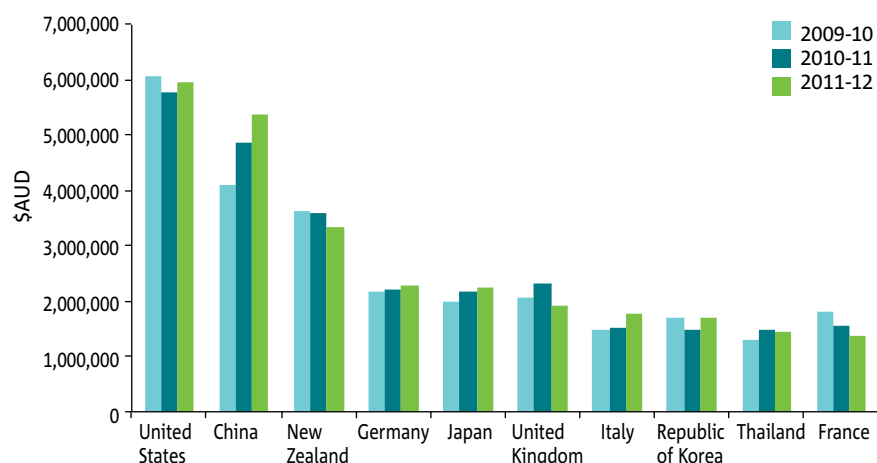


Figure 33. Australia's 10 largest export destinations for chemical exports

Source: Department of Foreign Affairs and Trade (DFAT, 2012)



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over that time period (CIE, 2009). The expansion of world trade and rapid growth amongst Asian trading partners is continuing and companies need to position themselves to take advantage of this. In terms of companies exporting to China and India, it has been shown that larger, more productive and more innovative companies are more likely to become exporters to these two countries given the high costs of conducting international activities (Navaretti et al., 2013).

In order to assist in global market access, Austrade administers the Export Market Development Grants scheme. The scheme encourages Australian SMEs to develop export markets (Austrade, 2012b). Exploring funding opportunities and initiatives such as

these will help the high proportion of SMEs to establish themselves in a global market. Staying in touch with customers and the market in general enhances the product innovation performance of a firm (Smits et al., 2011).

Market research can encompass a broad dimension of available industry information. Identifying the key information required by companies will ensure that research is effective and efficient. A study of chemical companies in the field of product development reveals four facets of market knowledge that are essential in product innovation: segment knowledge; application knowledge; product usage knowledge and customer knowledge (Table 2) (Smits et al., 2011).

The knowledge of customer needs identified in general marketing is likely to be inadequate in the chemicals and plastics industry (Smits et al., 2011). Chemical and plastic products are often versatile and can be used in a wide range of uses. Therefore the choice of application and the acquisition of appropriate application knowledge is more pertinent in the chemicals and plastics industry as opposed to an industry producing a high proportion of end consumer goods (Smits et al., 2011). The same product may be used in a wide variety of ways by downstream users and the producers of this product require a thorough understanding of all these uses in order to meet customer requirements.

In addition to specialist market knowledge, establishing global market access draws upon a greater scope of information than domestic market access. A thorough understanding of differences in business culture and meeting etiquette, variances in local market tastes and preferences and possible variations in supply chain steps may be required.

TABLE 2. MARKET KNOWLEDGE IN THE CHEMICALS AND PLASTICS INDUSTRY

Four Facets of Market Knowledge	Description
Segment knowledge	Market knowledge on parts of the overall market environment involving the aspects of segment size, segment growth rate and stakeholder behaviour.
Application knowledge	Knowledge focused on the nature of the customer application for the newly developed product
Product usage knowledge	Knowledge on how a product is used by customers and how a product behaves in downstream manufacturing processes
Customer knowledge	Additional customer information beyond needs and wants

5.9 Workforce Skills and Training

Investment in human capital is crucial to improving the productivity of the industry. A talent shortage can stall economic progress as employers delay or abandon growth plans or proceed at higher costs due to the need to hire overqualified candidates or imported labour (World Economic Forum, 2012). The inability to find skilled labour can translate to a reduced demand for unskilled labour to fill supportive roles (World Economic Forum, 2012).

Employers in the manufacturing sector are reporting skills gaps and recruitment difficulties as opposed to overall shortages (Manufacturing Learning Victoria, 2005). The skills requirement in the industry is slowly increasing and, particularly in operator jobs in the chemical and oil industry, Certificate III or IV is becoming the minimum entry point (Buchanan et al., 2002). In 2011, approximately 40 percent had an educational attainment lower than this threshold (Figure 34) (SkillsInfo, 2011). As a result of the skills gap, employers are turning to their own up-skilling initiatives to equip potential employees with the required skills.

While up-skilling by individual companies results in targeted education efforts, there are also negative spill-over effects whereby other firms try to poach newly-trained employees as opposed to making their own investments in human capital (Manufacturing Skills Australia, 2012). This can result in an underinvestment in building the necessary skill levels in the industry as a whole (Manufacturing Skills Australia, 2012). Companies who up-

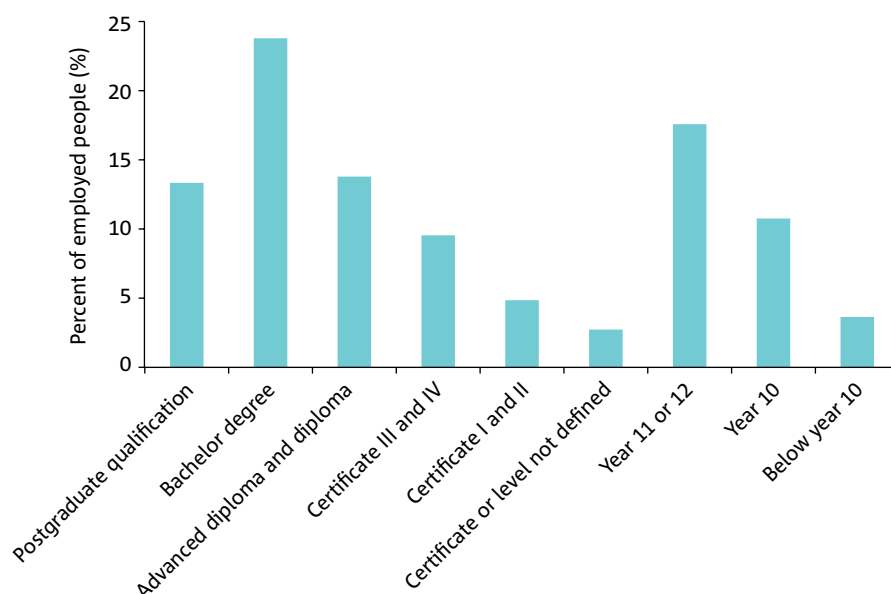


Figure 34. Educational attainment of employed people in basic chemical & chemical manufacturing, 2011

Source: SkillsInfo (2011)

skill also report on the difficulties of implementing such training while trying to maintain efficient operations in an operating environment focused on increasing global competitiveness (Manufacturing Learning Victoria, 2005).

The ageing of the workforce further compounds the problems posed by the skills gap. Currently, just below 20 percent of the employed persons in the manufacturing industry are aged 55 and above (Figure 35) (ABS, 2012f). As this cohort exits the labour force over the next 20 years, industry will need to ensure sufficient talent is attracted to the

industry to fill the gap. Currently, many employers are seeking experienced workers and finding recently qualified applicants unsuitable (Manufacturing Skills Australia, 2012). If future entrants to the labour force do not have the necessary entry-level skills, individual manufacturing companies will need to continue to up-skill their workforce.

Up-skilling may be more beneficial if undertaken by an industry-specific registered training organisation that is separate to individual companies that operate in the industry. Such training initiatives need to account

for the diversity in age groups with some age groups having a lower level of post-school qualifications but greater job experience and vice versa (Manufacturing Skills Australia, 2012). A common barrier for attracting potential entrants and retaining current employees in the manufacturing industry is the perception that manufacturing does not have a viable future pathway in the domestic economy (Manufacturing Skills Australia, 2012). Given that it is more effective to implement re-employment programs rather than manage unemployed workers (Manufacturing Skills Australia, 2012), timely and collaborative action is required by industry stakeholders to update the skills of the existing labour force to better equip them in a changing industry. This can involve local workforce agencies, unions, representative industry groups and government agencies collaborating with companies to best identify the skills required.

In the ACCI National Workplace Skills Survey (ACCI, 2011), it was found that the largest barrier to employing apprentices was the inadequate preparation in literacy and numeracy in particular. Fifteen percent reported that the Government financial incentives were insufficient (ACCI, 2011). To be effective, apprenticeship programs should adequately equip participants with the skills required in the entry level positions. Employers need to have sufficient financial incentives in order to make the required human capital investments.

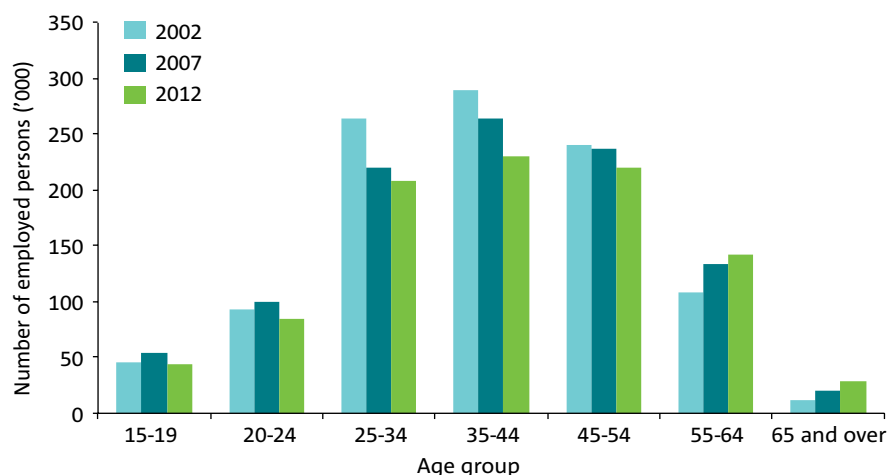


Figure 35. Employed persons in the manufacturing industry ('000), by age, year to August 2002, 2007, 2012

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



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5.10 Targeted Education and Awareness

The general public tends to have low levels of awareness of the chemicals and plastics industry. It typically only gains visibility when something goes wrong and its benefits to society are usually overlooked. For instance, the role that the chemicals industry plays in boosting and securing food production and reducing carbon emissions is often lost on the public consciousness (Johnston, 2012). Overseas industries suffer a similar reputation problem; however, there is some knowledge of the contributions of the industry. European research has found the most important benefit of the industry is perceived to be supplying 'products that enhance the quality of daily life' followed by providing 'innovative technologies for other industries' (Cefic, 2006).

Given that only approximately 20 percent of industry output is in the form of final goods (ABS, 2011b) a high level of public awareness may not be the most efficient avenue to pursue. It is likely that an education or awareness campaign would be more effective if targeted at immediate downstream users as opposed to consumers of final goods. The top five downstream industries of the chemicals and plastics industry include the manufacturing industry, construction, agriculture, mining and health care and social assistance (ABS, 2012b). Strengthening relationships with these industries is an opportunity for the chemicals and plastics industry to reinforce the enabling role that the industry plays. In addition key decision makers can be targeted to better inform these key influencers about the capabilities of the industry.

The significance of an effective and reliable supply chain represents an



opportunity for the chemicals and plastics industry. The reliability of a company's supply chain helps determine its reputation and credibility (Hendricks et al., 2003) and hence when there is a disruption in the supply of chemicals and plastic inputs these supplying companies receive a poor reputation. This reliance also presents an opportunity for the industry to capitalise on given that the industry is critical to the production of many other final goods. Education and awareness campaigns centred on supply chains can be used as a tool to engage other industries and promote the enabling role of the chemicals and plastics industry.

Targeting key decision makers and stakeholders and raising awareness

of the chemicals and plastics industry is likely to increase the social licence to operate. A social licence to operate exists when a company or industry has broad ongoing approval and acceptance of society to conduct its activities (Prno et al., 2012). While the licence is 'granted' by society as a whole (governments, communities, the public and media) it is largely local communities that enforce such permission (Prno et al., 2012).

The mining industry sometimes faces criticism from communities in and around mine sites in addition to public advocacy groups concerned with the environment, human rights, indigenous people, poverty alleviation and economic development (MMSD, 2002). The chemicals and plastics industry

is scrutinised by similar groups. The industry is likely to suffer from the same paradox as the mining industry whereby consumers enjoy the final goods but are less fond of the 'holes in the ground' needed for supply (MMSD, 2002). Given these perceptions, full compliance to state environmental regulations alone is no longer sufficient to satisfy society's expectations in regards to mining (Prno et al., 2012). As such, mining companies have effectively needed to gain a social licence to operate from affected local communities in order to avoid potentially costly conflict and exposure to social risks (Prno et al., 2012).

Mining companies have identified the imperative to engage affected stakeholder groups to effectively gain this social licence to operate. BHP Billiton (2012) have identified that their long term success depends on the ability to build mutually beneficial relationships and work collaboratively and transparently with these stakeholders, including business partners, governments, non-government organisation and host communities. Engagement with these stakeholders can be through monthly meetings to open public forums and a wide variety of issues are discussed. BHP also invests one percent of pre-tax profit to implement new and support existing community projects (BHP Billiton, 2012).

Currently, chemical and plastics companies engage with local affected communities to some degree. Given that companies in the industry already have a degree of public exposure through community funding initiatives, further initiatives can be undertaken

to specifically target affected communities (e.g., communities in the vicinity of production plant).

The lack of effectiveness of the social licence to operate in the case of SMEs compared to other sized businesses should be noted (Lynch-Wood et al., 2007). This is due to the fact that the public visibility of a company generally decreases as the size of a company decreases and thereby reducing the effectiveness of the social licence as a form of regulation for improving environmental behaviour (Lynch-Wood et al., 2007). As a result efforts towards gaining a social licence to operate have less impact on public perception of a single company than the whole industry. It is therefore likely that increasing the visibility of the industry as a whole may be more effective than increasing the awareness of individual companies. This may include voluntary self-regulation programs such as the industry's Responsible Care program, which includes a "Community Right-to-Know Code."

A social licence to operate may help address the negative industry stereotypes that can influence employment decisions. A survey of over 300 Australian graduates found that 11 percent did not wish to work in the chemicals industry solely because of its image (PwC, 2011a). Like all industries, the chemicals and plastics industry will also suffer from an ageing workforce. Given that this industry requires specialist skills, it is imperative that younger workers are employed in the industry.

As is the case with the social licence to operate, the mining sector faces a similar perception problem with 14 percent of Australian graduates not wishing to work in oil and gas, 8 percent in metals and 6 percent in energy, utilities and mining (PwC, 2011a). In America, the National Academy of Engineering sought to raise the popularity of engineering as a profession. While many individual organisations ran awareness campaigns, the most effective is believed to be the National Engineers Week due to its high visibility (National Academy of Engineering, 2002).

Career development is becoming increasingly important in what a company can offer a potential employee, known as a companies' employee value proposition (EVP) (PwC, 2012a). For an EVP to be effective, it is important to recognise what values are important to the various categories of employees working in the industry (PwC, 2012a). A survey conducted by PricewaterhouseCoopers (2011a) found that graduates in the chemicals industry value training and development programs and opportunities for career progression more highly than competitive wages and other financial incentives when considering what makes an attractive employer. Given this preference, chemicals and plastics companies can consider incentives beyond financial when seeking to employ graduates.

5.11 Services and Knowledge-Based Offerings

As it becomes increasingly difficult to compete in the area of high volume, low cost production of chemicals and plastics, companies are likely to increasingly explore alternative revenue streams. One option for Australian industry is to export Australian knowledge and capability to other markets. Another option is to move towards high value-added services-based solutions.

Developing new services is generally less risky than developing new products given that services can have ever-expanding boundaries and are not limited by what the product was first intended to do (Future Manufacturing Council, 2011). This course of action is not risk-free. Already the chemicals and plastics industry in developing Asia is highly technologically and scientifically advanced. Nevertheless there are likely to be pockets of under-developed potential where the Australian industry can provide service-oriented chemicals and plastics offerings at cost competitive rates. Less advanced manufacturing industries, such as in Africa, may also present such opportunities for Australian industry.

As the growth in the Australian mining industry increases, it has been accompanied by the development of mining expertise that is now becoming a major export industry itself. According to a report prepared by the Australian Bureau of Agricultural Resource Economics and Sciences (Tedesco et al., 2010), in 2008-09 sales revenue from the Australian mining technology services and engineering sector (MTSE) was estimated at A\$8.7 billion (0.7 percent of GDP) (Figure 36). This included exports of A\$2.5 billion. The MTSE sector is estimated to employ 31,300 people and spends A\$985 million per year on

research. The main export markets are Oceania, Africa, North America and Europe. Indonesia was noted as a particularly important country for exports. Global sales revenue has grown at 20 percent per year in recent times and Australian export sales revenue has grown at around 25 percent per year (Tedesco et al., 2010). Given the vast mineral reserves in developing country and the limited skills, infrastructure and capability to develop those resources in some countries, the MTSE sector may be well positioned to grow. The same may apply to the chemicals and plastics knowledge and services sector.

The advanced OECD economies of the United States and Europe experienced a phase of rapid industrialisation during the twentieth century. The rapid industrialisation saw increased demand for raw materials and the development of the manufacturing sector. As incomes grew, these economies shifted into the services

sector and currently around two-thirds of OECD country GDP is generated in the services sector. There is an expectation that China and the developing Asia region will follow a similar pathway (Holloway et al., 2010). Currently China is in the phase of industrialisation, building cities and manufacturing infrastructure at a rapid rate. The shift into the services sector in the future may see increased demand for services and knowledge related offerings.

In the United States steel production intensity (tons of steel per dollar unit of GDP) rose sharply until annual income (GDP per capita) reached around US\$12,000 (Holloway et al., 2010). It then declined, equally sharply, as income growth continued to current levels. Steel production intensity is a lead indicator of economy wide transition from industrialisation into the services sector.

If China follows the same pathway of economic development as the United

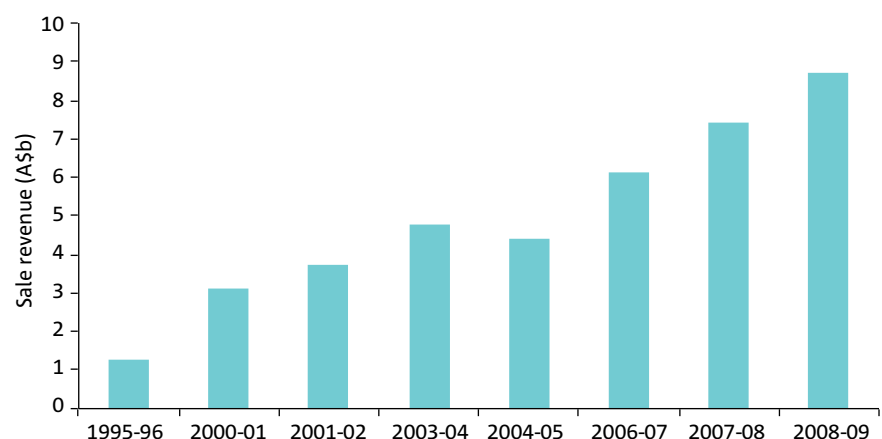


Figure 36. Sales revenue in the Australia MTSE sector

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

States, steel production intensity will peak at a higher income threshold and then decline. Recent years are showing a declining rate of steel production. From 2002 to 2006 year-on-year steel production in China grew at an average rate of 23 percent. In the following five years (2007-2011) this figure more than halved to 10 percent (Figure 37). These signs are being read as the beginnings of a long term shift into a services oriented economy. As the Chinese economy shifts to include this new dimension, there are likely to be opportunities for the Australian chemicals and plastics industry to capitalise on existing trade relationships with China and position itself as a key service provider.

The American Chemistry Council (ACC, 2012a) observes that “in recent years, many manufactured products have become increasingly commoditised because of globalisation and overcapacity. In response, many companies are seeking differentiation by offering solutions, rather than only products.”

In the energy sector this is occurring through innovative energy performance contracting (EPC). As an example, under an EPC an energy company ensures a building is kept at a desired temperature within agreed greenhouse gas emissions and other performance criteria. This may result in solar passive design being combined with traditional energy supply. The focus is on the service (warmth) not the product (electricity) (City of Melbourne, 2012). The same concept of service provision rather than product provision could be applied in the chemicals and plastics industry.

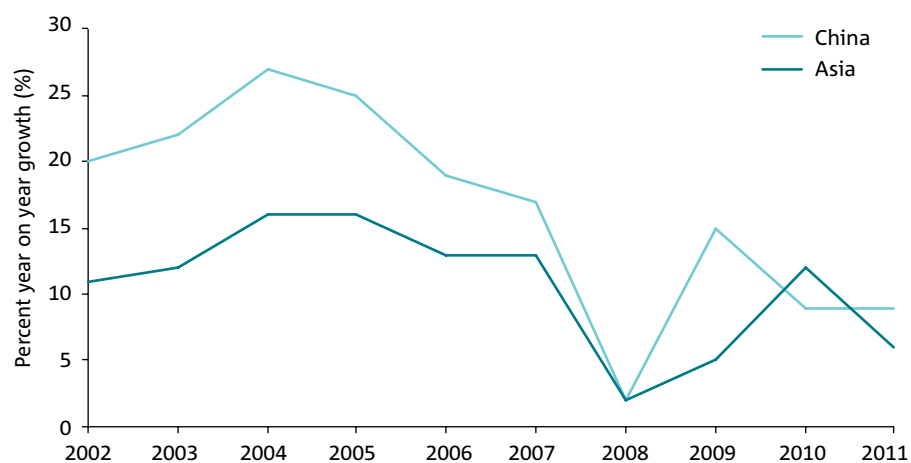


Figure 37. Declining steel production rates in China may be a long-term lead indicator of transition out of the rapid phase of industrialisation and into the services sector

Source: World Steel Association (WSA, 2011)

Other opportunities for the provision of services and know-how offerings include:

- **Occupational health, safety and environmental management.**

Australia generally has high health, safety and environment standards on an international stage. Australia ranks amongst the best performing countries of New Zealand, Finland, Denmark, Sweden, Norway, the United Kingdom and Switzerland. The number of fatalities per 100,000 employees is a key indicator. This is dropping more rapidly in Australia than any of the other countries. The know-how developed through this achievement could be exported as a service to developing countries (Productivity Commission, 2010).

- **Software and computing systems for chemicals and plastics production.**

At the global scale, a large software and computing industry has emerged to support the chemicals and plastics industry. In the United States companies in the plastics, chemicals and pharmaceuticals sector spend US\$5.4 billion on information technology in one year, or about 1.2 percent of total industry spending (ACC, 2012a). This includes spending on hardware, software and consultants. The American Chemistry Council reports that the growing complexity of information technology is causing many companies to increasingly outsource these functions. They also note the need for software will grow as the industry switches away from high-volume low-value production and into high-value added front-office functions. Technology is a major differentiator in the competitive landscape of chemicals and plastics manufacture.

- ♦ **Chemicals manufacturing plant design, maintenance and operation.**

Many companies have developed capability to design, operate and maintain chemicals plants owned by other companies. The American Chemistry Council (ACC, 2012a) notes that pharmaceuticals companies globally are increasingly outsourcing many of their fine chemicals needs in order to focus on research and development. There is a general trend towards increasing outsourcing across many industry sectors.

- ♦ **Chemicals and plastics market and consumer research.**

Knowledge about local and global chemicals and plastics markets is highly valued by emerging industries, with many companies seeking to establish themselves. Selling this market intelligence may be a valued service. This could be valuable for the many start-up companies in developing Asia.

- ♦ **Corporate governance and government policy design.**

The Australian chemicals and plastics industry is heavily regulated and contains large companies that have been active over many decades. This has led to knowledge about effective corporate governance and policy design. The chemicals and plastics industries in many other countries often do not have such advanced health, safety, environment and corporate governance models. This knowledge may be valued by emerging industries in other countries.

- ♦ **Sustainable design services over whole of life.**

The chemicals and plastics industry has developed sophisticated data, models and tools to assist with this, such as the PACIA Design for Sustainability with Plastics program.

While opportunities may exist in the chemicals and plastics industry itself, services and know-how offerings could also be extended to encompass opportunities in other industries. For example, as a provider of inputs into the pharmaceutical industry, there may be unexplored scope for the chemicals and plastics industry to provide services to

this downstream industry. As the range of drugs increases, public demand for information about the effect of the drugs on different diseases also increases (AEGIS, 2002). In the pharmaceutical industry, there may be opportunity to provide advisory services for the new products are being developed. Drug manufacturers have to accrue extensive knowledge about the effect of a wide range of products (AEGIS, 2002).

The chemicals and plastics industry can work to explore value-add opportunities by providing services associated with the products and communicate the advantages of the product.



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⑥ Charting a Way Forward



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6.1 Opportunity Matrix

The following table provides some examples of how the chemicals and plastics industry can apply the industry enablers identified in this report to capitalise on specific market growth opportunities. These will be subject to more detailed assessment in the formulation of specific actions and policies.

TABLE 3. EXAMPLES OF OPPORTUNITIES WHICH LIE AT THE INTERSECTIONS OF MARKET GROWTH AREAS AND INDUSTRY ENABLERS

Agriculture and food	Mining	Building and construction	Materials recycling	Healthcare and wellbeing
Feedstock development Currently the Australian chemicals and plastics industry is unable to supply other industries to its full potential due to the lack of feedstocks. Access to natural gas is a particularly important issue for the industry. To achieve sustained growth in all market sectors the Australian chemicals and plastics industry needs to obtain access to existing feedstocks, and identify new feedstocks through technological advances. Otherwise the industry's capability to cost-effectively manufacture essential products in other industries will be lost. There are limited prospects for capitalising on any market growth area without feedstock development.				
Energy supply and efficiency This industry enabler underpins the capacity of the chemicals and plastics industry to meet the growth in demand in all market growth areas. Ensuring access to energy supply at competitive prices will heavily influence the competitiveness of the industry, given the energy intensive nature of the industry and the use of energy sources as feedstocks. Efficiency gains realised in energy supply will contribute to improved competitiveness of the industry.				
Attracting capital Australia is a stable, highly skilled and technologically advanced economy and society. The Australian chemicals and plastics industry is well positioned to harness the opportunities of domestic growth in demand and the developing Asia region. Communication and awareness of the investment attractiveness of Australia will help the industry benefit from all market growth areas.				
Science, research and technology development				
Agriculture and food Science, research and technological advances could develop beneficial chemicals to improve crop yields, innovative packaging solutions and food additives that allow foods (especially high protein foods to travel further and longer and remain fresh). Wealth growth in Asia is leading to changed dietary preferences. This may be associated with demand for pre-packaged meals popular in western countries. There could be demand for convenience oriented packaging. The Food Industry Innovation Precinct can help set strategic priorities, build capability and encourage collaborations.	Mining The breakthroughs required by the mining sector are new chemical and plastic products that can decrease production cost and can improve the processing of ore bodies in light of declining ore grades. Commodity prices have fallen since the previous decade. Mining companies can maintain profit by cutting cost. Research into new innovative chemical and plastic products can help achieve this.	Building and construction The building and construction industry is continuing to seek environmentally friendly products that have a smaller ecological footprint whilst meeting tighter structural and aesthetic properties. Innovative plastics products, for example, are likely to be highly sought after. Global climate change may also call for innovation in products that can handle adverse conditions. Research is needed to continue to expand the functions of chemical and plastic products in construction. The Manufacturing Innovation Precinct can help set strategic priorities, build capability and encourage collaborations.	Materials recycling Products are needed to help reduce energy consumption, pollution and handle a wider diversity of feedstocks. Recyclable material is increasingly attractive, owing to a softening in commodity prices and declining mineral ore grades. Innovative chemical products that allow more efficient recycling will be highly sought after. There is a role for science, research and technology to help develop such products.	Healthcare and wellbeing The growth in chronic illness is pointing towards a possible increased demand for nutraceutical products. These are food products that have health and/or medical benefit. Human mobility and the rise of bacteria resistant to antibiotics may give rise to increased effort in the pharmaceuticals sector and sanitisation products. Science, research and technology can help develop the next generation of chemicals needed by the healthcare sector.

Corporate social responsibility

Agriculture and food

Food consumers are particularly aware of health, environmental and ethical aspects of the products they consume. Income growth in Asia may be associated with these factors playing a greater role in consumer choice. If the packing aspects are produced in a responsible manner, and this is perceived by the consumer to be the case, they may access greater market share.

Mining

The mining sector is acutely aware of corporate social responsibility and invests considerable resources in this space. Activities such as coal seam and shale gas extraction attract close community scrutiny and 'licence to operate' issues are often high on the agenda.

The chemicals and plastics industry in Australia also has a strong corporate social responsibility profile. Continuing to enhance and strengthen that profile will be critical to ensuring the industry can work effectively in the closely observed mining sector.

Building and construction

Recent decades have seen the rise and rise of green and sustainable building design. Through government regulations and consumer demand the environmental and energy efficiency of today's buildings is of considerable importance.

Although plastics hold great, often well tested, promise in achieving environmentally friendly buildings they are still under-utilised.

Strong corporate social responsibility will help build confidence in chemical and plastic products for tomorrow's buildings.

Materials recycling

Recycling offers an opportunity to improve environmental outcomes and harness material which would otherwise be deemed waste.

The chemicals and plastics industry will play a vital role in enabling recycling to grow. Many new and innovative products are likely to emerge.

This aspect of the chemicals and plastics industry may enhance its overall social responsibility and "licence to operate".

Healthcare and wellbeing

Society is highly sensitive to the possible health issues surrounding chemical and plastic products. This is sometimes because the products are poorly understood.

Higher levels of transparency and corporate social responsibility of the industry in Australia will help inspire confidence in these products.

Perceived and real corporate social responsibility is a pre-requisite for chemicals and plastics to play a major role in healthcare.

Market research and global market access

Agriculture and food

Global food markets are expanding and diversifying rapidly. This is largely being driven by income growth in developing Asia and worldwide population growth. In the medium to long term Australia may be well positioned to supply the emerging protein (e.g., dairy, eggs, meat, and fish) markets of Asia. The packaging industry has a vital role to play if this is to be achieved.

This would require research into where and what the new markets will demand.

Mining

The Australian mining industry is entering a new phase.

The era of very high mineral commodity prices is over. As prices have come down the industry is seeking ways to cut costs and maintain or increase production. This may see a reversal or improvement in the declining multi-factor productivity of mining.

Market research into opportunities for chemicals and plastics products to cut costs and improve productivity will help position both industries for growth.

Building and construction

The urbanisation boom of Asia has decades to continue. Hundreds of millions of people in China and India will move from rural areas into cities. This will translate into demand for building and construction services.

Market research into where the demand will arise and what products are likely to be needed will help the Australian industry better position itself.

A better understanding of trends in domestic building supplies demanded will also be of value. Energy price rises and extreme weather events may be creating a need for plastics products.

Materials recycling

Most industry datasets suggest a significant increase in recycling rates over the past decade. Many of Australia's recycled products are being sent offshore to feed export markets.

Despite the potential for growth the global and domestic recycling industry (current and future forecast) is poorly understood.

Market research will help chemicals and plastics producers understand the size and nature of the opportunity.

Healthcare and wellbeing

Healthcare is the most rapidly expanding area of societal expenditure in Australia and many other countries. It is being fuelled by the rise in chronic and lifestyle related illness and the ageing population.

This is translating to opportunities in the chemicals and plastics industry. Whilst growth in the healthcare sector is well documented there is limited research into the opportunities it creates for the chemicals and plastics industry.

Agriculture and food	Mining	Building and construction	Materials recycling	Healthcare and wellbeing
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Workforce skills and training

There is a need for trained chemical engineers and technicians in Australia working in the spaces of food processing, food packaging, recycling, mining services, healthcare and construction. Countries such as China, India, South Korea and Singapore are increasing many of these skills at a faster rate than Australia and are thereby gaining a competitive edge. If Australia loses its capabilities in chemical engineering they will not easily be regained in the future. Surveys by Engineers Australia – a peak national professional body – reveal that 70 percent of employers in Australia “experience difficulties” recruiting engineers of all types - including chemical engineers (Kaspura, 2011).

Targeted education and awareness

Agriculture and food	Mining	Building and construction	Materials recycling	Healthcare and wellbeing
<p>An improved understanding of the role the chemicals and plastics play in food transportation may help build consumer confidence and demand. Often the packaging is discarded by the consumer and perceived as unimportant. However, packaging can significantly impact the quality and convenience of food content. Good packaging can also minimise ecological footprint.</p>	<p>The mining sector is widely perceived, with good reason, as a mainstay of the Australian economy. The mining sector depends on products from the chemicals and plastics industry to operate. This link may not be visible to communities and political representatives. The mining industry in Australia is entering a phase of increased focus on cost reduction. Awareness in mining companies about how chemical and plastic products can cut costs may help build market share.</p>	<p>Innovative plastic products in the construction sector have the potential to outperform traditional products in terms of strength, durability and environmental performance. However, they have a battle to win in the consumer “mindset”. Many people have a preference for products that have been traditionally used for a long time.</p>	<p>Generally recycling is seen as positive activity by society because it reduces waste and pollution. However, modern recycling techniques depend upon specialised chemicals such as alcohols, acids, glycols and amines. The positive perceptions of recycling are countered by the negative perceptions of the chemicals used in the process. The community opposition to water recycling in Australia is an example. In many cases this debate was reactive and not informed about possible contaminants.</p>	<p>There are community fears about some chemical and plastic products in healthcare settings – or with perceived health impacts – that are not always founded on hard science or evidence. For some plastics products in particular this is creating decreased demand and producers are struggling to counter misinformation. The scare of “asbestos” still remains in many people’s minds. Education and awareness campaigns may help consumers better comprehend the safety of contemporary products.</p>

Services and knowledge-based offerings

Agriculture and food	Mining	Building and construction	Materials recycling	Healthcare and wellbeing
<p>Australia is a world leader in agrifood research. National capabilities in agricultural production, food handling and food processing are strong. Global food markets are set to expand and diversify. To what extent is know how relating to food preservation and packaging in Australia exportable to the agrifood sectors of other countries?</p>	<p>The mining services, technology and engineering industry has experienced global growth. It is being driven by minerals projects in developing countries. Although these countries hold rich mineral deposits some have not previously had the skills or infrastructure to develop them. In coming decades there may be opportunities to sell Australian know how in mining services – including chemicals and plastics aspects – to support minerals development in other countries.</p>	<p>Australia’s harsh climate puts buildings under stress from wind, rain and heat. Chemical and plastic products have been developed to help ensure our structures can withstand these elements. Australia also has high environment and sustainability requirements for built structures. Again chemical and plastic products play a key role. There is a possibility that the intellectual property behind our building designs will hold value to rapidly urbanising parts of the world including developing Asia, the Middle East and South America.</p>	<p>Australia has high rates of plastic and other materials recycling. The Australian Council of Recycling (ACOR) has over 20 member companies many of which are recognised as world leaders. We have been a relatively early adopter of both recycling technology and policies. Recycling rates are not yet as high for many parts of the developing Asia region. However, as the demand for raw materials rises these countries are likely to expand their recycling capabilities. Australia may be in a position to sell know how and help other countries develop their industries.</p>	<p>In Australia and worldwide healthcare expenditure is on the rise – and is likely to continue rising for the foreseeable future. Chemical and plastic products are used ubiquitously throughout healthcare services. A particular area of growth may be associated with the ageing population. As technology continues to create more devices, chemicals and systems for healthcare there may emerge a need for intermediary advice. Which devices, systems and chemicals are best for which applications? Answering this question for healthcare service providers may be an opportunity.</p>

6.2 Working with the Market

6.2.1 Market Conditions

This report takes a market centric approach in exploring a pathway forward for sustainable growth. The market growth areas represent opportunities associated with natural supply and demand forces emerging over the coming two decades. The industry enablers are all actions that are harmonious with market forces.

Without action, the chemicals and plastics industry in Australia is likely to decrease in size over the coming decades. Conditions on the demand side will be favourable, with continued growth in the global consumption of chemical and plastic products resulting from growth in downstream industries, increases in global population and rapid income growth in the developing world.

The challenges faced by Australia's chemicals and plastics industry are mostly supply-side:

- a) The difficulty Australian chemicals and plastics manufacturers face in accessing critical feedstocks, especially natural gas;
- b) Increased competitive production and export of low-cost chemicals and plastic products from other countries, in particular Asia and the Middle East; and
- c) The competitive development of advanced chemicals and plastics manufacturing infrastructure, techniques and science, research and technology in other countries.

These drivers are partly the result of global supply and demand forces. However, global chemicals and plastics markets operate under imperfect conditions. Governments worldwide use production subsidies and trade-

barriers to protect, support and enable domestic industries. There is also the possible loss of societal value not easily computed in monetary units. The chemicals and plastics industry is so deeply embedded in so many other industries, and people's daily activities, that the loss of Australian industry may have impact beyond the market realm.

6.2.2 Market Failure

A critical question for policy makers is the extent to which the forces acting on the chemicals and plastics industry may be considered a form of "market failure." Market failure occurs when the forces of supply and demand are not allocating resources efficiently. This can be associated with over- or under-production and a loss of value not easily quantified in dollar units, but recognised as intangibles with impacts on society. Some of the causes of market failure are described as follows:

- a. Artificial barriers to entry and trade distortions.** Patents, laws, regulations, subsidies and trade barriers (e.g. export or import costs or restrictions) may prevent firms from entering and supplying a market. This can lead to an inefficient monopoly (one supplier) or oligopoly (a few suppliers). It is worth noting that some monopolies and oligopolies are naturally forming where unfettered supply and demand forces make a single (or few) firm(s) the most efficient option.
- b. Information failure.** When producers and consumers do not have access to, or the ability to interpret, information relating to their choices. Under these conditions they are not able to act within their own best interests which results in the inefficient allocation of resources.

c. Public goods. These are goods and services of value to society but, owing to their nature, cannot be owned by any person or firm. For example, intellectual property is not protected through copyright laws may be subject to over-consumption (due to zero/low cost) and under production (no price signal).

d. Externalities. An externality can be a positive or negative impact generated by the production activities of a firm which impacts other parties however holds no economic cost or benefit for the producing firm. For example, a positive externality may occur when a supermarket opens in a local shopping centre it may generate additional customers, and revenue, for a nearby coffee shop or bakery.

Interventions in the marketplace are assessed through the lens of market failure. Market failure is a well-established concept in economics and has been demonstrated to occur in many areas. It explains why governments are involved in areas such as infrastructure development, healthcare, defence and environmental management. Where a case for market failure can be clearly established then policies can be designed which manage that failure and ensure social net benefits.

It is stressed that this report makes no recommendation on whether or not government interventions are needed; however, it does suggest that any interventions should give consideration to natural supply and demand forces and market failure theories.

7 Our Methods



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This study applied both qualitative and quantitative information and has been developed using evidence based research captured in the megatrends report “Elements in Everything” and stakeholder feedback from interviews, and a workshop held on 13 November 2012.

This strategic directions report identifies alternative pathways for industry, government and the community. However, it does not make any recommendations about what should occur. Our aim is to describe possible futures and inform the decisions of others.

7.1.1 Stakeholder Interviews

Interviews with key stakeholders were designed to help validate the megatrends and strategic directions developed by CSIRO as part of the PACIA and DIICCSRTE Foresight project. Key stakeholders were identified and contact details provided by the Plastics and Chemicals Industries 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 associated transition pathways 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 megatrend?
- Do you agree with the associated transitional pathway?
- Is there evidence that supports this megatrend/pathway?
- Are there any trends/pathways not currently covered?

7.1.2 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. Feedback from this workshop resulted in a significant modification to the structure of this report. Rather than describing transition pathways, approximately one for each megatrend, the report describes strategic directions using market growth areas and industry enablers as the key method for achieving industry transformation.

⑧ Conclusion



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This report examines how the chemicals and plastics industry can address challenges and opportunities relevant not only to the industry itself but to Australia's broader society and economy. The industry is currently in decline, facing increasing pressure from cost-competitive imports.

However, opportunities exist as well. An earlier report by CSIRO, "Elements in Everything," identified six global megatrends that will impact the industry over the next 20 years. These megatrends are social, environmental and economic shifts that will open up new market growth areas for the chemicals and plastics industry.

The report identifies two possible scenarios for the future of the industry: “current trajectory” and “sustainable growth”. The current trajectory scenario is likely to occur if no significant actions are taken. The sustainable growth scenario will require actions to address the challenges and opportunities facing the industry.

In this current trajectory scenario, it is likely that the industry will continue to contract as it faces increased competition from imports and limited access to feedstocks, leading to further job losses and off-shoring of production facilities. This could potentially lead to a permanent and nearly irreversible loss of domestic production capability and engineering talent. The current trajectory scenario would lead to increased dependence on imported chemicals and plastics, adding risk to supply chains in nearly every downstream industry.

Alternatively, the sustainable growth scenario would preserve the essential everyday benefits that the chemicals and plastics industry provides and that are often taken for granted, such as food security, hygiene and cleaning products, and water supply and treatment. Domestic supply chain security would be preserved, making downstream industries less susceptible to foreign supply shocks. The sustainable growth scenario would also see the chemicals and plastics industry contribute valuable innovations to Australian industry. Because of the industry’s unique position in the supply chain, these innovations could have the potential to have a large multiplier effect throughout downstream industries and the Australian economy as a whole.

Clearly sustainable growth is the desired future for the industry. This report broadly explores a number of industry enablers that can help the industry move towards a sustainable growth path. Industry enablers are activities that can be taken to create new opportunities or to address major issues that may be holding back growth.

While it is beyond the scope of this report to develop detailed roadmaps for implementing the industry enablers or pursuing the market growth areas, a successful industry strategy is likely to involve a number of industry enablers applied to the various market growth areas through coordinated action. Further consideration will be needed to identify the specific actions and specific stakeholders.

Choices about the way forward for the chemicals and plastics industry will continually arise for industry, government and community and other key stakeholder decision makers. They will occur in company boardrooms and government departments. There are likely to be positive and negative aspects associated with all options. The aim will be to ensure long term benefits for Australia’s economy, society and environment.



References

- ABS (2008) Population Projections Australia 2006 to 2101 Catalogue Number 3222.O. Canberra: Australian Bureau of Statistics.
- ABS (2010a) Australia's Environment Issues and Trends 2010 Catalogue Number 4613.O. Canberra: Australian Bureau of Statistics.
- ABS (2010b) Australian Economic Indicators Catalogue Number 1350.O Canberra: Australian Bureau of Statistics.
- ABS (2011a) Australian Demographic Statistics, June 2011 Catalogue Number 3101.O. Canberra: Australian Bureau of Statistics.
- ABS (2011b) Australian National Accounts: Input-Output Tables, 2007-08 Final Catalogue Number 5209.O.55.001. Canberra: Australian Bureau of Statistics.
- ABS (2011c) Experimental Estimates for the Manufacturing Industry, 2009-10 Catalogue Number 8159.O. Canberra: Australian Bureau of Statistics.
- ABS (2012a) Australian Industry, 2010-11 Catalogue Number 8155.O. Canberra: Australian Bureau of Statistics.
- ABS (2012b) Australian National Accounts: Input-Output Tables, 2008-09 Catalogue Number 5209.O.55.001. Canberra: Australian Bureau of Statistics.
- ABS (2012c) Australian System of National Accounts Catalogue Number 5204.O. Canberra: Australian Bureau of Statistics.
- ABS (2012d) Construction Work Done, Australia, Preliminary. Catalogue Number 8755.O. Canberra: Australian Bureau of Statistics.
- ABS (2012e) Counts of Australian Businesses, including Entries and Exits, Jun 2007 to Jun 2011 Catalogue Number 8165.O. Canberra: Australian Bureau of Statistics.
- ABS (2012f) Labour Force, Australia, Detailed, Quarterly Catalogue Number 6291.O.55.003. Canberra: Australian Bureau of Statistics.
- ABS (2013) International Trade in Goods and Services, Australia Catalogue Number 5368.O. Canberra: Australian Bureau of Statistics.
- ACC (2012a) 2012 Guide to the Business of Chemistry. Washington D.C.: American Chemistry Council.
- ACC (2012b) Plastics in Building and Construction, from <http://plastics.americanchemistry.com/Market-Teams/Building-and-Construction>
- Access Economics (2008) Exceptional Returns: The Value of Investing in Health R&D in Australia II. Canberra: Prepared for the Australian Society for Medical Research.
- ACCI (2011) Employers' Commitment to Training. Canberra: Australian Chamber of Commerce and Industry.
- AEGIS (2002) Selling Solutions: Emerging Patterns of Product-Service Linkage in the Australian Economy. Sydney: Australian Expert Group in Industry Studies.
- AIHW (2012) Australia's health 2012. Canberra: Australian Institute of Health and Welfare.
- Alexandratos, N., & Bruinsma, J. (2012) World agriculture towards 2030/2050: The 2012 Revision ESA Working Paper No. 12-03. Rome: Food and Agriculture Organisation of the United Nations.
- American Chemistry Society (1996) Technology Vision 2020 - The US Chemical Industry. Washington D.C.: American Chemistry Society.
- Ananda, J., Domazetis, G., & Hill, J. (2008) A roadmap to a green chemical industry in Australia. Environment, Development and Sustainability, 11(5), 1051-1071.
- Artz, K. W., Norman, P. M., Hatfield, D. E., & Cardinal, L. B. (2010) A Longitudinal Study of the Impact of R&D, Patents, and Product Innovation on Firm Performance. Journal of Product Innovation Management, 27(5), 725-740.
- ATKearney (2012a) Chemical Industry Vision 2030: A European Perspective. Sydney: ATKearney Consulting.
- ATKearney (2012b) Collaboration: A New Mantra for Chemical Industry Growth. Sydney: ATKearney Consulting.
- AusIndustry (2013) Clean Technology Investment Program. Canberra: AusIndustry.
- Austrade (2012a) Australia Benchmark Report 2012. Canberra: Australian Trade Commission.
- Austrade (2012b) Export Market Development Grants in Brief. Canberra: Australian Trade Commission.
- Australian Government (2004) Australian Functional Food. Canberra: Invest Australia.
- Australian Government (2009) A Healthier Future for all Australians - Final Report of the National Health and Hospitals Reform Commission. Canberra.
- Australian Government (2012a) Australia in the Asian Century White Paper. Canberra.
- Australian Government (2012b) An Overview of the Clean Energy Legislative Package. Canberra: Australian Government.
- Australian Government (2012c) Prime Minister's Manufacturing Taskforce - Report of the Non-Government Members. Canberra.
- Australian Government (2012d) Quarterly Updated of Australia's National Greenhouse Gas Inventory: June 2012. Canberra: Department of Climate Change and Energy Efficiency.
- Australian Government (2013a) National Pollutant Inventory Retrieved 21 January, 2013, from <http://www.npi.gov.au/>
- Australian Government (2013b) Why Australia - Reasons to consider investing in Australia. Canberra: Retrieved from <http://www.austrade.gov.au/Invest/Why-Australia/>
- Australian Industry Group (2006) Manufacturing Futures. Sydney.
- Australian Treasury (2010) Australia to 2050: future challenges Intergenerational Report. Canberra.
- Azapagic, A., & Perdan, S. (2000) Indicators of Sustainable Development for Industry: A General Framework. Process Safety and Environmental Protection, 78(4), 243-261.
- Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 364(1526), 1985-1998.
- Barnett, M. L. (2006) Finding a Working Balance Between Competitive and Communal Strategies. Journal of Management Studies, 43(8), 1753-1773.
- Barnett, M. L., & Hoffman, A. J. (2008) Beyond Corporate Reputation: Managing Reputational Interdependence. Corporate Reputation Review, 11(1), 1-9.
- Bartolome, L., Imran, M., Cho, B. G., Al-Masry, W. A., & Kim, D. H. (2012) Recent Developments in the Chemical Recycling of PET. In D. D. Achilias (Ed.), Material Recycling - trends and Perspectives. Croatia: InTech.
- Bergeson, L. L., Auer, C. M., & David Peveler, R. (2012) TSCA and the Regulation of Renewable Chemicals. Industrial Biotechnology, 8(5), 262-271.
- BHP Billiton (2012) Sustainability Report 2012. Melbourne.
- Bioscience, C. C. (2010) Biorefinery Scoping Study: Tropical Biomass. Report prepared for Department of Innovation, Industry, Science & Research.
- Black & Veatch (2012) Strategic Directions in the U.S. Natural Gas Industry. Kansas: Black & Veatch.

- BLS (2012) International Comparison of Hourly Compensation Costs in Manufacturing, 2011. Washington D.C.: Bureau of Labor Statistics, U.S. Department of Labor.
- Booz & Co. (2012) Profits in a Slowdown: How Australian Mining Companies Can Cut Costs and Grow Stronger. Sydney: Booz & Company Inc.
- BP (2012) BP Statistical Review of World Energy June 2012. London: BP.
- BREE (2011) Australian energy projections to 2034–35, December. Canberra: Bureau of Resources and Energy Economics.
- BREE (2012a) Australian bulk commodity exports and infrastructure - outlook to 2025. Canberra: Bureau of Resources and Energy Economics.
- BREE (2012b) Energy in Australia 2012. Canberra: Australia Government Retrieved from <http://www.bree.gov.au/documents/publications/energy-in-aust/energy-in-australia-2012.pdf>.
- BREE (2012c) Resources and Energy Major Projects October 2012. Canberra: Bureau of Resources and Energy Economics.
- BREE (2012d) Resources and Energy Quarterly September Quarter 2012. Canberra: Bureau of Resources and Energy Economics.
- Buchanan, J., Briggs, C., & Evesson, J. (2002) Renewing the Capacity for Skills Formation: the Challenge for Victorian Manufacturing A Report for the LESC and MICC. Melbourne: Victorian Learning and Employment Skills Commission.
- Carlton, R., & Thompson, H. (2009) Product Stewardship - Is there a role for better collaboration? Outlooks on Pest Management, 20(3), 126-127 (122).
- Carroll, A. B., & Shabana, K. M. (2010) The Business Case for Corporate Social Responsibility: A Review of Concepts, Research and Practice. International Journal of Management Reviews, 12(1), 85-105.
- Cefic (2006) Cefic Pan European Survey - Image of the Chemical Industry 2006. Brussels: The European Chemical Industry Council.
- CFO Research Services (2009) Physical Risks to the Supply Chain. Boston: Report prepared in collaboration with FM Global.
- Chadwick, J. (2012) Mining Chemicals. International Mining, July, pp. 48-54.
- Cherubini, F. (2010) The biorefinery concept: Using biomass instead of oil for producing energy and chemicals. Energy Conversion and Management, 51(7), 1412-1421.
- Christopher, M. (2000) The Agile Supply Chain: Competing in Volatile Markets. Industrial Marketing Management, 29(1), 37-44.
- CIE (2009) Benefits of trade and trade liberalisation Prepared for Department of Foreign Affairs and Trade: The Centre for International Economics.
- City of Melbourne (2012) Energy performance contract Retrieved 21 October 2012, from <http://www.melbourne.vic.gov.au/1200buildings/what/Pages/EnergyPerformanceContract.aspx>
- Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007) The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. Decision Sciences, 38(1), 131-156.
- CSIRO (2011) The world's first polymer banknote. Melbourne: Commonwealth Scientific and Industrial Research Organisation.
- DAFF (2012) Australian food statistics 2010-11. Canberra: Department of Agriculture, Fisheries and Forestry.
- DEEDI (2010) The Use of Polymeric Chemicals in Queensland Coal Mines. Brisbane: Department of Employment, Economic Development and Innovation.
- Deloitte (2009) The decade ahead: Preparing for an unpredictable future in the global chemical industry A Manufacturing industry report: Deloitte.
- Deloitte (2011) The next phase: Opportunities in China's pharmaceuticals market. China: Deloitte.
- Deloitte Access Economics (2012) The glass half full Business Outlook June 2012. Sydney: Deloitte Access Economics.
- Department of Mines and Energy (2013) Unconventional Oil & Gas. Northern Territory Government Retrieved 20 February 2013, from http://www.nt.gov.au/d/Minerals_Energy/index.cfm?header=Unconventional%20Oil%20and%20Gas
- DFAT (2012) Trade in Primary and Manufactured Products Australia 2011-12. Canberra: Department of Foreign Affairs and Trade.
- DIISR (2011a) Australian Innovation System Report 2011. Canberra: Department of Innovation Industry, Science and Research.
- DIISR (2011b) Focusing Australia's publicly funded research review: Maximising the innovation dividend, Review key findings and future directions. Canberra: Department of Innovation, Industry, Science and Research.
- DomGas Alliance (2012) Australia's Domestic Gas Security. Perth.
- Dornburg, V., Hermann, B. G., & Patel, M. K. (2008) Scenario projections for future market potentials of biobased bulk chemicals. Environmental science & technology, 42(7), 2261-2267.
- DRET (2008) Cyanide Management Leading Practice Sustainable Development Program for the Mining Industry. Canberra: Department of Resources Energy and Tourism.
- DRET (2011a) Energy Efficiency Opportunities Assessment Handbook. Canberra: Department of Resources, Energy and Tourism.
- DRET (2011b) Significant Opportunities Register - Chemical Manufacturing. Canberra: Department of Resources, Energy and Tourism.
- DRET (2012) Energy White Paper 2012. Canberra: Department of Resources Energy and Tourism.
- Drews, M. (2010) Measuring the business and societal benefits of corporate responsibility. Corporate Governance, 10(4), 421-431.
- DSEWPac (2012) The Australian Recycling Sector Report prepared in conjunction with Net Balance. Canberra: Department of Sustainability, Environment, Water, Population and Communities.
- EEX (2012) Opportunities - Chemicals and Plastics Manufacturing. Energy Efficiency Exchange Retrieved 10 April, from <http://eex.gov.au/>
- Environment Protection and Heritage Council (2010) National Waste Report 2010. Canberra: Department of the Environment, Water, Heritage and the Arts.
- Euromonitor International (2011) Basic Chemicals in Australia ISIC 2411. London: Euromonitor International Ltd.
- European Commission (2011) Plastic Waste: Ecological and Human Health Impacts, November 2011 Science for Environment Policy. United Kingdom.
- FAO (2003) Agriculture, food and water: a contribution to the World Water Development Report. Rome: Food and Agriculture Organisation of the United Nations.
- FAO (2011a) FAOSTAT, from <http://faostat.fao.org/>
- FAO (2011b) Global Food Losses and Food Wastes: Extent, Causes and Prevention. Rome: Food and Agriculture Organisation of the United Nations

- FAO (2011c) Looking ahead in world food and agriculture: Perspectives to 2050. Rome: Food and Agriculture Organisation of the United Nations.
- FAO, IFAD, IMF, OECD, UNCTAD, WFP, The-World-Bank, WTO, IFPRI, & UNHCTF (2011) Price Volatility in Food and Agricultural Markets: Policy Responses. Rome: Food and Agriculture Organisation.
- Frost & Sullivan (2011) Global Nutraceutical Industry: Investing in Healthy Living. India.
- Frost & Sullivan (2012a) Analysis of the Plastics Polymers in Medical Devices Market. Market Engineering July 2012. United States.
- Frost & Sullivan (2012b) Trends in Chemicals and Materials - Healthcare and Personal Care July 2012. Melbourne.
- Future Manufacturing Council (2011) Trends in manufacturing to 2020. Canberra: Department of Innovation, Industry, Science and Research.
- Geoscience Australia and BREE (2012) Australian Gas Resource Assessment 2012. Canberra: Geoscience Australia and Bureau of Resources and Energy Economics.
- Global Construction Perspectives and Oxford Economics (2011) Global construction 2020. London: Global Construction Perspectives
- Greene, D. L. (2010) Measuring energy security: Can the United States achieve oil independence? *Energy Policy*, 38(4), 1614-1621.
- Hajkowicz, S., Negra, C., Barnett, P., Clark, M., Harch, B., & Keating, B. (2012) Food price volatility and hunger alleviation - can Cannes work? *Agriculture and Food Security*, 1(8), doi:10.1186/2048-7010-1181-1188.
- Hawkes, C. (2009) Identifying Innovative Interventions to Promote Healthy Eating Using Consumption-oriented Food Supply Chain Analysis. *Journal of Hunger and Environmental Nutrition*, 4(3/4), 336-356.
- Hawkes, C., & Ruel, M. (2011) Value chains for nutrition. Washington DC: International Food Policy Research Institute.
- Hendricks, K. B., & Singhal, V. R. (2003) The effect of supply chain glitches on shareholder wealth. *Journal of Operations Management*, 21, 501-522.
- Holloway, J., Roberts, I., & Rush, A. (2010) China's Steel Industry. Reserve Bank Bulletin, December Quarter(19-26).
- Hyder Consulting (2012) Waste and Recycling in Australia 2011 Report prepared for Department of Sustainability, Environment, Water, Population and Communities. Sydney: Hyder Consulting Pty Ltd.
- IBISWorld (2012) Medical and Surgical Equipment Manufacturing in Australia IBISWorld Industry Report C2832. Melbourne: IBISWorld.
- ICCA (2007) Product Stewardship Guidelines. Germany: International Council of Chemical Associations.
- ICCA (2009) Innovations for Greenhouse Gas Reductions. Germany: International Council of Chemical Associations.
- IFA (2011) Fertilizer Outlook 2011 - 2015. Paris: International Fertilizer Industry Association.
- Iles, A., & Martin, A. N. (2012) Expanding bioplastics production: sustainable business innovation in the chemical industry. *Journal of Cleaner Production*, In press.
- IMF (2012a) World Economic Outlook April 2012: Growth Resuming, Dangers Remain. Washington D.C.: International Monetary Fund.
- IMF (2012b) World Economic Outlook October 2012: Coping with High Debt and Sluggish Growth. Washington D.C.: International Monetary Fund.
- IP (n.d.) Integrated Packaging. Victoria: Integrated Packaging.
- Janssen, M., Chambost, V., Stuart P. (2008) Successful partnerships for the forest biorefinery. *Industrial Biotechnology*, 4(4), 352-356.
- Johnston, E. (2012) Sustainability in the Chemical Industry. *Green Energy and Technology*.
- Joyce, B. L., & Stewart, C. N., Jr. (2012) Designing the perfect plant feedstock for biofuel production: using the whole buffalo to diversify fuels and products. *Biotechnology Advances*, 30(5), 1011-1022.
- Kaspura, A. (2011) The engineering profession - A statistical overview. Canberra: Engineers Australia.
- Kent, C. (2013) Reflections on China and Mining Investment in Australia Address to the Committee for Economic Development of Australia, 15 February. Perth: Reserve Bank of Australia.
- King, A. A., Lenox, M. J., & Barnett, M. L. (2002) Strategic responses to the reputation commons problem. In A. J. Hoffman & M. J. Ventresca (Eds.), *Organizations, Policy and the Natural Environment: Institutional and Strategic Perspectives*. Stanford, California: Stanford University Press.
- Korhonen, H. (2009) Milk-derived bioactive peptides: From science to applications. *Journal of Functional Foods*, 1(2), 177-187.
- Koryakovtseva, K., & Hincks, J. (2012) Australian Chemicals. London: Global Business Reports.
- KPMG (2011a) China's pharmaceutical industry - poised for the giant leap. Beijing: KPMG Advisory.
- KPMG (2011b) KPMG International Survey of Corporate Responsibility Reporting 2011. Australia: KPMG.
- KPMG (2012) Manufacturing competitiveness in Australia. Australia: KPMG International.
- Laurijssen, J., Marsidi, M., Westenbroek, A., Worrell, E., & Faaij, A. (2010) Paper and biomass for energy?: The impact of paper recycling on energy and CO2 emissions. *Resources, Conservation and Recycling*, 54(12), 1208-1218.
- Linehan, V., Thorpe, S., Andrews, N., Kim, Y., & Beaini, F. (2012) Food demand to 2050: Opportunities for Australian agriculture. Australian Bureau of Agricultural and Resource Economics and Sciences.
- Londo, H., & Meeusen, M. (2010) Policy Making for the Biobased Economy. The Bio-based Economy-Biofuels, Materials and Chemicals in the Post-oil Era, ed by Langeveld H, Sanders J, and Meeusen M. Earthscan, London and Washington DC, 203-213.
- Luo, L., van der Voet, E., & Huppes, G. (2010) Biorefining of lignocellulosic feedstock-Technical, economic and environmental considerations. *Bioresource Technology*, 101(13), 5023-5032.
- Lynch-Wood, G., & Williamson, D. (2007) The Social Licence as a Form of Regulation for Small and Medium Enterprises. *Journal of Law and Society*, 34(3), 321-341.
- Manufacturing Learning Victoria (2005) Plastics and Chemicals Industries Association Skills Need Research Project Report prepared for the Plastics and Chemicals Industries Association. Melbourne.
- Manufacturing Skills Australia (2012) Environmental Scan 2012. Sydney.

- Martinuzzi, A., Gisch-Boie, S., & Wiman, A. (2010) Does Corporate Responsibility Pay Off? Exploring the links between CSR and competitiveness in Europe's industrial sectors: Vienna University of Economics and Business.
- Mathers, C. D., & Loncar, D. (2006) Projections of Global Mortality and Burden of Disease from 2002 to 2030. *PLoS Medicine*, 3(11).
- McKinsey and Company (n.d.-a) India Pharma 2015: Unlocking the Potential of the Indian Pharmaceuticals Market. India.
- McKinsey and Company (n.d.-b) India Pharma 2020: Propelling access and acceptance, realising true potential. India.
- Meixell, M. J., & Gargeya, V. B. (2005) Global supply chain design: A literature review and critique. *Transportation Research Part E: Logistics and Transportation Review*, 41(6), 531-550.
- Mitchell, A. (2012) Full transcript of interview with RBA's Stevens, December 19, Australian Financial Review. Retrieved from http://www.afrc.com/p/national/economy/full_transcript_of_interview_with_INJhIV6htucNaYmJN8RSP
- MMSD (2002) Breaking New Ground: Mining, Minerals and Sustainable Development. London: International Institute for Environment and Development.
- Moreno, D. A., Carvajal, M., L'opez-Berenguer, C., & Garcia-Viguera, C. (2006) Chemical and biological characterisation of nutraceutical compounds of broccoli. *Journal of Pharmaceutical and Biomedical Analysis*, 41, 1508-1522.
- Muller, D. B., Wang, T., Duval, B., & Graedel, T. E. (2006) Exploring the engine of anthropogenic iron cycles. *Proceedings of the National Academy of Sciences of the United States of America*, 103(944), 16111-16116.
- National Academy of Engineering (2002) Raising Public Awareness of Engineering. Washington D.C.: The National Academies Press.
- Navaretti, G. B., Bugamelli, M., Cristadoro, R., & Maggioni, D. (2013) Are Firms Exporting to China and India Different from Other Exporters? In G. Gomel, D. Marconi, I. Musu & B. Quintieri (Eds.), *The Chinese Economy: Recent Trends and Policy Issues*. Heidelberg: Springer-Verlag.
- NFF (2012) NFF National Congress 22-23 October: Food and Fibre Boom - From grass roots to global. National Farmers' Federation, from <http://www.nff.org.au/congress.html>
- NIEIR (2006) A report on the economic and social contribution of the Plastics and Chemicals Industries to Victoria and Australia. Melbourne: National Institute of Economic and Industry Research.
- NIEIR (2012) Large scale export of East Coast Australia natural gas: Unintended consequences. Melbourne: National Institute of Economic and Industry Research.
- OECD (2009) The Bioeconomy to 2030: Designing a Policy Agenda - Main findings and policy conclusions OECD International Futures Project. Paris: Organisation for Economic Development and Cooperation.
- OECD (2012a) Australia Business Enterprise R-D by industry Retrieved 26 October, 2012, from http://stats.oecd.org/Index.aspx?DataSetCode=BERD_INDUSTRY
- OECD (2012b) OECD Economic Outlook Number 92. Paris: Organisation for Economic Cooperation and Development.
- OECD & FAO (2012) OECD-FAO Agricultural Outlook 2012-2021. Paris: OECD Publishing and FAO.
- PACIA (2008a) Submission to the Carbon Pollution reduction Scheme Green Paper. Melbourne: Plastics and Chemicals Industries Association.
- PACIA (2008b) Sustainability Leadership Framework. Melbourne: Plastics and Chemicals Industries Association.
- PACIA (2011a) PACIA 2011 National Plastics Recycling Survey. Melbourne: Plastics and Chemicals Industries Association.
- PACIA (2011b) Sustainable Plastics Recovery. Melbourne: Plastics and Chemicals Industries Association.
- PACIA (2012) Building with plastics, from <http://www.pacia.org.au/programs/buildingwithplastics>
- PACIA (2013a) From carpets to car parts: Marplex uses carpet waste to create automotive plastics. Melbourne: Plastics and Chemicals Industries Association.
- PACIA (2013b) Plantic cuts waste by 40 tonnes and improves productivity - Case study. Melbourne: Plastics and Chemicals Industries Association.
- Park, S.-H., & Chan, K. S. (1989) A Cross-Country Input-Output Analysis of Intersectoral Relationship between Manufacturing and Services and their Employment Implication. *World Development*, 17(2), 199-212.
- Parratt & Associates (2010) Scoping Biorefineries: Temperate Biomass Value Chains: Department of Industry, Innovation, Science, Research and Tertiary Education.
- Phillips McDougall (2010) The Cost of New Agrochemical Product Discovery, Development and Registration in 1995, 2000 and 2005-8 A Consultancy Study for Crop Life America and the European Crop Protection Association. United Kingdom.
- Pike Research (2011) Green Chemical Industry to Soar to \$98.5 Billion by 2020 Retrieved 17 October, 2012, from <http://www.pikeresearch.com/newsroom/green-chemical-industry-to-soar-to-98-5-billion-by-2020>
- Pike Research (2012) Global Investment in New Biorefinery Infrastructure will Total \$170 Billion through 2022, Forecasts Pike Research Retrieved 17 October, 2012, from <http://www.businesswire.com/news/home/20120926005205/en/Global-Investment-Biorefinery-Infrastructure-Total-170-Billion>
- Pilbara Development Commission (2012) Pilbara Regional Economy Version 2: Government of Western Australia.
- Plastics Europe (2009a) The Compelling Facts About Plastics 2009. An analysis of European plastics production, demand and recovery for 2008. Belgium: Association of Plastics Manufacturers.
- Plastics Europe (2009b) Plastics: too valuable to be thrown away Retrieved 26 October, 2012, 2012, from <http://www.plasticseurope.org/information-centre/news/news-archives-2009/plastics-too-valuable-to-be-thrown-away.aspx>
- Pongrácz, E., & Pohjola, V. J. (2004) Re-defining waste, the concept of ownership and the role of waste management. *Resources, Conservation and Recycling*, 40(2), 141-153.
- Prime Minister's Manufacturing Taskforce (2012) Report of the Non-Government Members. Canberra: Department of Industry, Innovation, Science, Research and Tertiary Education.
- Prno, J., & Scott Slocombe, D. (2012) Exploring the origins of 'social license to operate' in the mining sector: Perspectives from governance and sustainability theories. *Resources Policy*, 37(3), 346-357.
- Productivity Commission (2005) Economic Implications of an Ageing Australia Research Report. Canberra.
- Productivity Commission (2010) Performance Benchmarking of Australian Business Regulation: Occupational Health and Safety. Research Report. Canberra.

- PwC (2011a) Millennials at work: reshaping the workplace. United Kingdom: PricewaterhouseCoopers.
- PwC (2011b) Shale Gas - a renaissance in US manufacturing? : PricewaterhouseCoopers.
- PwC (2012a) Mind the gap: solving the skills shortage in resources. Sydney: PricewaterhouseCoopers.
- PwC (2012b) Mine - The growing disconnect Review of global trends in the mining industry - 2012. Melbourne: PricewaterhouseCoopers.
- Rao, P. M., Chandra, R., & Shin, J. (2012) R&D offshoring in multinational enterprises: Relevance of transaction cost and internalization theories. *Competitiveness Review: An International Business Journal* incorporating *Journal of Global Competitiveness*, 22(5), 376-395.
- RBA (2013) Statement on Monetary Policy February 2013. Sydney: Reserve Bank of Australia.
- Research Australia (2011) Shaping Up: Trends and Statistics in Funding Health and Medical Research Occasional Paper Series: Two. Melbourne.
- Robinson, B. H. (2009) E-waste: an assessment of global production and environmental impacts. *The Science of the Total Environment*, 408(2), 183-191.
- Safe Work Australia (2013) Lost time injury frequency rates (LTIFR) Retrieved 21 January, 2013, from <http://www.safeworkaustralia.gov.au/sites/swa/statistics/ltifr/pages/lost-time-injury-frequency-rates>
- Sheldon, R. A. (2011) Utilisation of biomass for sustainable fuels and chemicals: Molecules, methods and metrics. *Catalysis Today*, 167(1), 3-13.
- Siddique, R., Khatib, J., & Kaur, I. (2008) Use of recycled plastic in concrete: a review. *Waste management*, 28(10), 1835-1852.
- SkillsInfo (2011) Workforce characteristics, from <http://www.skillsinfo.gov.au/industry-reports-and-charts/workforce-characteristics>
- Smith, M., Hargroves, K., Stasinopoulos, P., Stephens, R., Desha, C., & Hargroves, S. (2007) Engineering Sustainable Solutions Program: Sustainable Energy Solutions Portfolio: The Natural Edge Project.
- Smits, A., Vissers, G., & Dankbaar, B. (2011) Exploring market knowledge in product development of chemical firms. *Journal of Business Chemistry*, 8(1), 17-33.
- Syed, A., Melanie, J., Thorpe, S., & Penney, K. (2010) Australian energy projections to 2029-30. ABARE research report 10.02. Canberra: Australian Bureau of Agricultural and Resource Economics.
- Tapex (2012) Plasback Retrieved 20 October, 2012, from <http://www.tapex.com.au/divisions/environmental/products/item/37-plasback>
- Tedesco, L., & Haseltine, C. (2010) An economic survey of companies in the Australian mining technology services and equipment sector. ABARE-BRS research report 10.07. Canberra: Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences.
- The Aspen Institute (2013) The Manufacturing Resurgence: What it Could Mean for the U.S. Economy. Washington D.C.: The Aspen Institute.
- The Boston Consulting Group (2009) The Innovation Imperative in Manufacturing. Boston.
- The Manufacturing Institute (2009) The Facts About Modern Manufacturing 8th Edition. Washington D.C. .
- Tomlinson, P. R. (2010) Co-operative ties and innovation: Some new evidence for UK manufacturing. *Research Policy*, 39(6), 762-775.
- UNCCD (2011) Desertification: a visual synthesis. Bonn, Germany: United Nations Convention to Combat Desertification.
- UNCTADstat (2013) Commodity price indices by category. New York: United Nations Conference on Trade and Development.
- UNEP (2013) Project converting waste plastic into fuel Retrieved 24 January, 2013, from <http://www.unep.org/ietc/ourwork/wastemanagement/projects/wasteplasticsproject/tabid/79203/default.aspx>
- United Nations (2011) World Population Prospects, the 2010 revision. New York: Department of Economic and Social Affairs, Population Division, United Nations.
- United Nations (2012) World Urbanization Prospects: The 2011 Revision. New York: United Nations Department of Economic and Social Affairs.
- Upstill, G., Jones, A. J., Spurling, T., & Simpson, G. (2006) Innovation Strategies for the Australian Chemical Industry. *Journal of Business Chemistry*, 3(3), 9-25.
- Valadkhani, A. (2003) Using Input-Output Analysis to Identify Australia's High Employment Generating Industries. *Australian Bulletin of Labour*, 29(3), 199-217.
- Vivoda, V. (2012) Oil-slick politics: Canberra slippery on refinery shutdowns Retrieved 23 October, 2012, from <http://theconversation.edu.au/oil-slick-politics-canberra-slippery-on-refinery-shutdowns-8529>
- Vlysidis, A., Binns, M., Webb, C., & Theodoropoulos, C. (2011) A techno-economic analysis of biodiesel biorefineries: Assessment of integrated designs for the co-production of fuels and chemicals. *Energy*, 36(8), 4671-4683.
- Wagner, S. M., & Bode, C. (2006) An empirical investigation into supply chain vulnerability. *Journal of Purchasing & Supply Management*, 12, 301-312.
- WEF (2012) The Global Competitiveness Report 2012-2013 Insight Report. Geneva: World Economic Forum.
- Wilson, D., & Dragusanu, R. (2008) The Expanding Middle: The Exploding World Middle Class and Falling Global Inequality Global Economics Paper No: 170: Goldman Sachs.
- World Bank (2012) World DataBank, from <http://databank.worldbank.org/data/home.aspx>
- World Economic Forum (2012) The Future of Manufacturing A World Economic Forum Report in collaboration with Deloitte Touche Tohmatsu Limited. Switzerland.
- World Steel Association (2009) The three Rs of sustainable steel Fact Sheet. Belgium.
- Worrell, E., Laitner, J. A., Ruth, M., & Finman, H. (2003) Productivity benefits of industrial energy efficiency measures. *Energy*, 28(11), 1081-1098.
- WSA (2011) Steel production data Retrieved 27 October, 2012, from <http://www.worldsteel.org/statistics/statistics-archive/2011-steel-production.html>
- Yellishetty, M., Mudd, G. M., Ranjith, P. G., & Tharumarajah, A. (2011) Environmental life-cycle comparisons of steel production and recycling: sustainability issues, problems and prospects. *Environmental Science & Policy*, 14, 650-663.





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