

Australia 2030

Navigating our uncertain future

May 2016

CSIRO Futures

CSIRO Futures is the strategic advisory and foresight arm of Australia's national science agency. We build on CSIRO's deep research expertise to help clients create sustainable growth and competitive advantage by harnessing science, technology and innovation. We are a trusted advisor to some of Australia's largest companies and government, helping senior decision-makers develop evidence-based strategies to address major opportunities and challenges.

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Foreword



In 2015, we engaged with more than 7000 creative people, customers and thought-leaders. We asked them, ‘What does Australia need?’

This exercise underlined the critical importance of accelerating the pace of innovation in Australia and highlighted a significant opportunity for science and technology to drive positive, disruptive change across new and existing markets. This work has shaped our priorities, research portfolio, and most importantly, the drive to get our science into people’s hands more quickly by better understanding their needs.

CSIRO Futures, our strategic advisory arm, personifies our transition toward being a more market-aware organisation. This awareness emphasises the need for science excellence and an innovative approach to R&D which facilitates the rapid development, adoption and deployment of technologies into industries that deliver growth.

As we know, there is a significant innovation gap in Australia. The 2015 Global Innovation Index ranked Australia 10th in the world for innovation inputs, but 72nd for innovation efficiency. We rank last in the OECD for research-business collaboration, and our relative rankings for STEM education are in decline. We can do better.

Plugging this innovation gap is critical to Australia’s future success. It is through groups like CSIRO Futures that bridges will be built between research organisations and industry, and Australian firms will gain access to new knowledge and expertise – enabling them to increase their capacity for innovation and their ability to put it into practice.

To innovate for the future, we must be prepared for all the opportunities and challenges that may arise. Australia has great potential to unlock new sources of growth – be it through new products and services, industries or business models – but they are reliant on making informed decisions today.

Australia 2030: navigating an uncertain future builds on the knowledge of CSIRO’s 5000-plus research experts and provides an approach to help sectors and individual businesses assess the trade-offs that exist within decisions on future challenges and opportunities.

Dr Anita Hill
Executive Director
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Australia's economy: an uncertain future

Where we're coming from

Australia has enjoyed an enviable position over the last two decades, with demand for the nation's abundant resources leading to strong economic growth and rising standards of living.

Australian GDP grew at an annual rate of 3.3 per cent between 1992 and 2011 and per capita income grew by two-thirds over this period (Figure 1: Real per capita disposable income (1990-2015)).¹

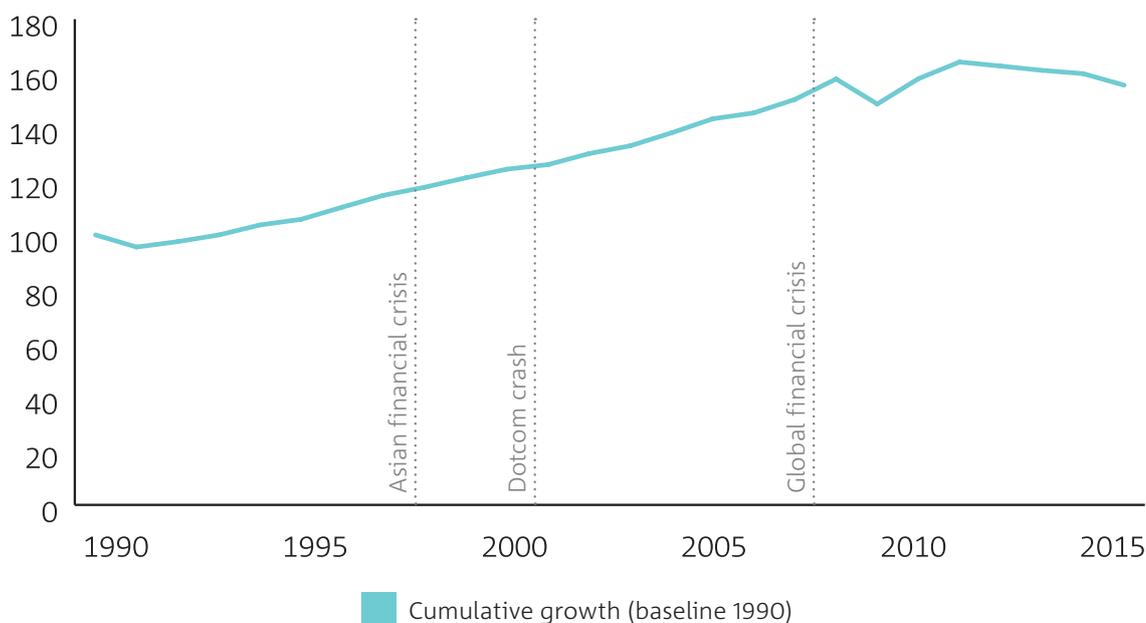
The economy also displayed great resilience compared to other developed economies, weathering the 1997-98 Asian financial crisis, the 2000-01 'dotcom crash,' and the 2007-08 'global financial crisis' without a single year of economic contraction.

While this resilience has its roots in Australia's market-oriented reforms

of the 1980s, recent growth has been largely due to a global resources boom which caused commodity prices to rise rapidly on strong Asian demand.

The last decade saw significant growth in Australian exports of iron ore, coal and liquefied natural gas (LNG). The mining boom alone is estimated to have boosted real per capita disposable income by 13 per cent from 2000 to 2013.² This represents approximately 45 per cent of total real per capita disposable income growth over this period for a sector that contributes less than 10 per cent of Australian GDP.

Figure 1 Real per capita disposable income (1990-2015)



Source:
Adapted from
ABS 5206.0 Table 1

1 Strutchbury, M. (2015), The rise, stall and threatened fall of Australia's great prosperity, 8 May 2015. Australian Financial Review.

2 Downes, P. et al (2014), The Effect of the Mining Boom on the Australian Economy – Research Discussion Paper. Reserve Bank of Australia.

But this is changing. Commodity prices have dropped significantly from their peak in 2011. The price of iron ore, Australia's largest export commodity, has fallen from US\$180 per tonne to below US\$65 per tonne.³ The decline in commodity prices has led to a significant reduction in capital investment in the resources sector and declining terms of trade. For the foreseeable future, the resources sector alone is unlikely to continue to drive income growth to the extent that it has over the last two decades.

In addition, global socio-economic conditions are changing rapidly. The last two decades have seen unprecedented growth in global prosperity and a shift in the balance of economic power away from developed countries in North America and Europe and towards developing countries in Asia, Latin America, and Africa. This will continue, with global incomes expected to double and the number of people living in 'high income' nations increasing from 1 billion to 3 billion by 2050.⁴ This will continue to open up new markets for Australian exporters, but also expose them to competition from relatively low-cost producers.

At the same time, new business models and disruptive technologies are transforming industries and threatening established businesses faster than ever before. This started with digital services and is quickly spreading into more traditional industries like agribusiness, medicine, manufacturing, minerals and energy. This will present enormous opportunities, but to capitalise on them Australian companies need to quickly embrace transformational business models and disruptive technologies or risk being left behind by faster-moving competitors.

The combination of these factors leaves Australia facing a number of questions about its economic future. With slowing growth in the resources sector and increasing competition from overseas, what will sustain future economic growth? In light of the rapid pace of technological change, how will Australia maintain competitiveness in existing industries and build comparative advantage in new and emerging industries? And what do we need to do today to ensure we are prepared to meet future opportunities and challenges?

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For the foreseeable future, the resources sector alone is unlikely to continue to drive income growth to the extent that it has over the last two decades.

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3 Ng, J. and Stringer, D. (2015) Bloomberg Business, Iron Ore Plummets Below \$40 a Ton as Global Glut Hurts Outlook, 7 December 2015

4 Hatfield-Dodds, S. et al (2015), Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970-2050. CSIRO, Canberra.

The innovation imperative

One of the most important factors that will drive future Australian economic growth and competitiveness is strong leadership in science, technology and innovation. Australia's Chief Scientist estimates that advanced physical and mathematical sciences make a direct contribution to the Australian economy of around \$145 billion a year, or about 11 per cent of GDP.⁵ This amount doubles when you include the flow-on impacts of these sciences. Other studies have shown that technological innovation, driven by research and development (R&D) investment, contributes around 50 percent of GDP growth in developed countries.^{6,7} This is the 'innovation imperative'. In an increasingly interconnected and rapidly changing world, Australia risks being left behind if it fails to innovate and build innovation capacity.

Innovation will be important on two fronts. First, it will be key to driving future productivity growth in established industries. This is important because the resources boom masked a decline in Australia's

productivity. Over the past 10 years, Australia's productivity has declined more sharply than in many other OECD economies (Figure 2).⁸ Left unchecked, declining productivity could slow Australia's annual income growth to 0.5 per cent by 2017.⁹

Second, innovation will be key to developing new companies and new industries based on emerging science and technologies. With many of these innovations disrupting existing industries, it will be important to use these breakthroughs to generate new sources of competitive advantage internationally. For example, autonomous vehicles have the potential to change the way individuals commute, create new share-ride and tourism services, reshape vehicle insurer and licencing business models and remodel industry supply chains and logistics operations.

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Studies have shown that technological innovation, driven by R&D investment, contributes around 50 percent of GDP growth in developed countries.

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5 Australian Government Chief Scientist and Australian Academy of Science (2015), Joint Media Release: Science – A Major Contributor to the Economy, 25 March 2015.

6 OECD (2015), OECD Innovation Strategy 2015 – An agenda for policy action. Meeting of the OECD Council at Ministerial Level Paris, 3-4 June 2015

7 Australian Academy of Technological Sciences and Engineering (2013), Science and Technology Policy Statement – May 2013

8 Department of Industry and Science, Industry Monitor (2015) <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/IndustryMonitor/section1.html#anchor1>, accessed 10 August 2015

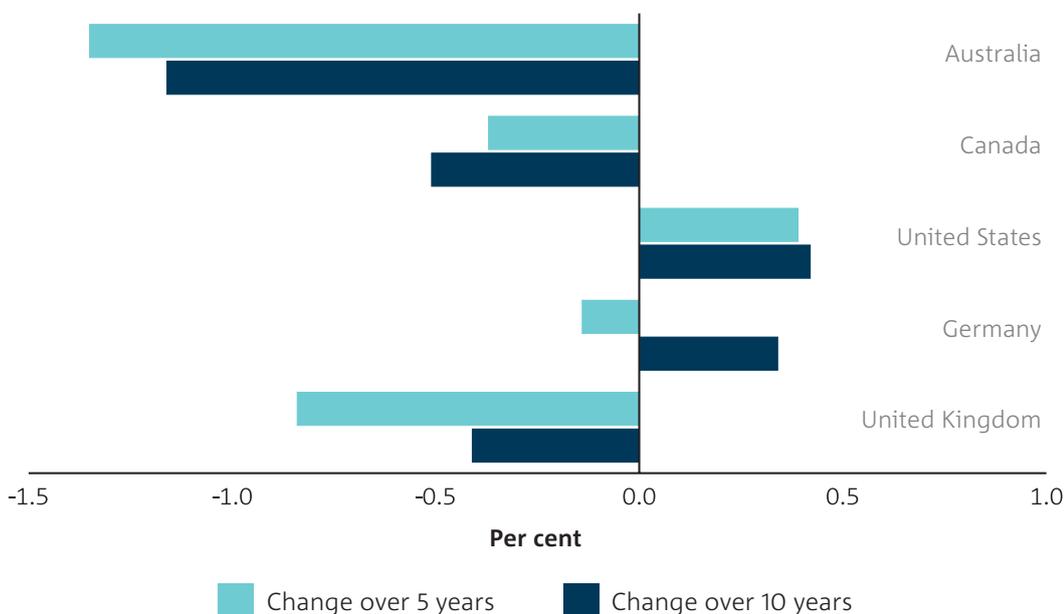
9 McKinsey & Company (2012), Beyond the Boom: Australia's productivity imperative

But to succeed on both fronts, Australia needs to improve its innovation performance. As a percentage of GDP, Australia's expenditure on R&D sits below the OECD average.¹⁰ Further, in the 2015 Global Innovation Index, Australia ranked 72nd (out of 141 countries) in "innovation efficiency" – the ratio of innovation output (e.g. commercial outcomes) to innovation input (e.g. R&D spending).¹¹ When compared against OECD peers, Australia's innovation efficiency rank is 30 (out of 34). Although Australia has a science and research sector that is acclaimed internationally, it is not well exploited by industry.¹²

Given that improved performance in innovation will be essential to Australia's future economic growth, where should Australia's government and companies be directing this effort? In a rapidly changing world and uncertain future, what investments will allow Australia to harness future opportunities across the widest range of possible futures?

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Although Australia has a science and research sector that is acclaimed internationally, it is not well exploited by industry.
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Figure 2 Australia's multifactor productivity



Source: The Conference Board Total Economy Database™ (September 2015), Growth Accounting and Total Factor Productivity, 1990–2014.

10 Australian Council of Learned Academics (2014), The role of science, research and technology in lifting Australian productivity

11 Cornell University, INSEAD, and WIPO (2015), The Global Innovation Index 2015: Effective Innovation Policies for Development, Fontainebleau, Ithaca, and Geneva.

12 The Conversation, Australia's road obsession is holding back productivity (2015) <http://theconversation.com/australias-road-obsession-is-holding-back-productivity-36212>, accessed 2 September 2015 Australian Government Chief Scientist and Australian Academy of Science (2015), Joint Media Release: Science – A Major Contributor to the Economy, 25 March 2015.

This report

This report aims to assist senior decision-makers in both government and industry answer these questions and plan today's innovation investments to meet future opportunities and challenges. It uses a scenarios-based approach to account for future uncertainty and guide strategic planning.

Australia has the potential to prosper in this uncertain future and experience the level of economic growth we have become accustomed to over the last few decades, but it must be achieved through new avenues, with innovation and early adoption of new technology playing a large role. This report presents a framework for organisations to strategically tackle this emerging challenge.

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Australia has the potential to prosper in this uncertain future.
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2030 scenarios

In the next section we expand on CSIRO's prior megatrend analysis and modelling work to develop four divergent scenario narratives for Australia in 2030. These scenarios illustrate the vastly different conditions Australia could face, depending on how the trends play out.

Sector impacts

In Section 3 we analyse the impact each of these scenarios could have on five key Australian sectors. This highlights how potential areas of growth at a sector level could vary significantly across the scenarios, while highlighting considerations for strategic planning and providing an example of the role that science, technology and innovation could play in enabling the sector to target the growth area.

Strategic framework

Finally, in Section 4 we present a four-step framework for companies to guide strategic planning and science, technology and innovation investment decisions. This framework provides a structured way to customise the scenarios to the operating context of an individual company, identify and prioritise growth opportunities, and build and implement an innovation portfolio to capitalise on these opportunities.

Australia

2030 scenarios

We can't predict the future but we can manage it through effective planning. Scenario planning is a tool that can be used to understand and prepare for a variety of possible futures facing Australia. Scenarios are evidence-based narratives of the world at a future point in time. Unlike forecasting, scenario planning is not intended to predict the future, but rather to communicate a wide range of possible outcomes and the consequences of each. Scenario planning can be an effective way to expand thinking about the future, understand trade-offs between different actions, and guide strategic planning at both a national and corporate level.

Expand thinking

First, scenario planning is a good way to expand thinking about the future beyond the conventional wisdom and to protect against 'groupthink'. When developing strategic plans, decision-makers often form rigid assumptions about what the future holds, particularly when those assumptions are affirmed by numerous forward-looking reports.

This can be dangerous. If those assumptions turn out to be incorrect, resources may be wasted on ineffective or counterproductive actions. And even if the assumptions hold, if other companies in the sector are using similar assumptions (groupthink) and developing similar plans, there will be little opportunity for strategic differentiation.

Understand trade-offs

Scenario planning can also provide insight on the trade-offs between different decisions, particularly the allocation of finite resources (labour, capital, government expenditure, etc.) across a range of possible futures. By taking into account uncertainty about the future, the performance of investment decisions and strategic actions can be analysed against multiple possible futures. This can help create build resilience against multiple future scenarios. A course of action that looks favourable under one scenario might prove to be a mistake in another.

Guide strategic planning

Finally, by expanding thinking about the future and better understanding trade-offs between different actions, scenario planning can be a highly effective tool for strategic planning at both a national level and within individual companies. Scenario planning is useful not only to understand possible futures and react to them, but also to guide proactive actions that will influence ideal outcomes.

At a national level, scenarios can form the basis for industry roadmaps that identify significant opportunities and challenges across a wide range of potential futures. These roadmaps can be used to guide government policy and investment decisions. They can also help build a platform for change across a diverse set of stakeholders by putting outcomes in the appropriate context for individual stakeholders. This enables stakeholders in industry, government and research organisations to work together towards a common goal.

At a corporate level, scenario planning can be used to guide strategy and investments. Used effectively, scenario planning can provide a basis for stimulating senior management discussion on a number of important questions. Just as market and competitive analysis is a key component in developing a business strategy, scenario planning can be used to assess external social, economic, environmental, and technological trends and develop strategies to meet the opportunities and challenges they present. This can build organisational resilience against future risks and create competitive advantage by anticipating opportunities faster than the market.

Scenario development

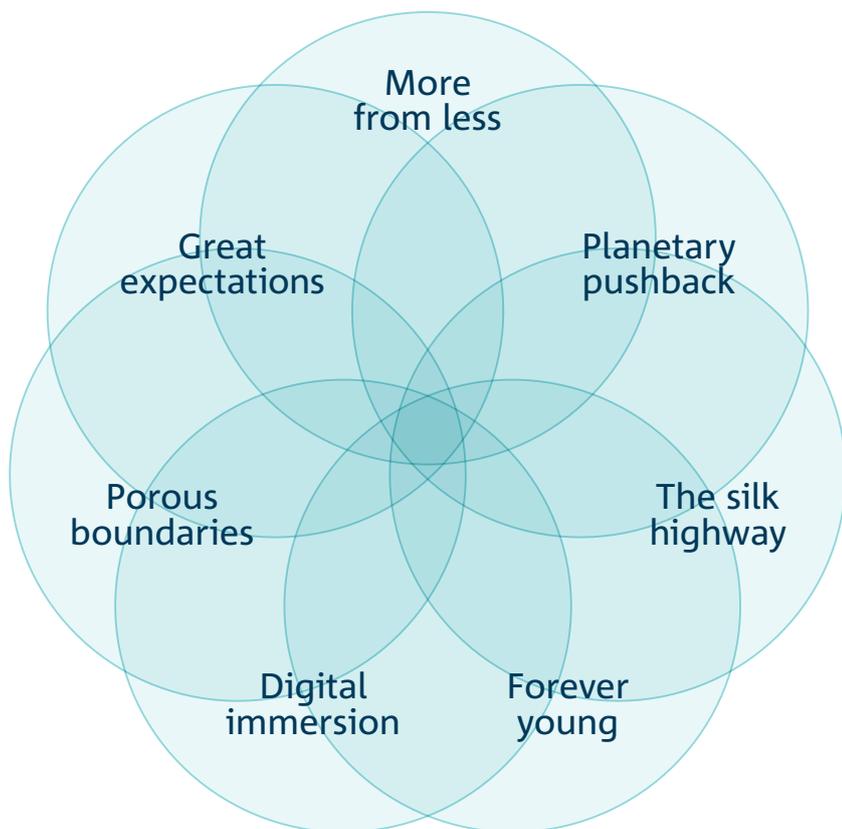
This section presents four plausible and divergent scenarios for Australia in 2030, each based on different combinations of social, economic, environmental and technological drivers. These scenarios are illustrative narratives that draw on existing modelling and foresight evidence. Each is purposely extreme in an attempt to provide a sharp contrast between different potential futures and more clearly illustrate the trade-offs involved. They are not mutually

exclusive, nor are they the only possible futures. In fact, the actual future may be a combination of two or more of the scenarios. The value of developing scenarios is not in deciding which is most likely, but rather in contrasting what each scenario can mean for different sectors and what Australia would need to do under each scenario.

These scenarios have been influenced by a number of inputs, drawing on CSIRO's broad and deep capabilities.

For the past seven years, CSIRO has been tracking global megatrends (see Figure 3) with the aim of helping government, industry, and research institutions prepare for upcoming opportunities and challenges. These megatrends have been a critical input into the scenarios. In addition to providing a strong evidence base, unique combinations of megatrends lead to highly varied global and national settings, inflection points and decisions.

Figure 3 The CSIRO Megatrends



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The value of developing scenarios is not in deciding which is most likely, but rather in contrasting what each scenario can mean for different sectors and what Australia would need to do under each scenario.
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The most recent iteration of the CSIRO Megatrends, developed in 2015, provide insights into significant economic, environmental, social and technological trends that will shape the world over the next 15 years:

More from less

Innovation will be required to meet human needs by more efficient use of mineral, water, energy and food resources in light of escalating demand and constrained supply. Climate change and land use patterns will place pressure on water and food production systems, while mineral and petroleum resources will be deeper are harder to access. At the same time population growth and income growth are placing upward pressure on demand for these resources. Science, technology, business processes, government policy, lifestyle patterns and cultural norms will all play a role in developing new ways of ensuring quality of life for current and future generations.



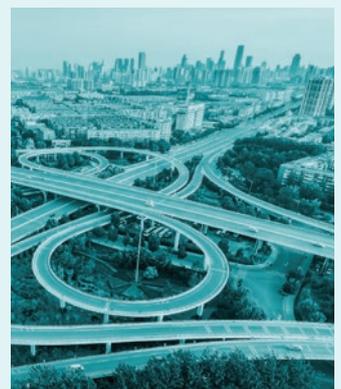
Planetary pushback

Changes in earth systems from the global to microbial will create challenges for humanity. At the microbial scale widespread, excessive and incorrect use of antibiotics is associated with an increasing number of resistant strains of bacteria, posing a serious threat to human health. At the regional scale, agricultural production systems are challenged by herbicide and pesticide resistant pests and diseases. At the global scale, greenhouse gas emissions are changing climate systems, raising temperatures and resulting in more frequent extreme weather. More positively, governments, companies and societies are doing more than ever before to combat these challenges.



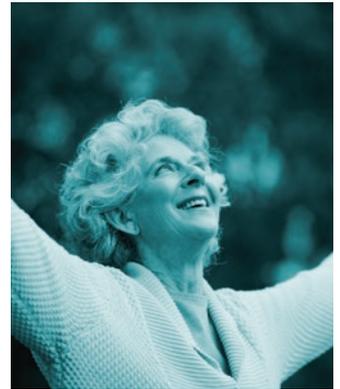
The silk highway

The world economy will continue to shift from west to east and north to south. The rapid growth of emerging economies will see billions of people transition out of poverty and into the middle income classes. With China and India becoming the new economic powerhouses, new export markets, trade relations, business models and cultural ties will be developed for Australia. Rapidly growing Asian economies are transitioning from industrialisation phases into advanced service sector economies that are hungry for education, healthcare, entertainment, tourism and financial services.



Forever young

The aging population will be an asset, providing a wealth of skills, knowledge, wisdom and mentorship. However this will also present challenges, such as a widening retirement savings gap and rapidly escalating healthcare expenditure. This will change people's lifestyles, the services they demand and the structure of the labour force. People will likely retire later in life, gradually wind back and change duties in a tapered model of retirement and spend increasingly large sums of money through the healthcare system to combat age related illnesses.



Digital immersion

The world will continue to be increasingly connected. People, businesses and governments are increasingly moving into the virtual world to deliver and access services, obtain information, perform transactions, shop, work and interact with each other. The rapid growth in connectivity will change organisational and individual behaviour, reducing the level of in-person interactions. Exponential growth in computing power, device connectivity, data volumes, internet users, artificial intelligence and technological capabilities will transform the way we live.



Porous boundaries

Digital technology transformation combined with globalisation will reshape organisational designs, governance systems and employment models. This will continue to break down traditional boundaries around countries, regions, companies, governments and professional fields. New horizontal networks are being constructed leading to a much more agile and flexible landscape for these segments. The peer-to-peer economy is set to bypass many of the traditional intermediaries in banking and finance, retail, tourism, transport, knowledge work and many other industries. Successful models hinge upon intelligent connectivity within rapidly evolving networks.



Great expectations

As populations grow wealthier, demand will rise for services and experiences over products. People will have an increasing expectation for personalised services that meet their unique needs and wants whilst being delivered en masse. Income growth will provide higher levels of discretionary expenditure for experiences, on-demand and instant services will be taken for granted, and consumers will increasingly seek moral and other 'feel good' outcomes. While wealthy people have great expectations, the billions of poor people in the world continue to have basic expectations – a gap that will be a priority for the international community to close in the coming decades.



The second key input into the scenario development process has been CSIRO's Australian National Outlook 2015 report, which models Australia's physical economy and natural resource use to 2050.

Future scenarios are described for Australia by modelling multiple trajectories for global drivers (population, climate and carbon abatement) and national drivers (agricultural productivity, land use, consumption mix, working hours and energy and water efficiency).

The report looks at the integration of nine economic and environmental models to holistically understand interactions across the "energy-water-food" nexus (Figure 4). Australia's material and energy-intensive industries account for 25 per cent of economic value and employment, but around 75 per cent of our use of energy, water and materials.¹³

The key message of the report is that Australia has the capacity to pursue economic growth, sustainable resource use and reduced environmental pressures simultaneously.

This concept is also explored in the Australia 2030 scenarios. Key findings of the report include:

- Australia's choices will shape our prosperity. Agility, innovation and productivity will be vital to make the most of a positive – but uncertain – global economic outlook;
- Sustainability and economic growth can be partners not competitors; and
- Decisions we make as a society matter – and will shape Australia's future more than decisions we make as businesses or individuals.

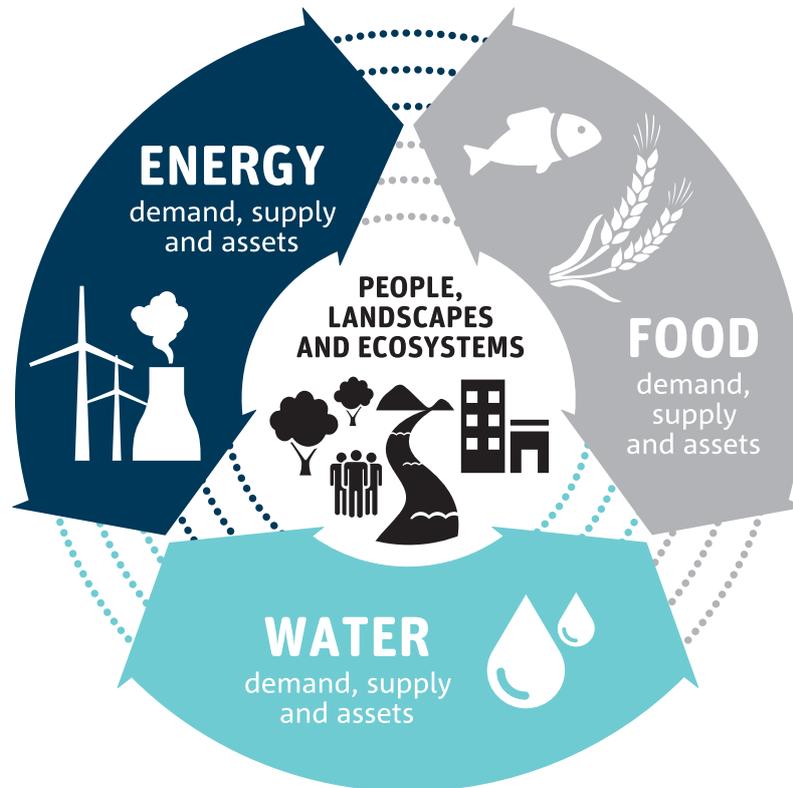


Figure 4 CSIRO Australian National Outlook 2015

¹³ Hatfield-Dodds, S. et al (2015), Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970-2050. CSIRO, Canberra. [ing back productivity \(2015\) http://theconversation.com/australias-road-obsession-is-holding-back-productivity-36212](http://theconversation.com/australias-road-obsession-is-holding-back-productivity-36212), accessed 2 September 2015

Finally, a number of CSIRO sector-specific forecasting reports were considered in the scenario development process. For example, the state of the energy market under each scenario was influenced by considering various combinations of the energy trends and predictions outlined in CSIRO's Future Grid Forum¹⁴ and CSIRO's modelling of energy markets.¹⁵

While all of these inputs provide an indication of the current global and domestic underlying trends impacting Australia's future, they can be heavily influenced by national and global decisions made today. Making assumptions about the different decisions that are made, and in doing so enhancing or reducing the prominence of the underlying trends, enables the creation of

a variety of scenarios. The scenarios presented in the following section were tested, refined and tailored as an input into CSIRO's own 2015-2020 strategy and ongoing research portfolio planning.

14 CSIRO (2013), Change and choice: The Future Grid Forum's analysis of Australia's potential electricity pathways to 2050

15 Brinsmead, T. et al (2014), Australian electricity market analysis report to 2020 and 2030, CSIRO Report No. EP141067 Hatfield-Dodds, S. et al (2015), Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970-2050. CSIRO, Canberra.

Differing futures: the scenarios



Digital DNA

Australia experiences a dramatic shift towards a digital services and knowledge-driven economy made possible by the exponential growth of computing power, an increasingly connected world, and the wide range of new technologies and business models this enables. Australia is stable, wealthy, and heavily connected into global supply chains and trade networks.



Mining and dining

Australia's economy benefits from a second wave of the resources boom driven by growth and urbanisation in developing economies. Minerals, energy and food represent the majority of Australian exports and are the underpinning wealth generators for the economy.

The following pages provide a high-level overview of each of the four scenarios, including an evidence-based qualitative and directional evaluation of the impact they would have on Australia. Three of these scenarios present different yet relatively positive views of Australia's future: *Digital DNA*; *Mining and dining*; and *Clean and lean*. The remaining scenario is the most challenging of the four scenarios from Australia's perspective: *Weathering the Storm*.



Clean and lean

Decoupling of economic growth and environmental sustainability has led countries to simultaneously pursue both objectives. Consumers seek out healthier lifestyles and Australia works with other advanced economies to address carbon abatement, resource efficiency and sustainability. Economic growth slows temporarily but is on track to quickly rebound with the growth of 'clean and green' products and services that fetch a price premium with consumers increasingly prioritising healthy living.



Weathering the storm

Global geopolitical instability increases, driven by climate change and regional conflicts over access to land, food and water. Tensions threaten to destabilise trade alliances and disrupt global supply chains, leading to prolonged global economic stagnation. Although demand for Australian food exports remains high, overall trade declines and Australia focuses on rebooting industries to service domestic demand.



Digital DNA

Australia experiences a dramatic shift towards a digital services and knowledge-driven economy made possible by the exponential growth of computing power, an increasingly connected world, and the wide range of new technologies and business models this enables. Australia is stable, wealthy, and heavily connected into global supply chains and trade networks.



Key megatrends

Digital immersion

- **Increasing productivity** – Technology-driven productivity gains lead to strong economic growth, despite an overall decrease in working hours.¹⁶
- **Increasing computing power** – Exponential growth continues as more and more devices are connected (conservative estimates predict 20 billion connected devices by 2020¹⁷) and their data is stored, analysed and actioned in data-driven decision making.
- **Increasing resource efficiency** – Technological advances lead to large increases in resource efficiency (mining, energy, agriculture) and reduction in emissions.

Porous boundaries

- **Increasing levels of international trade** – Technology acts as an equaliser, reducing trade barriers between countries by allowing the free movement of labour and capital, largely through virtual outsourcing. For a number of decades, world trade has grown on average nearly twice as fast as world production.¹⁸
- **Disruptive business models** – The recent ascendancy of peer-to-peer marketplaces and the rise of platform economics in a globalised labour market characterised by entrepreneurial activity continues to create new business models, industries and government systems.¹⁹

¹⁶ Hatfield-Dodds, S. et al (2015), Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970-2050. CSIRO, Canberra.

¹⁷ Van der Meulen, R. (2015), Gartner Says 6.4 Billion Connected 'Things' Will Be in Use in 2016, Up 30 Percent From 2015, Gartner. Newsroom, vol. 10 November, 2015.

¹⁸ World Trade Organization (2013), World Trade Report 2013: Factors facing the future of world trade

¹⁹ Hajkowicz, S. et al (2016), Tomorrow's Digitally Enabled Workforce: Megatrends and scenarios for jobs and employment in Australia over the coming twenty years. CSIRO, Brisbane.



The world in 2030

In 2030, the world has become smaller, faster and more connected. Reaching the steeper sections of the exponential growth curve in computing power, device connectivity, data volumes and artificial intelligence has resulted in significant productivity gains and a shift towards data-driven research.¹⁹ While these capability trends were largely predicted, the extensive adoption and integration of these technological advances has enabled unparalleled productivity increases and widespread economic growth despite a reduction in working hours. It has changed the way we interact with technology and each other, and has resulted in the mass adoption of data-driven decision making across most sectors.

New technologies have created new industries and new jobs – with flexible, agile, networked and connected workplaces now spanning all sectors.¹⁹ There has also been a significant rise in the number of entrepreneurs, creating their own jobs and running their own micro-businesses that sell direct to global markets. However these new industries have also disrupted many existing industries, driving a need for different skillsets. Further job displacement has also occurred through continued globalisation which has enabled businesses to outsource work to lower cost labour markets overseas. Nearly all industries benefit in some form from operational efficiencies.

To compensate for this labour market displacement, governments increase expenditure on R&D, education and

skills targeted towards new and evolving industries. This involves significant investment in science and technology. In line with this, the OECD nations (in aggregate) have doubled their R&D expenditure.

Global economic growth is driven by productivity increases in developed countries resulting from automation, remote operations, augmented reality, data analytics, and other emerging technologies. While the countries (including Australia) that acknowledged the importance of these areas leveraged existing capabilities to grow, countries that lacked the appetite or resources to invest in these areas have fallen well behind.

A shift in consumer preferences toward data-driven services and away from physical commodities has created a booming global services sector. By 2020, private investment had already shifted toward science, technology and innovation, with the benefits of these investments being experienced in the mid-late 2020s.

As more and more industries continue to take up data-based solutions, exponential growth filters through along with the associated productivity gains and economic growth. This growth, combined with creative destruction, causes new industries to build more new industries. For example, electric vehicles (now extremely cost effective and widely owned) create a stronger battery and renewables sector as well as new data-based services.

This growth is not contained to developed economies either.

Free trade, global supply chains and ‘technology leapfrogging’ allow developing regions to skip the infrastructure and education investments of previous iterations of technology and catch-up to the developed world. Data-driven developments are now seen as the ‘great equaliser’ of the modern world.

The growth of interconnected networks, systems and devices has inherently come with equal growth in pathways and tools that can be used to gain access to devices, bank accounts and even identities – presenting greater cyber security challenges. While this is anticipated to continue as a threat, the sophistication of theft/hacking-prevention technologies is also improving and presenting as an important emerging industry.

**“
New technologies have created new industries and new jobs – with flexible, agile, networked and connected workplaces now spanning all sectors.
”**



Digital DNA

Impact on Australia

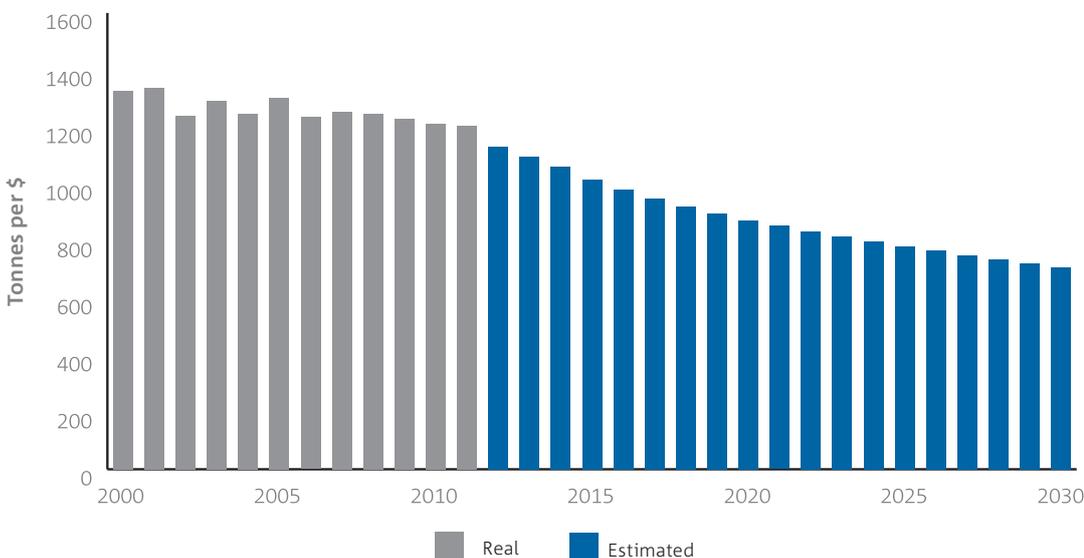
Adoption of data-driven technologies – including automation and algorithms – has occurred across all key existing and emerging sectors. This has displaced almost half of all Australian jobs.²⁰ While some workers are able to be re-purposed to monitor or maintain the underlying technology or re-skilled to participate in other industries, others leave the workforce entirely.

Technology breakthroughs relating to recycling and smart grids increase resource and energy efficiency globally, which in turn reduces the demand for Australian resources and energy exports. Additional breakthroughs in energy storage lead to a widespread adoption of electric cars and renewable energy.

While some established industries of 2016 (mining, agriculture) are no longer Australia's key sources of exports, they remain globally competitive through advances in data-driven technology that has assisted in productivity gains within these now contracted industries. Many businesses in these traditional industries have made a conscious decision to invest in service sectors, noting consumer shifts away from commodities. This decision re-shapes these industries and provides a new source of comparative advantage for the nation, drawing on our rapid adoption of data and digital technologies and our legacy and expertise in resource-based industries.

The digital revolution has also had a significant influence on healthcare, with integrated data systems fostering a culture of collaboration and information sharing between researchers, clinicians and patients. The rapid convergence of research domains and associated ease of access to information has increased the speed at which medical advances are made. Now, decision-makers (health professionals) are far more informed when diagnosing and treating patients.

Figure 5 Tonnes of material extraction per dollar of GDP, Australia, 2000-2030



Source: Adaptation of data from CSIRO Australian National Outlook 2015

20 CEDA (2015), Australia's future workforce? June 2015.

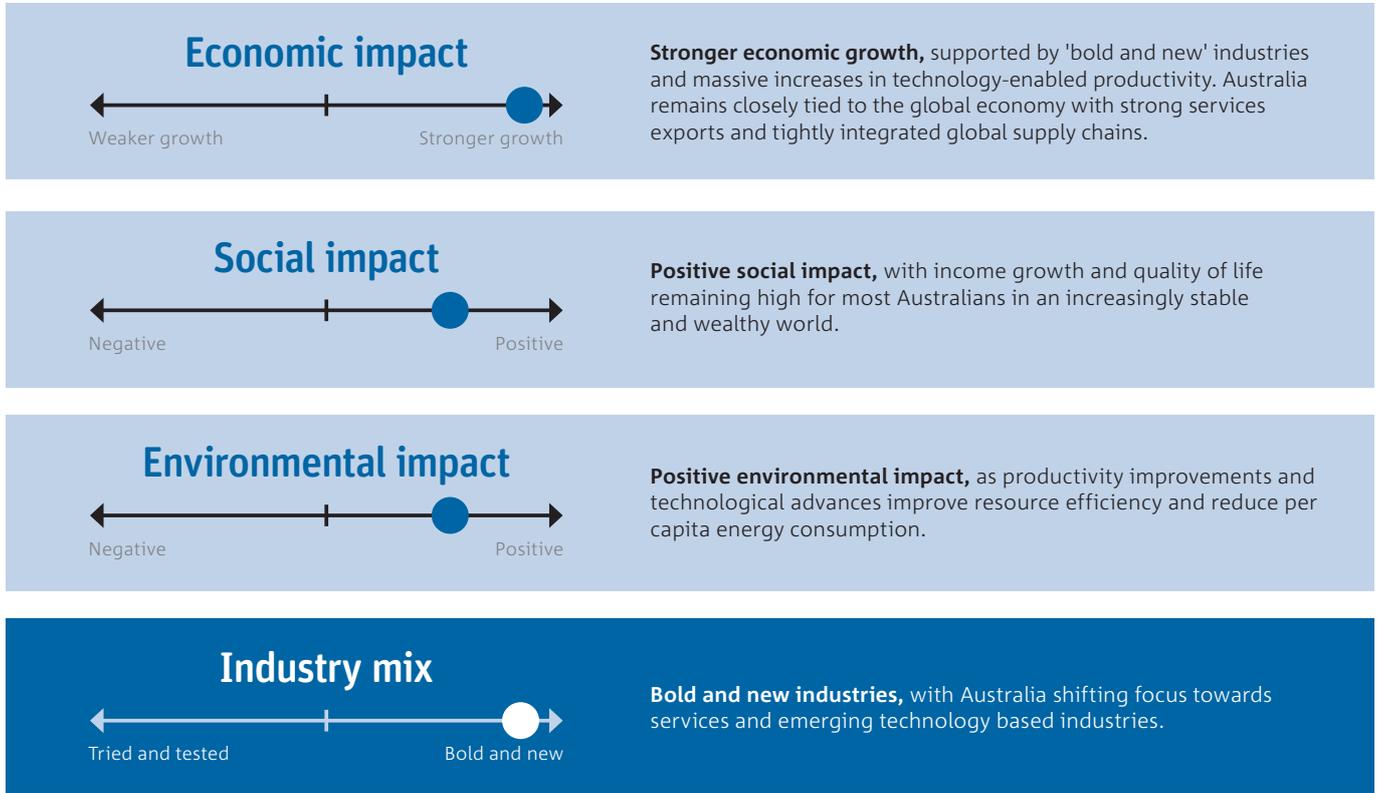
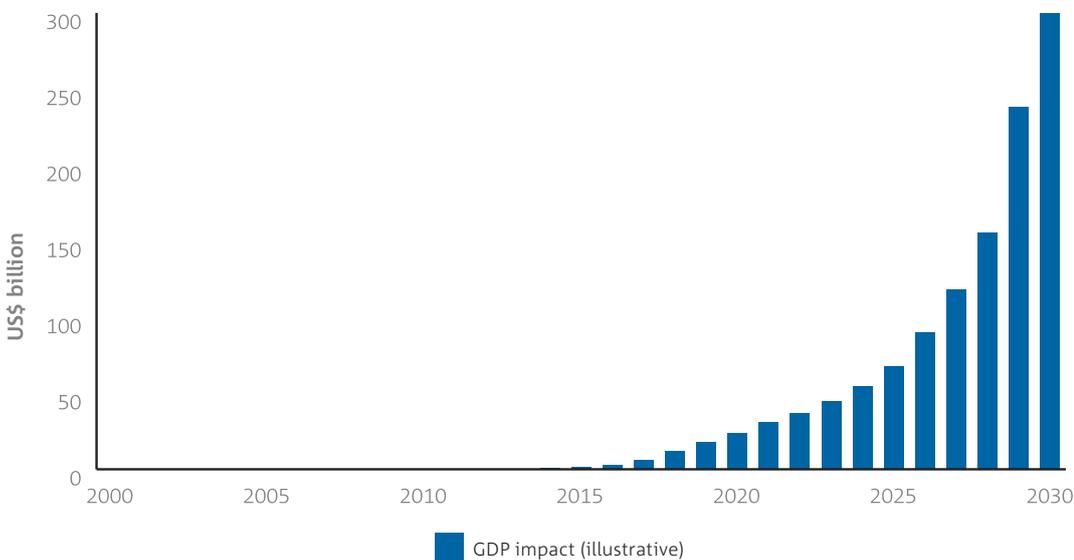


Figure 6 Impact of the 'Internet of Things' on Australian GDP, 2015-2030



Source: CSIRO illustrative enhancement of projections from (i) Accenture Strategy (2015), Country Spotlights: How much can the Industrial Internet of Things Fast-Track Your Economic Growth; and (ii) Palmer, D. (2016), Cisco launches Internet of Things innovation centre in Sydney <https://delimiter.com.au/2016/02/17/cisco-launches-internet-things-innovation-centre-sydney/>, accessed 21 March 2016.



Mining and dining

Australia's economy benefits from a second wave of the resources boom driven by growth and urbanisation in developing economies. Minerals, energy and food represent the majority of Australian exports and are the underpinning wealth generators for the economy.



Key megatrends

More from less

- **Resource efficiency follows current trends** – Per capita resource use in G7 nations is projected to increase from 18 tonnes per capita to 27 tonnes per capita by 2050.²¹
- **Moderate carbon abatement efforts** – Greenhouse gas emissions from G7 countries are projected to increase by 17 per cent from current levels by 2050 with moderate carbon abatement.²¹

The silk highway

- **Asian economic growth and urbanisation** – By 2022, China's middle class alone could rise from 300 million to 630 million, accounting for 45 per cent of China's population.²²
- **Increasing global energy demand** – Worldwide energy usage is forecast to rise by 37 per cent by 2040.²³ By 2030, China will overtake the United States and become the largest consumer of oil.
- **Increasing and changing food demand** – By 2030, the world's developing countries increase daily food consumption by 120 kcal/person (4 per cent), which includes continued but declined growth rates in meat.²⁴

- **Increasing material consumption** – The amount of material extracted from natural resources and consumed worldwide has doubled since 1980, driven by large increases in metals, construction minerals and fossil energy carriers.²⁵



The world in 2030

In 2030, globalisation has increased competition across supply chains of all industries. Global trade has increased due to lower tariffs and several rounds of new multi-lateral trade agreements. Australia had signed trade agreements with India, Indonesia and Malaysia, similar to the free-trade agreements signed between Australia and China, Japan and South Korea in 2015.

China has continued to grow at 5-7% per year and passed the United States as the world's largest economy (by nominal GDP) in 2023. China's growing middle class now accounts for over 50 per cent of its population. This has led to substantial increases in per capita calorie consumption and food demand, particularly for high protein food sources. As a result, food prices have trended upwards over the last 15 years.

China's rate of urbanisation and industrialisation has slowed but continues to grow, and China is still the world's largest producer and consumer of steel. Emerging economies throughout Asia, Latin

America and Africa experience another wave of growth, which has resulted in significant increases in global resource and energy demand.

However, advances in renewable energy generation and storage have been slow to develop and many countries have been hesitant to enact strong carbon abatement policies out of fear that they would slow economic growth. Coal and gas remain the preferred low-cost energy sources, particularly in the developing world. Global carbon abatement remains below the targets agreed upon in the 2015 United Nations Climate Change Conference. Developed countries have shifted focus towards building resilience against increasingly extreme and unpredictable weather events, rather than mitigating the driving environmental forces.

To meet growing resource demand, technology investment has been strong but largely focused towards tried and tested sectors (e.g. mining, energy and agriculture). This has been coupled with a new wave of capital investment and exploration in mining and energy sectors.

“
To meet growing resource demand, technology investment has been strong but largely focused towards tried and tested sectors.

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21 Hatfield-Dodds, S. et al (2016), Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies. Report prepared for the UNEP International Resource Panel on behalf of G7 leaders (in review), CSIRO and IIASA, Canberra and Laxenburg.

22 Australian Trade Commission (2015), Northern Australia: Emerging opportunities in an advanced economy

23 International Energy Agency (2014), World Energy Outlook 2014

24 Alexandratos, N. and J. Bruinsma. (2012), World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No. 12-03. FAO, Rome.

25 OECD (2015), Material resources, Productivity and the Environment, OECD Green Growth Studies, OECD Publishing, Paris.



Mining and dining

Impact on Australia

After a shorter than expected bust, the Australian mining industry has been rejuvenated by this second wave of resource demand. Australia remains one of the world's leading producers of iron ore, copper, coal, uranium and LNG. New investment and exploration leads to the discovery of new mineral deposits, and breakthroughs in science and technology make it possible to economically mine these deeper and more challenging resources.

Technology breakthroughs in automation, data analysis, modelling and mineral processing have changed the nature of mining work, and Australia leads the world in the development and export of these technologies and integrated systems. More efficient extraction techniques have allowed companies to meet part

of the high demand by obtaining value from low grade ores – previously treated as waste material or unmined.

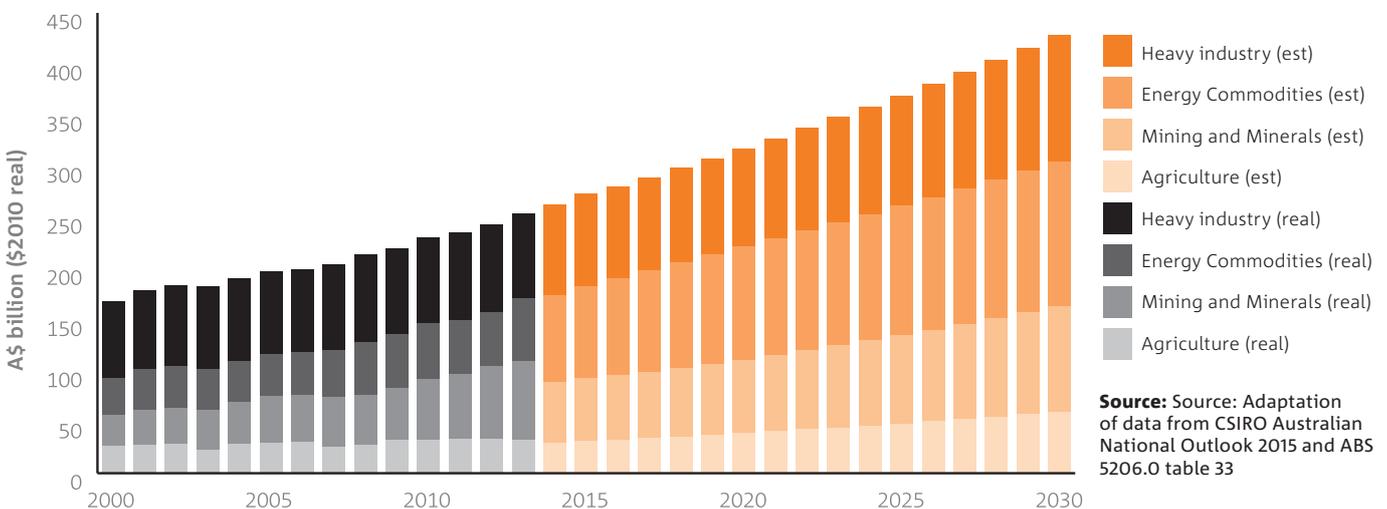
These breakthroughs have created a thriving services industry, which now contributes nearly as much to economy as the primary industry itself. It has also created a new pool of skilled labour and quickly returned Australia to a strong growth period with high yields on capital investment. Despite the continued exponential growth of digital technologies in primary industries, adoption has not been as strong in other Australian sectors.

With a number of new Australian LNG plants online, exports of the gas have tripled with most heading to Asian customers under long-term contracts. With the increase in overseas demand, domestic supply has fallen and energy prices in Australia have doubled.

This, coupled with a strong Australian dollar, has caused great stress on domestic energy-intensive industries like manufacturing.

Australia's agricultural sector has also experienced a boom, largely driven by rising food demand from Asia. The government has invested heavily in the northern Australia plan and the region now accounts for the majority of Australia's food exports. Investments in food quality and biosecurity have allowed Australian agricultural products to maintain their market differentiation and premium prices.

Figure 7 Australian material and energy intensive industries, total gross value added, 2000-2030





Economic impact

← Weaker growth

|

Stronger growth →

Stronger economic growth, supported by 'tried and tested' primary resources industries and the supporting services sector. Australia remains closely tied to the global economy with strong resource exports and tightly integrated global supply chains.

Social impact

← Negative

|

Positive →

Neutral to positive social impact, with income growth and quality of life remaining high for most Australians, but potential for climate change to have a tangible negative effect.

Environmental impact

← Negative

|

Positive →

Neutral to negative environmental impact, with coal and gas remaining significant sources of energy and resource efficiency remaining at current trend levels. Some impact can be mitigated by policy settings.

Industry mix

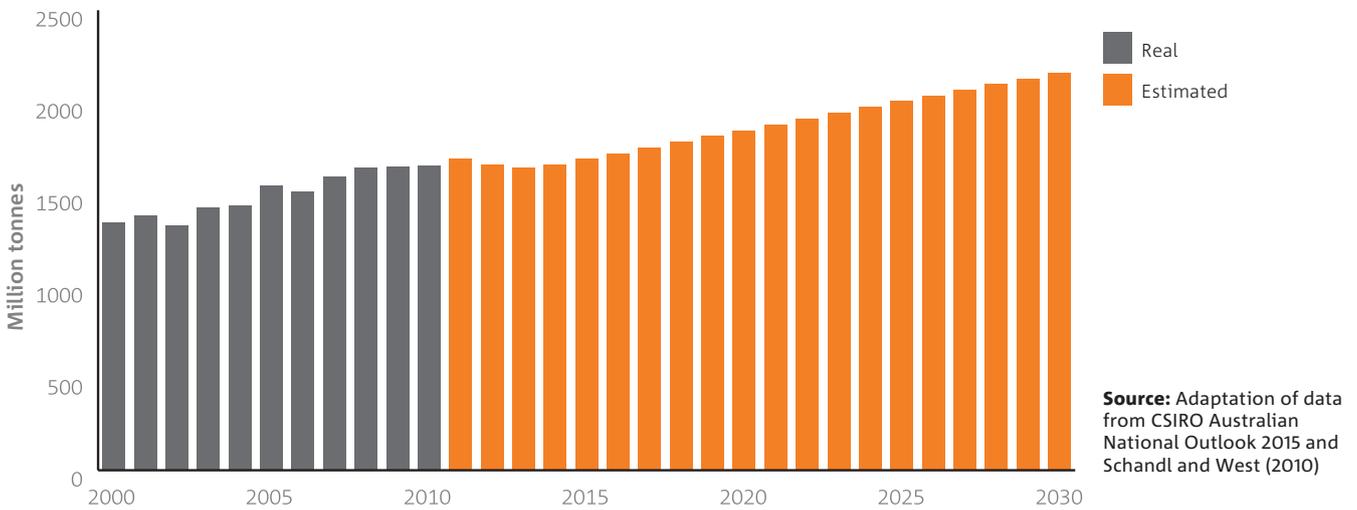
← Tried and tested

|

Bold and new →

Tried and tested industries, with Australia focussing on supporting its resource based industries such as Mining and Agriculture.

Figure 8 Australian domestic material extractions, 2000-2030





Clean and lean

Decoupling of economic growth and environmental sustainability has led countries to simultaneously pursue both objectives. Consumers seek out healthier lifestyles and Australia works with other advanced economies to address carbon abatement, resource efficiency and sustainability. Economic growth slows temporarily but is on track to quickly rebound with the growth of 'clean and green' products and services that fetch a price premium with consumers increasingly prioritising healthy living.



Key megatrends

Great expectations

- **Declining material consumption** – Relative to population and income growth, material consumption declines as consumers shift towards personalised products and experiences.²⁶
- **Increased focus on health** – Societies are paying more attention to diets, exercise regimes and mental health issues, with consumers demanding more personalised products and services.

Planetary pushback

- **Strong carbon abatement efforts** – The combination of resource efficiency and global climate action could see G7 emissions fall by 74 per cent from current levels by 2050.²⁷
- **Increasing resource efficiency** – Recycling and the 'circular economy' leads to a levelling off in demand for primary resources.²⁶



The world in 2030

In 2030, after 14 years of increasing intensification of extreme and unpredictable weather events due to climate change, public support for environmental and social sustainability has reached a tipping point. A strong global coalition has been developed, led by the USA and China (still the two global super-powers). Further, a UN convention on climate change in 2025 had a profound impact – a global price on carbon was set. This forced a rapid uptake globally of triple bottom line accounting (where outcomes are measured against economic, environmental and social targets).

The global carbon price also caused a significant shift in government policies towards resources efficiency, impacting all industries and their business operations in some way (land, water, energy, technology). While technology investment has continued to grow, it has largely focused on digital solutions for waste reduction and further enabling the use of renewable energy sources. An increased and stronger understanding of the impacts of long term environmental and social trends has resulted in substantial changes to investment priorities, organisational models, voting patterns and consumer preferences.

Simultaneously, a circular economy has emerged, largely driven by the European Union. This involves significantly greater levels of recycling and reuse as well as large reductions in waste across global transparent ‘clean and green’ supply chains. Infrastructure planning has shifted towards the integration of energy systems, with high energy-using industries being constructed in ‘hubs’. For example, energy generating businesses are now co-located with high energy uses such as manufacturers and mineral processing companies, which share energy flows and systems so that waste from one business can be used as an input in another.

Consumers, particularly in developed economies, have become extremely health conscious – placing great importance on healthy diets but also food products that have been produced in sustainable ways. Other lifestyle choices such as exercise and work-life balance are also a priority for individuals. With the growing amount of available data (food packaging requirements, health and fitness apps and more accurate and detailed medical testing), consumers are equipped with – and continue to demand more of – an abundance of information for health-related decision making.

“
Consumers, particularly in developed economies, have become extremely health conscious – placing great importance on healthy diets but also food products that have been produced in sustainable ways.
”

26 Hatfield-Dodds, S. et al (2015), Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970-2050. CSIRO, Canberra.

27 Steve Hatfield-Dodds et al (2016), Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies. Report prepared for the UNEP International Resource Panel on behalf of G7 leaders (in review), CSIRO and IIASA, Canberra and Laxenburg.



Clean and lean

Impact on Australia

While the significant changes in the business environment increase efficiencies and reduce costs associated with wastage in the long-term, many small businesses in capital intensive industries are unable to afford the initial investment in new equipment, processes and systems, and are forced to close down.

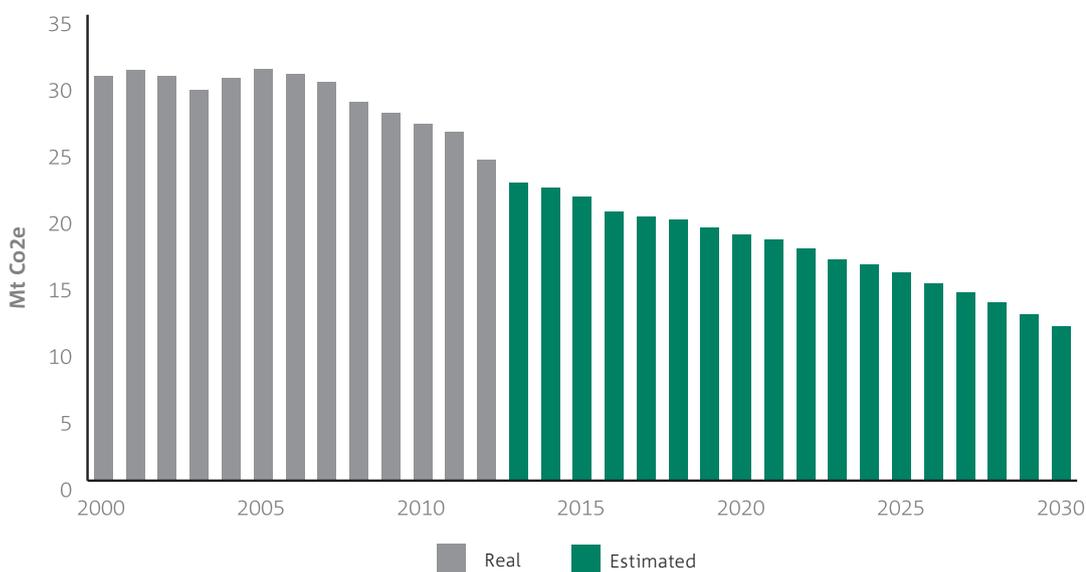
Of those that survive, some are further stifled through over-regulation. Larger businesses are only now beginning to offset their earlier 'green' investments, with a projected period of strong economic growth on the short-term

horizon and the long-term possibility of Australia becoming a carbon credit exporter.

To partly counter the short-term negative economic impacts, protectionist measures were introduced with the creation of green trade alliances. These agreements reduced trade barriers between Australia and other countries that adopted the highest level of 'green' requirements on businesses. Australia is now able to charge a premium for its green credentials both in 'green trade' markets as well as countries outside of these agreements.

Australian consumers have become increasingly aware of healthy living, dedicating more time to exercise, nutrition and mental wellbeing. This has reduced some of the strain on the healthcare system and has resulted in consumers being more willing to pay for and manage their healthcare services.

Figure 9 Domestic net greenhouse gas emissions per capita, 2000-2030



Source: Adaptation of data from CSIRO Australian National Outlook 2015, CCA (2014) and ABS 3105.0



Economic impact

← Weaker growth

→ Stronger growth

Neutral economic growth, with economic growth experiencing a temporary decline as industries restructure themselves to meet increasing environmental expectations. However growth is projected to recover post-2030 as new green industries continue to be created and optimised.

Social impact

← Negative

→ Positive

Positive social impact, with Australian's focussing on healthier lifestyle choices – eating well and exercising – improving general wellbeing and reducing the incident rate of mental illnesses.

Environmental impact

← Negative

→ Positive

Positive environmental impact, as businesses work towards more sustainable practices – reduced energy and water usage, reduced wastage across supply chains and lower carbon emissions.

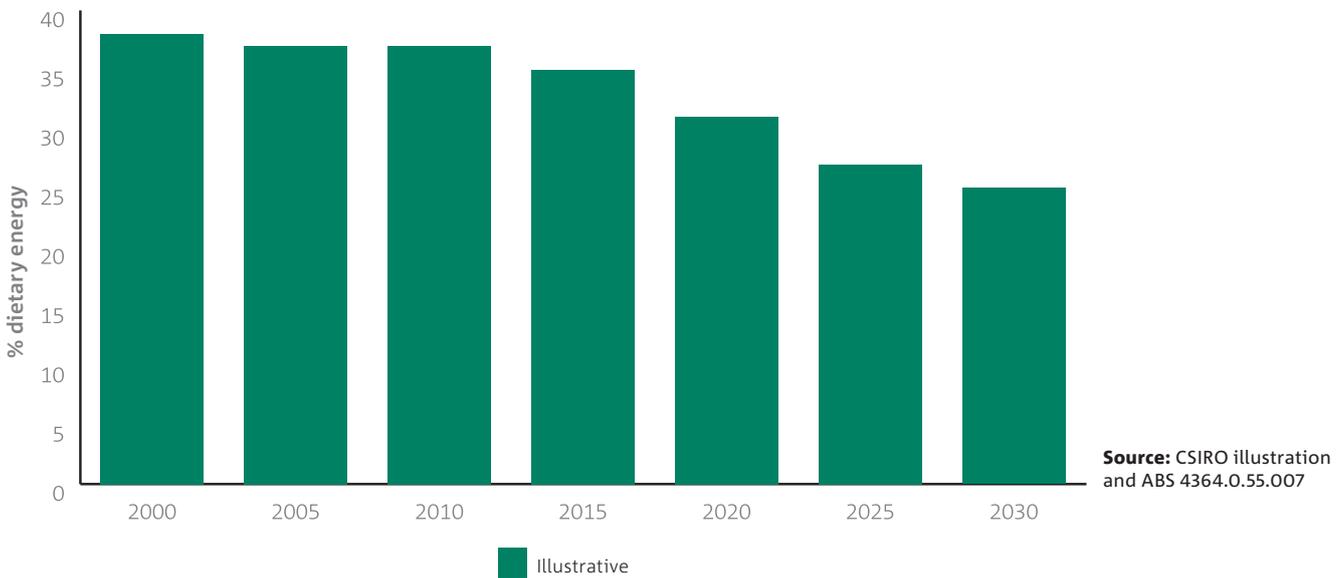
Industry mix

← Tried and tested

→ Bold and new

Bold and new industries, with new clean and green operating models being adopted by many traditional industries.

Figure 10 Percentage of dietary energy obtained from unhealthy foods, 2000-2030





Weathering the storm

Global geopolitical instability increases, driven by climate change and regional conflicts over access to land, food and water. Tensions threaten to destabilise trade alliances and disrupt global supply chains, leading to prolonged global economic stagnation. Although demand for Australian food exports remains high, overall trade declines and Australia focuses on rebooting industries to service domestic demand.



Key megatrends

More from less (failure to adapt)

- **Increasing water scarcity** – Global water demand is forecast to increase by 55 percent between 2000 and 2050.²⁸
- **Limited natural resources** – Declining ore grades and depletion of petroleum reservoirs lead to increased competition.

Planetary pushback (failure to adapt)

- **Growing impacts of antimicrobial resistance** – Failing to tackle antimicrobial resistance could result in an estimated cumulative loss to the global economy by 2050 that ranges between \$2.1 trillion and \$124.5 trillion.²⁹
- **Severe weather events** – Bushfires, cyclones, floods and rising sea levels occur more frequently and more extremely and could trigger mass migrations.

- **Decline in available agricultural land** – The world loses 12 million hectares of productive agricultural land each year due to drought and desertification.³⁰
- **Global trade disruption** – Trade relationships decline due to biosecurity risks and threats of human pandemics spreading.

The world in 2030

In 2030, after 14 years of increasing intensification of extreme and unpredictable weather events due to climate change, tensions have mounted over water scarcity, food insecurity and stalled economic growth. These drivers have combined to cause significant geopolitical instability, resulting in reduced trade and globalisation as cross-border flows of labour, capital and products decline.

Nations have become increasingly insular, protecting the resources and technologies that are abundant in their domestic markets. Ineffective government expenditure in response to climate events and geopolitical instability has driven greater levels of debt, and there is a strong focus on protectionist policies that prioritise national security, health and addressing biosecurity risks.

These are largely designed to protect smaller businesses and industries, with less consideration for environmental impacts or issues of sustainability.

The weakening of governments in South East Asia, and prolonged territorial disputes (e.g. South China Sea), have led to a rise in terrorism in the region. Advances in digital technologies have enhanced the sophistication and damage caused by cyber-attacks globally, in turn eroding the public's confidence in online systems and further undermining global finance and trade.

Regional conflicts over scarce natural resources have caused the mass displacement of people. These individuals, many of which lack access to clean drinking water, deteriorate in health and cause large-scale disease outbreaks.

“

Ineffective government expenditure in response to climate events and geopolitical instability has driven greater levels of debt.

”

28 OECD (2012), OECD Environmental Outlook to 2050: The Consequences of Inaction

29 Taylor, J. et al (2014), Estimating the economic costs of antimicrobial resistance: Model and Results, RAND Corporation

30 UNCCD Brochure <http://www.unccd.int/Lists/SiteDocumentLibrary/WDCD/DLDD%20Facts.pdf>, accessed 26 February 2016 King, S. et al (2014), Make for Asia – The emerging Asian middle class and opportunities for Australian manufacturing, CSIRO, Australia.



Weathering the storm

Impact on Australia

Disrupted global supply chains have required many of Australia's domestic industries to reboot and focus on servicing local needs with the significant reduction in imports. This has involved a number of industries that were previously closed down to re-establish (e.g. automobile manufacturing), as well as the development of industries that Australia has never meaningfully participated in (e.g. electronics).

Digital technologies have continued to advance, but the exponential growth experienced up to 2020 has begun to ease as collaboration and interconnectedness decreases. In an attempt to counter the increasing levels of national debt, the Australian Government introduces a series of taxes (such as a diverted profits tax), however these policies further stifle global trade.

While pandemics arising from the mass displacement of people have not yet spread to Australia, they pose as an ongoing and significant biosecurity threat. In addition to the human health risk, this threat has created risks for the agricultural sector which is one of the few remaining export sources for the nation. This has also placed further strain on our significantly reduced imports.

Figure 11 Level of trade, 2000-2030

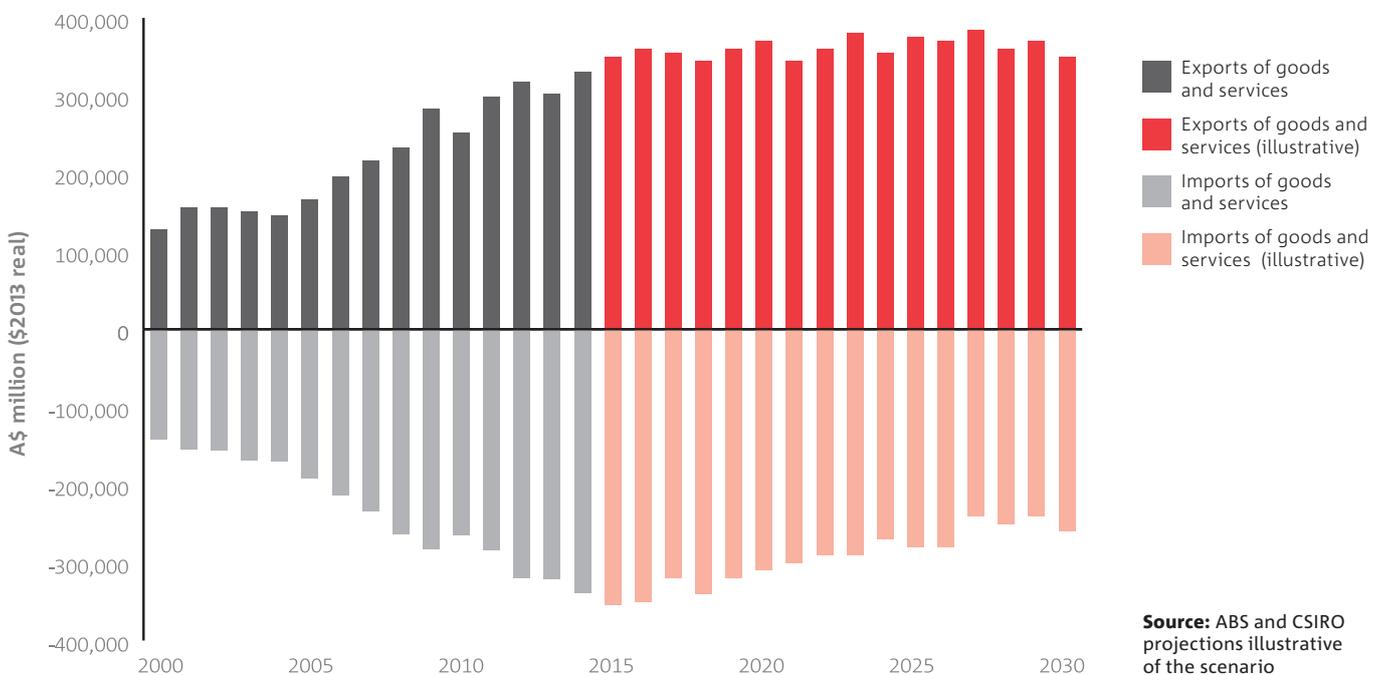
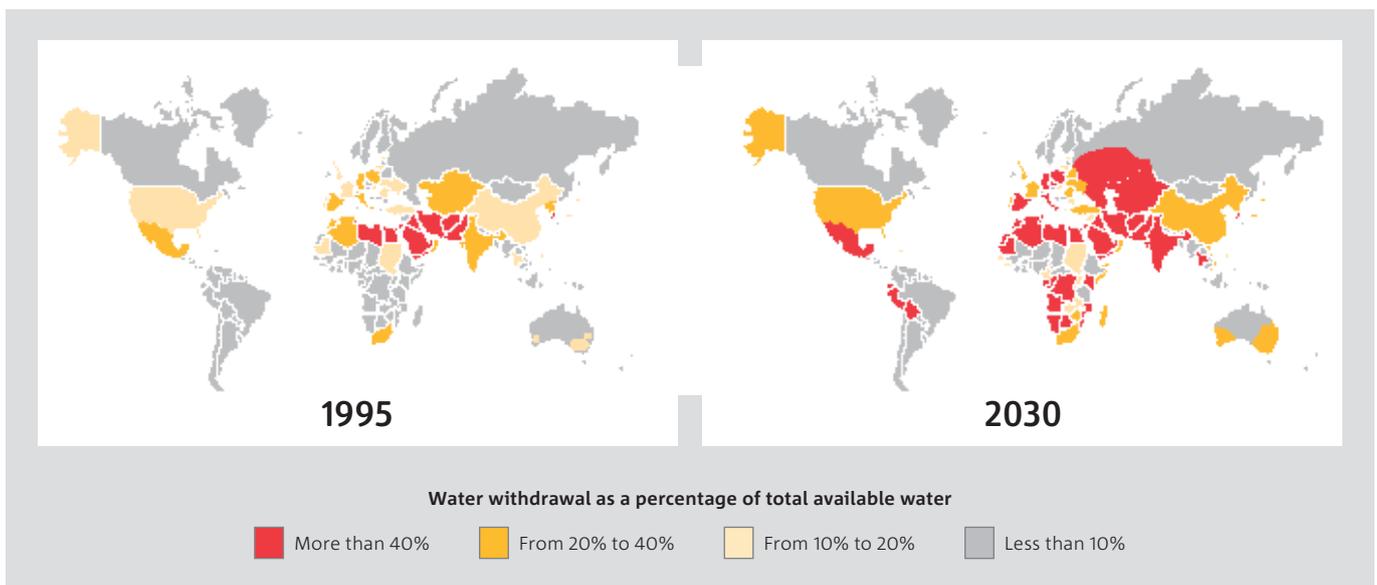




Figure 12 Water scarcity, 1995 and 2030



Source: (i) Illustrative 2030 Weathering the Storm scenario adapted from United Nations Environment Program <http://www.unep.org/dewa/vitalwater/jpg/0400-waterstress-EN.jpg>
(ii) CSIRO (2011), Water: Science and Solutions for Australia

Australian **sector** implications

Each of the four scenarios outlined in the previous section open the door to a number of sectoral and national opportunities for Australia. This section explores these opportunities across five key Australian sectors. It considers the impact each scenario could have on potential growth areas and the role that innovation in science and technology could play in enabling these opportunities.

“

We can influence which scenario we move towards but it will require vision and investment.

”

Through this analysis, it becomes clear that investments made today will fare markedly differently under each scenario. The process of applying scenarios to sectors is designed to expand thinking by considering the trade-offs present in the allocation of scarce resources under uncertain futures, ultimately informing strategic planning.

We can influence which scenario we move towards but it will require vision and investment. Committing resources and capital towards courses that are believed to best navigate towards the ideal future will be a critical influence on success, however obtaining the full benefit of the opportunities that arise will require the nation to address its innovation imperative.

Compared to other OECD countries, Australia has a poor record in terms of translating R&D into commercial outcomes. Our nation faces cultural challenges, including transitioning from a ‘technology adopter’ to a ‘technology creator’ mindset and more strongly and collectively recognising the worth of value adding. Australia currently ships large quantities of raw materials, however ‘value adding’ will be extremely important for companies and sectors to incorporate as we move towards a knowledge and data driven economy.

When assessing the opportunities that arise under each scenario, the nation must target those that exploit characteristics (skills, resources, geography) unique to Australia to build long-term comparative advantage and export markets. In many cases this will involve the creation of new products and services, industries and business models. However this does not mean Australia must start from scratch. Many of these opportunities can be realised by building on our strengths in established industries.

In this rapidly changing world, what structures (business size mix, business models), cultures and skills will be required under these possible futures? What decisions and investments need to be made now to set us on the path towards our ideal future? How do we grow and retain our own skills for long-term success rather than rely on outsourcing or recruitment from overseas? How can Australia prosper by developing competitive advantage and export opportunities in these key industries?

Sectors for assessment

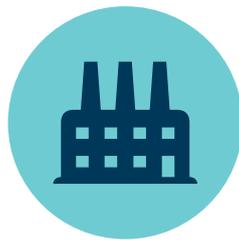
Acknowledging the importance of established industries in creating new opportunities for our future, this section applies the scenarios to five key Australian sectors. The Australian Government has also targeted similar growth areas through the Industry Growth Centre initiative.



Food and agriculture



Healthcare and pharmaceuticals



Manufacturing



Mining and METS



Oil, gas and energy

Each of the scenarios presented in the previous section have varying consequences for these five sectors (Figure 13). Some scenarios open up new export markets for existing Australian sectors or provide desirable market conditions for the creation of new industries within a sector. Other scenarios may shift investment, funding or consumer demand away from the traditional industries of a sector, forcing companies to adapt or die.

These qualitative ratings represent the proportion of economic growth that the sector contributes, and do not consider the absolute level of economic growth under each scenario or the contribution of sectors outside the scope of this report (e.g. ICT, financial services). For example,

the *Food and agriculture* sector is a primary contributor to economic growth under the *Mining and mining* scenario and a secondary contributor under *Digital DNA*, however the latter may be a more positive outcome for the sector if the total economic growth under the *Digital DNA* scenario is large enough.

For each combination of scenario and sector, growth opportunities exist. While market conditions are never ideal for all companies, those that choose to strategically target opportunity portfolios that provide long-term agility and first mover advantage will be best placed to capture a profitable share of international markets.

“

For each combination of scenario and sector, growth opportunities exist.

”

Sector contributions to economic growth

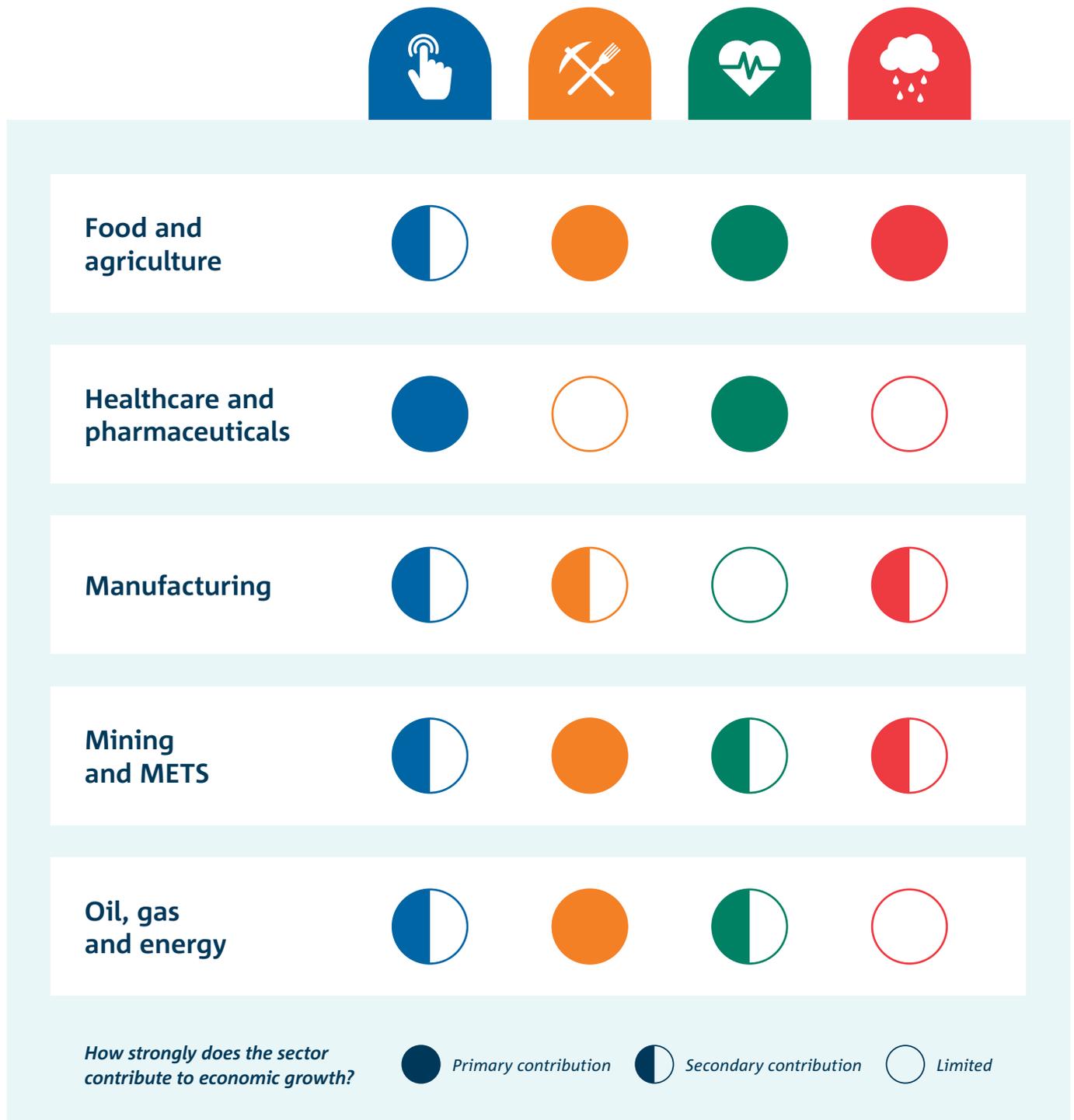


Figure 13 Sector contributions to economic growth by scenario



Food and agriculture

This report defines the food and agriculture sector to include both farm gate activities (agriculture, aquaculture and associated services) and post-farm gate activities (food and beverage product manufacturing). Potential growth areas discussed for this sector relate to new service export markets, increasing output to meet growing demand, speciality exports and becoming a key provider in a low trade world.

Under each scenario, the potential sectoral growth areas and key considerations for strategic planning change. The scenario discussions that follow highlight these differences and provide an example of the role that science and technology could play in enabling the sector to target the identified growth area.



Industry at a glance



\$52B

Industry
value added



728,000

Employment



\$0.9B

Annual business
spend on R&D

Food and agriculture growth areas



Digital DNA

Service exports

While the majority of global agricultural research investment comes from developed countries, it is now primarily focused on consumer preferences (e.g. processed, organic and humane products), rather than the yield-enhancing technology still sought after in developing regions. Australia's historically strong agricultural expertise (e.g. management of land, water, biosecurity, nutrition, etc.) is now in high demand, and the nation is able to expand its secondary services industry.

In addition to land management and 'on-farm' food waste, Australian businesses provide a wealth of knowledge around capturing value from recoverable edible waste for consumption and recoverable non-edible waste (for use in industrial chemicals, biofuels and feedstock).

Key considerations:

- How can farmers, many of which have been in business over 50 years, incorporate digital solutions into their existing practices in order to compete with new and technologically advanced competitors?
- What skills and technology are now required of producers in a world where direct to consumer supply chains are becoming increasingly common.

Potential technology enabler:

Australia's growing capability in data analytics could be coupled with low cost and highly connected sensors to help businesses (locally and abroad) digitise processes across their operations (e.g. automated farm-hands) and drive data-based decision making from planting through to transport logistics.



Mining and dining

High output / low cost

With Australia experiencing a resources boom, the food and agriculture sector flourishes with growth across many sub-sectors. Urbanisation, globalisation and rising wealth in Asia has resulted in substantial increases in per capita calorie consumption and demand for all food types, especially high protein foods, which Australia now services through increased output levels.

Australian food and agriculture businesses have experienced reduced costs through additional trade agreements (particularly with Asia), reduced regulations and the economies of scale gained through higher outputs. However, many businesses that concentrated their investments on achieving efficiency gains (rather than output gains) found themselves to be unprepared for the heightened demand.

Key considerations:

- How can the sector continue to increase its output to capitalise on increasing global demand, while addressing growing environmental risks such as the increasing intensification of water demand?
- What food and beverage products can rapidly and cost-effectively be scaled to capitalise on higher global demand?

Potential technology enabler:

Low genome sequencing costs (\$100 million in 2001 to under \$2,000 in 2016) and the knowledge it provides about how multiple genes control traits can play a major role in helping Australia's agricultural sector develop food that has higher agricultural output / yield, increased drought tolerance and extended shelf life.



Clean and lean

Specialty exports

The combination of rising incomes, an ageing population, rising levels of chronic disease and social awareness for healthy and sustainable products has created an opportunity for Australia to export specialised food and fibre products.

In addition to addressing quality needs, these exports also target demand for specific sustainable, social or health related attributes (e.g. addressing dietary requirements of illnesses).

Key considerations:

- What opportunities exist to improve efficiencies and allow Australian businesses to remain competitive against suppliers that don't operate under the same social restrictions and costs of compliance?
- How can producers economically transition from being bulk 'one-size-fits-all' suppliers to tailored specialty exporters?

Potential technology enabler:

Agronomics, the application of soil and plant sciences to soil management and crop production, can be used to apply technologies and management practices that enhance resource efficiency for water, nutrients and labour. This reduces operating costs and is more environmentally friendly due to lower levels of wastage.



Weathering the storm

Key provider

With global trade barriers disrupting traditional supply chains, Australia's strong political relationships, trade alliances and reputation for quality produce has positioned the nation to be one of the few global suppliers of both fresh and processed food products. In these unstable times total demand has decreased as people go into 'survival' mode and appetites shift towards 'no frills' products rather than customised or quality offerings. Essentially, Australia is now able to provide for a larger share of a smaller pie, predominantly competing against lower cost providers who still have open trade avenues.

Key considerations:

- With quality being less of a priority, how can high quality Australian producers reduce their costs of production to produce bulk commodities in order to compete with cheaper competitors?
- How can Australian food and agriculture businesses protect their level of output against the increased threat of pests and diseases associated with the mass displacement of people who flee regions harshly effected by extreme weather events and political instability?

Potential technology enabler:

Advanced preservation techniques could assist Australia in supplying to geographically distant trade partners and help prevent the spread of food-based pathogens both abroad and domestically. Novel processing and preservation technologies can create food products that are nutritional, safe, eco-friendly (with reduced chemicals and water requirements) and long-lasting, with lower production costs through reduced wastage and energy requirements.



Healthcare and pharmaceuticals

This report defines the healthcare and pharmaceuticals sector to include hospitals, residential care, other medical and health care services, medical and surgical equipment manufacturing and pharmaceuticals. Potential growth areas discussed for this sector relate to advanced surgical techniques, integrated health services, early prevention and patient empowerment, and targeted drug design.

Under each scenario, the potential sectoral growth areas and key considerations for strategic planning change. The scenario discussions that follow highlight these differences and provide an example of the role that science and technology could play in enabling the sector to target the identified growth area.



Industry at a glance



\$56B

Industry value added



753,000

Employment



\$5.6B

Annual business spend on R&D

Healthcare and pharmaceuticals growth areas



Digital DNA

Minimally invasive and short recovery surgery

Increased knowledge sharing and advances in digital technologies have enabled a new wave of minimally invasive surgery techniques that present fewer risks through improved accuracy and reduced invasiveness. This type of surgery has become commonplace, almost completely replacing more traditional forms of open surgery, as it results in less post-operative pain and scarring and faster recovery times. It is also preferred by clinicians due to the cost savings associated with reduced hospital stays.

Key considerations:

- How will education and training need to adjust in order to ensure Australian surgeons have the required skill sets for this new technology?
- What types of procedures could be performed entirely by robots – both technically and ethically?

Potential technology enabler:

Advancements in robotics and video displays can enable additional precision for this type of surgery, even compared to traditional laparoscopic techniques, as a robot provides improved vision (through high definition imaging) and additional degrees of motion to more accurately mimic the range of motions of the wrist.



Mining and dining

Integrated health services

With funding shifting towards the booming resource-based markets, capital investment is decreased in the healthcare and pharmaceuticals sector, causing the sector to look toward operating models and technologies that provide cost efficiencies given the increased funding pressures. Telehealth platforms are heavily utilised as they reduce the time requirements (and therefore costs) of clinicians and lower the capital requirements of care through in-home services.

In order to capitalise on this opportunity, pharmaceutical and life sciences companies will need to alter their supply chain and sales/marketing approaches to engage directly with consumers.

Key considerations:

- What data management systems and technical capabilities will be required for the sector to manage the large amount of information collected through eHealth solutions?
- How could nimble self-funded start-ups and small-to-medium enterprises drive new thinking and technological change for a health sector that is under significant funding pressure?

Potential technology enabler:

With the wide geographical dispersion of many Australians – a common characteristic of resource-driven economies – remote diagnostics and in-home patient monitoring of vitals can provide the base for a range of services including specialised medical triage (directing ambulances to the patients of greatest need) and rehabilitation plans.



Clean and lean

Early prevention and patient empowerment

With a societal push towards healthy living and preventative health, and a growing consumer base that has become increasingly responsible for financing their own care, opportunities exist around empowering this growing consumer base with access to affordable self-management healthcare solutions. Self-management solutions not only have positive health implications (through increased health education and awareness of patients), but also reduce the costs on the healthcare system through reduced hospital stays.

With the population being more health conscious and taking charge of their personal medical data, there is a greater demand for apps and web-based platforms for information storage.

Key considerations:

- With clinicians interacting directly and less often with patients through apps and other self-managed eHealth solutions, what roles and services are no longer required, and how might unutilised health professionals be re-deployed in other new or emerging fields?
- In a world where patients are taking greater responsibility for their own prevention, diagnosis and treatment, at what point does the duty of care pass over from clinician to patient?

Potential technology enabler:

Technology apps and mobile devices that draw on an individual's personal medical record and daily activity logs could enable the development of automated new care delivery models that facilitate self-care, prevention and wellness.



Weathering the storm

Targeted drug design

With geopolitical instability globally and concerns around resource supplies, more advanced forms of healthcare systems and pharmaceutical solutions have fallen by the wayside as the nation's focus shifts towards doing the best with what we have. The ongoing threat of epidemics from other countries spreading to Australia has resulted in the government spending its limited healthcare budget on more advanced quarantine protocols, stockpiling of vaccines and investments in the pharmaceutical sector focusing on targeting diseases.

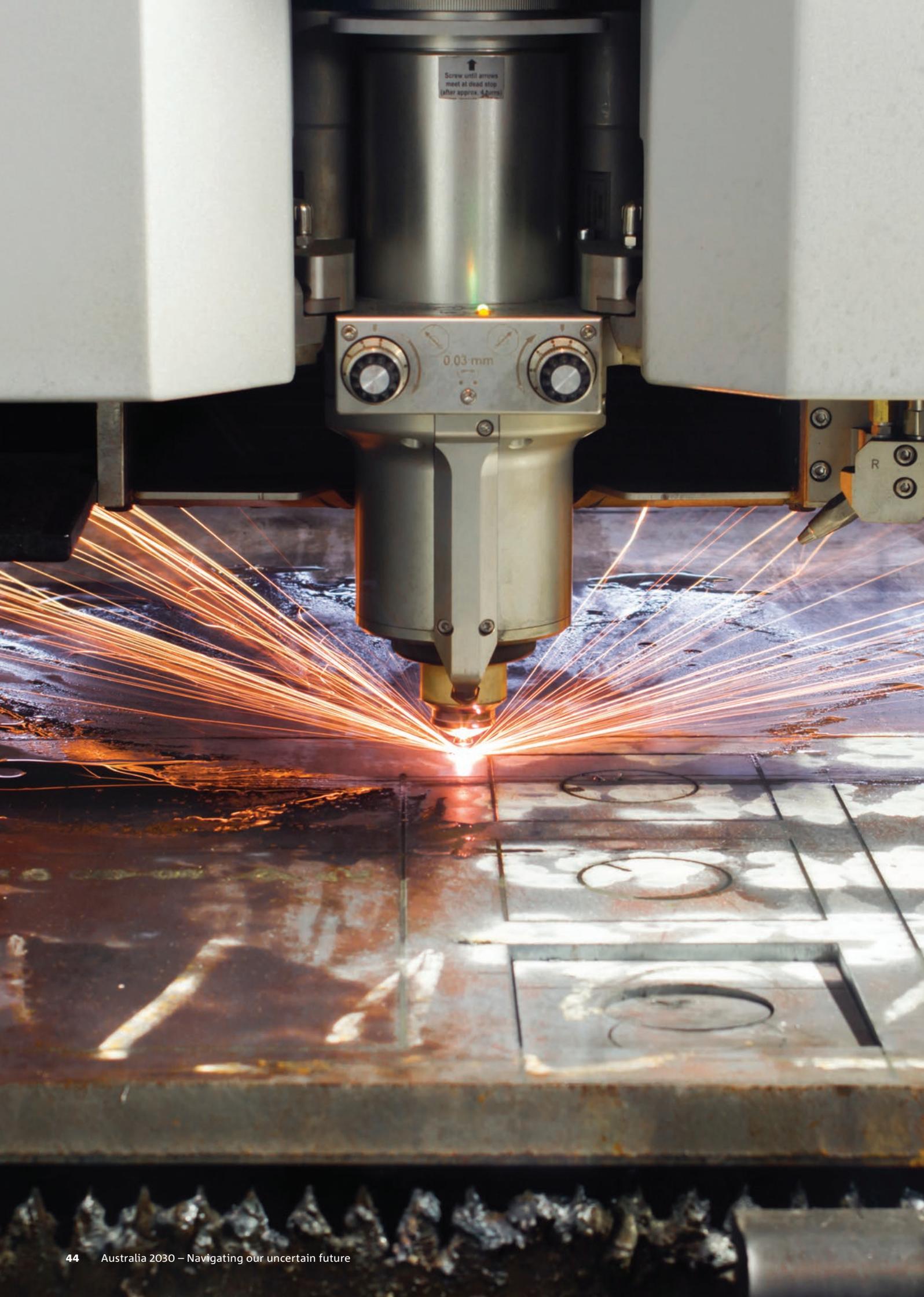
The focus on using drug design to address epidemic risks creates an opportunity for the pharmaceutical sector to leverage recent advancements in technology (and associated cost reductions) to develop medication that is tailored to an individual's genetic make-up.

Key considerations:

- How can Australia's pharmaceutical companies adjust their business models from 'mass produced after clinical trials' to 'tailor made' while maintaining earnings?
- How could tailored drug design be used to overcome the barriers associated with antimicrobial resistance – largely a result of continued over prescription of antibiotics?

Potential technology enabler:

Genomics and epidemiology can be used to track existing and emerging epidemics and develop new therapies before they reach Australian shores. Low genome sequencing costs (\$100 million in 2001 to under \$2,000 in 2016) make screening an individual's genetic information more economically viable and could be used to identify or design treatments that have higher efficacy with zero adverse effects.



Manufacturing

This report defines the manufacturing sector to include the design and production of textiles, wood-based products, chemicals, polymers, machinery and equipment. Food and beverage products and medical equipment manufacturing are covered under the food and agriculture and healthcare and pharmaceuticals sector discussions, respectively. Potential growth areas discussed for this sector relate to intelligent and connected products and solutions, high-value products, sustainable products and domestic market opportunities.

Under each scenario, the potential sectoral growth areas and key considerations for strategic planning change. The scenario discussions that follow highlight these differences and provide an example of the role that science and technology could play in enabling the sector to target the identified growth area.



Industry at a glance



\$68B
Industry
value added



625,000
Employment



\$3.8B
Annual business
spend on R&D

Manufacturing growth areas



Digital DNA

Intelligent and connected products and solutions

Massive step-change advances in digital technologies and data management capabilities has resulted in over 100 billion connected devices worldwide. In the home, there is high demand for security alarms, audio and visual systems, appliances and lighting that can all be controlled remotely from a single device. Likewise, manufacturers utilise connected solutions that allow the remote monitoring of all aspects of plants and equipment for process optimisation.

Sensors can be applied throughout the manufacturing supply chain. They can be used on-site to automate, speed up, or create more efficient manufacturing processes.

Key considerations:

- How can manufacturers best utilise the enormous amount of data collected through intelligent and connected products to create new opportunities while respectfully handling the personal information of their customers?
- How could the sector attract the required advanced software expertise against competition with other international regions to move towards services sector offerings such as value add remote monitoring solutions?

Potential technology enabler:

Sensors can be incorporated into products to provide real-time product assistance to consumers while also providing performance feedback to manufacturers. This would allow manufacturers to detect failure in advance and improve on future designs – resulting in the rapid evolution of products.



Mining and dining

Premium high-value products

With high commodity prices, high energy costs and a strong Australian dollar negatively impacting manufacturing exports, the Australian manufacturing sector has experienced a significant contraction. However, the increasing wealth across Asia and Australia's booming resource industries (mining, oil and gas, agriculture) has created an opportunity for the remaining manufacturers to service demand for high value products with superior properties and attributes.

With existing trade pathways, close geographic proximity and high quality manufactured products, Australian manufacturers are well placed to take advantage of this opportunity.

Key considerations:

- How can advanced manufacturing companies re-focus their existing operations to service the needs of booming primary industries, including attracting skilled labour with knowledge in these industries?
- How can the contracted manufacturing sector address the growing issues around water scarcity and increased energy demand while fighting to stay alive?

Potential technology enabler:

Advanced materials can be applied to a range of equipment, packaging and products across resource-based industries to improve quality and longevity. This can be achieved by reducing the weight or maintenance requirements of the product, or by increasing durability, strength and performance. Advanced materials can act passively (self-cleaning, self-repairing, controlled release of chemicals) or actively (In-situ sensors/nanomaterials which gather information and react once a critical state is reached).



Clean and lean

Sustainable product lines

In this cleaner, healthier global society, there is pressure from both consumers and government for manufacturers to produce more sustainable product lines. Efficient manufacturing processes support an improved environmental image and brand for Australia, with the production of manufactured products with superior environmental credentials being highly valued by overseas markets.³¹ Characteristics may include reduced emissions, waste and materials in the product creation stage and improved environmental performance during the product's life (e.g. lower energy or water requirements).

Key considerations:

- What opportunities are created in a world where the manufacturing value chain is disrupted and involves sending digital designs to manufacturing (or 3D printing) facilities near to the point of consumption rather than shipping physical goods?
- What Australian products could be highly-differentiated in the face of greater global transparency and traceability of total product lifecycles and triple bottom line impacts?

Potential technology enabler:

The process of additive manufacturing (3D printing) involves less waste and materials than traditional forms of manufacturing and can be used to improve performance, reduce input costs and minimise/eliminate assembly and maintenance requirements. This technology will also support a paradigm shift in Australian industry by supporting manufacture on demand to further reduce waste. In a world with public and government support for environmental protection, additive manufacturing could be used to create unique coral-shaped structures, which encourage coral polyps to colonise and regenerate damaged reefs.



Weathering the storm

New domestic markets

With the significant decline in global trade, the manufacturing sector turns its attention to servicing the domestic market. This includes expanding into markets that were previously supplied to Australia entirely through imports, such as electronics, in an effort to become as self-sufficient as possible. With this 'survival' mentality, premium high-value and optimised products are not a priority, either domestically or for the residual amount of exports still occurring. Instead, domestic markets seek 'no frills', reliable products.

Key considerations:

- With a net reduction in demand for manufactured goods, what high-growth opportunities exist in essential domestic markets to help sustain the sector?
- With geopolitical instability globally, how can Australia attract the required international skills and technologies in previously uncharted manufacturing industries to service local demand?

Potential technology enabler:

Digitised and integrated solutions to design, development and production systems, as well as robotics and automation, can optimise manufacturing processes through high throughput and low costs. These technology areas also enable the rapid adaptation to changed market conditions in this volatile scenario.

31 King, S. et al (2014), Make for Asia – The emerging Asian middle class and opportunities for Australian manufacturing, CSIRO, Australia.



Mining and METS

This report defines the mining and METS sector to include coal and metal ore exploration and mining, and associated mining support equipment and services. Potential growth areas discussed for this sector relate to expanding our METS footprint, unlocking new sources of supply, sustainable production and products, and taking greater control over larger portions of the value chain.

Under each scenario, the potential sectoral growth areas and key considerations for strategic planning change. The scenario discussions that follow highlight these differences and provide an example of the role that science and technology could play in enabling the sector to target the identified growth area.



Industry at a glance



\$94B
Industry
value added



152,000
Employment



\$1.7B
Annual business
spend on R&D

Mining and METS growth areas



Digital DNA

Expanded METS footprint

The rapid adoption of data and digital technologies within Australia, coupled with our mining legacy and expertise in services, differentiates METS providers in international markets. This allows mining service exports to thrive, meeting the growing demand from international mining companies for expertise and technological advancements that facilitate productivity and efficiency gains.

In particular, the rise in connectivity and remote sensing technologies enables new remote monitoring and analytics solutions. This has resulted in some Australian METS firms altering their business model from providing technologies and products to working with producers to provide end-to-end services internationally, remotely monitoring entire overseas mining operations.

Key considerations:

- How could mining exploration, development and operational know-how combined with advanced digital infrastructure be used to create first mover opportunities under this scenario?
- What technological barriers (such as interoperability) could limit METS providers from driving greater level of mining analytics and services.

Potential technology enabler:

Digitisation, modelling and integration of all processes and systems within a mine site can be used to enable process optimisation and risk minimisation. Intelligent and integrated mines could see the iterative characterisation of the in-situ features of the ore body and its surrounds, used to develop a 3D model of the mine and create a central repository of data for the mine. As mining proceeds, collected data improves the reliability of the in-situ data model which enables decisions to be made based on day/month old data rather than month/year old data.



Mining and dining

Unlock new supply

Exports of Australian minerals, metals and METS have all expanded to meet high global mineral and metal demand. This in turn creates a need to identify new Tier 1 deposits, unlocking new supplies and provinces. METS providers, researchers and government agencies have worked in partnership with sector producers to remove exploration and development barriers. This has accelerated the translation of science and technology advancements that increase the discovery of new mineral deposits and reduce costs related to the extraction of deeper, more challenging resources. Internationally, Australian know-how and expertise is sought after to rapidly increase production volumes.

Key considerations:

- How could strategic infrastructure, capability and exploration investments be used to create opportunities to capitalise on the high global demand in this scenario?
- What strategies or solutions will be required to increase the resilience of the sector against climate or weather related shocks that exist under this scenario?

Potential technology enabler:

Developing improved exploration strategies and unlocking new resource supplies could be realised by advanced Lab-at-Rig facilities/instruments. These drill rigs will be able to directionally drill faster, be more mobile and environmentally friendly, while also providing a wide range of more accurate geochemical, mineralogical, petrophysical and geophysical data. This information will be collected in real-time during the drilling program, with algorithms assisting the degree of automation and speed to result delivery, allowing a more accurate selection of exploration target sites with greater certainty of resource potential.



Clean and lean

Sustainable production and exports

A shift in consumer preference towards sustainable production makes it difficult for many mining companies to maintain a social licence to operate. However, Australia's past sustainability investments spanning from greater environmental scrutiny of operations to more stringent worker safety and rehabilitation policies create 'green' credentials that offer a point of differentiation over some international providers. Australia's leadership in this area creates additional opportunities for the METS sector to help those seeking to deploy more efficient processes to address environmental concerns. At the same time, growth in triple bottom line accounting drives demand for superior value-added 'green' exports that are cleaner and less energy intensive in downstream processes.

Key considerations:

- Given the pressure to reduce land use and increase recycling, which commodities would be early targets for recycling and reuse, and which are unable to be adapted?
- How could waste streams be leveraged to provide sources of revenue under this scenario?

Potential technology enabler:

Compared to more traditional methods of underground or open pit mining, in-situ recovery (ISR) has the potential to support sustainable mining operations. ISR is less energy and water intensive, substantially more environmentally friendly (lower visual disturbances and water recycled via a closed loop system), and can be structured to require significantly smaller capital investments than those associated with a more conventional mine.³² A major economic benefit of ISR is that it avoids the significant amount of effort associated with waste removal and handling (tailings dumps, evaporation ponds) as experienced by traditional mining methods.



Weathering the storm

Vertical integration

With global trade declining substantially, all mining and METS exports have fallen. However, some larger companies in the sector have survived by increasing their level of vertical integration, operating further downstream to counter market risks. With the reboot of Australia's manufacturing sector, metals manufacturing and its integration with mining has increased. Many Australian smelters and refineries have been resurrected as international competition and trade decline. Other parts of the sector have adopted a partially integrated strategy using joint venture, strategic alliances and long-term contracts to weather the uncertainty in global market.

Key considerations:

- In the face of disrupted global supply chains, what mix of minerals or metals does Australia need to be mining in order to meet local demand?
- With uncertain demand and lower exports, how could mine sites maintain enough flexibility to go from closure to being online once trade resumes?

Potential technology enabler:

With increases in vertical integration, advanced predictive analytics can be applied to optimise performance and integration across the value chain using external commodity price and demand data to automate (or assist with) decisions from exploration all the way through to transport logistics and manufacturing.

³² Martens, E. et al (2012), In situ recovery of gold: Column leaching experiments and reactive transport modelling, Hydrometallurgy: 125-126, 16-23



Oil, gas and energy

This report defines the oil, gas and energy sector to include oil and gas exploration, extraction, production and transport, as well as gas and electricity supply. Potential growth areas discussed for this sector relate to smart grid and energy services, exploration and extraction of underutilised supply sources, renewable exports and coal exports.

Under each scenario, the potential sectoral growth areas and key considerations for strategic planning change. The scenario discussions that follow highlight these differences and provide an example of the role that science and technology could play in enabling the sector to target the identified growth area.

Industry at a glance



\$57B
Industry
value added



80,000
Employment



\$1.4B
Annual business
spend on R&D

Oil, gas and energy growth areas



Digital DNA

Smart grid and energy services

Technological advancements have driven significant efficiency in smart grids, enabling a step change in decision-making and load forecasting by combining real-time smart meter data and advanced analytics and modelling. Improved management of the grid supports greater information flows which drive personalised energy pricing schemes and growth in electricity generated by renewable energy sources.

The rapid technology adoption (such as the wide-spread use of electric vehicles) combined with efficiency gains across the network alter energy consumption patterns. For example, many households and buildings are operating off the grid and many appliances and products have become connected and intelligent further altering energy usage.

Key considerations:

- What are the implications of consumer driven energy technologies outpacing state, national and global energy policy?
- How might energy providers plan and maintain long-term capital infrastructure investments under an environment where energy consumption patterns are rapidly changing?

Potential technology enabler:

Data-driven technology advances can dramatically improve operational efficiencies for Australian oil, gas and coal providers, improving their competitiveness in a highly uncertain market. Fully integrated web-based visualisation platforms can be used to measure, track and manage incoming data from across the oilfield, including wellhead conditions, pipeline flows and mechanical system updates. Data capture and management systems across the grid could enable a step-change in operating efficiencies and the creation of new business models.



Mining and dining

Oil and gas

With increased global energy demands, continued energy security concerns in Asia and minimal renewables to complement this demand, Australian exports for oil and gas have increased substantially. While coal is still an important export for Australia, it is LNG that is the largest export market, with higher oil and gas prices making unconventional gas economically viable.

To meet the demands of this booming resources sector, businesses and governments have invested heavily in infrastructure and efficiency gaining technology. Noting the increase in global demand, low-cost international producers enter the market to capture some of the growth, but are not large enough (or efficient enough) to heavily impact Australia's comparative advantage of being rich in resources and knowledge.

Key considerations:

- How can the sector increase its oil and gas acreage (i.e. through onshore and expanded deep water exploration) to capitalise on the favourable market conditions?
- What can the sector do to attract and encourage investment and talent to grow the supporting energy services sector?

Potential technology enabler:

Automation, sensors and analytics can be used to continuously and cost-effectively monitor and detect anomalous behaviour in equipment, assisting with preventative maintenance. However, the real-step change in productivity will come from the re-allocation of these workers to high-order tasks, such as modularising processes so that they can be redesigned, optimised and/or eliminated based on real-time data, market conditions and business needs.

³³ CSIRO (2015), Direct Injection Carbon Engine <http://www.csiro.au/en/Research/EF/Areas/Coal-mining/Advanced-carbon-power/Direct-Injection-Carbon-Engine>, accessed 21 March 2016



Clean and lean

Renewable exports

The share of renewables in the global energy mix has increased significantly. This growth has created greater demand for technologies and services that assist with the integration and storage of renewables – particularly for the many countries still in transition from fossil fuels. This emerging export market includes optimisers, smart systems and other integration-related knowledge applicable to both complex large-scale commercial environments and households.

With increased pressure on more sustainable and environmentally-friendly practices, both on-shore and off-shore oil and gas extraction industries contract.

Key considerations:

- How can environmental incentives, mature global carbon accounting mechanisms and domestic renewable technologies and expertise be used to accelerate the lead-time for new exportable renewable services and technologies?
- What infrastructure planning and energy integration services could be created to help energy generating businesses co-locate with high energy users (manufacturers, mineral processing companies), to share energy flows and systems so that waste from one business can be used as input for another?

Potential technology enabler:

With high abatement and a global push towards environmentally-friendly operations, Carbon Capture and Storage (CCS) has the market conditions required to become economically viable. CCS integrates the capture, transportation and storage of CO₂ gases emitted from industrial processes and power generating plants, allowing coal-fired plants to provide electricity at a lower carbon intensity. This science and technology area could create a new knowledge export market around CCS technology for countries still operating coal fired plants.



Weathering the storm

Coal exports

With volatility and uncertainty surrounding most industries, the energy market relies on tried and tested energy sources such as coal rather than further developing the potential of renewables. High oil and gas prices coupled with regional conflicts in oil supplying areas like the Middle East has also increased the attractiveness of coal.

The significant decline in global trade more generally means that many countries are concerned about meeting local energy needs. This has caused issues related to global competition, social licences for operation and capital investment to become less relevant.

With many countries pushed into 'survival' mentalities, Australia has been able to capitalise on its strong political and trade partnerships to continue to supply coal abroad – and to a lesser extent, LNG.

Key considerations:

- How could the energy stockpiling that occurs under this scenario be used to create long-term opportunities for when global trade resumes?
- How might deep-water oil and gas production change in the face of rising geopolitical tensions and climate related weather events?

Potential technology enabler:

Technologies that allow coal to replace oil or gas as a fuel will facilitate heightened demand for Australian coal. Fuel diversification will allow nations to be more self-sufficient and less reliant on more volatile trade partners. One example of such a technology is a Direct Injection Carbon Engine – an adapted diesel engine that converts coal into a water-based slurry that maximises electricity generation and extends the life of the engine.³³

Strategic planning framework

Future strategic decision making will need to take into consideration the rapid pace of change, market disruption, and future uncertainty and volatility. Incorporating these factors into strategic planning is a difficult task. The framework summarised in this section has been developed over a series of projects as a way of applying the scenarios from Section 2 and the sector implications from Section 3 to strategic planning, guiding decision-making at a corporate level.³⁴ Specifically, the elements of this report relate to the first step – Explore. The framework can be used in both top-down strategic planning and exploratory ‘bottom-up’ development to assist in developing or strengthening a comparative advantage in the market.

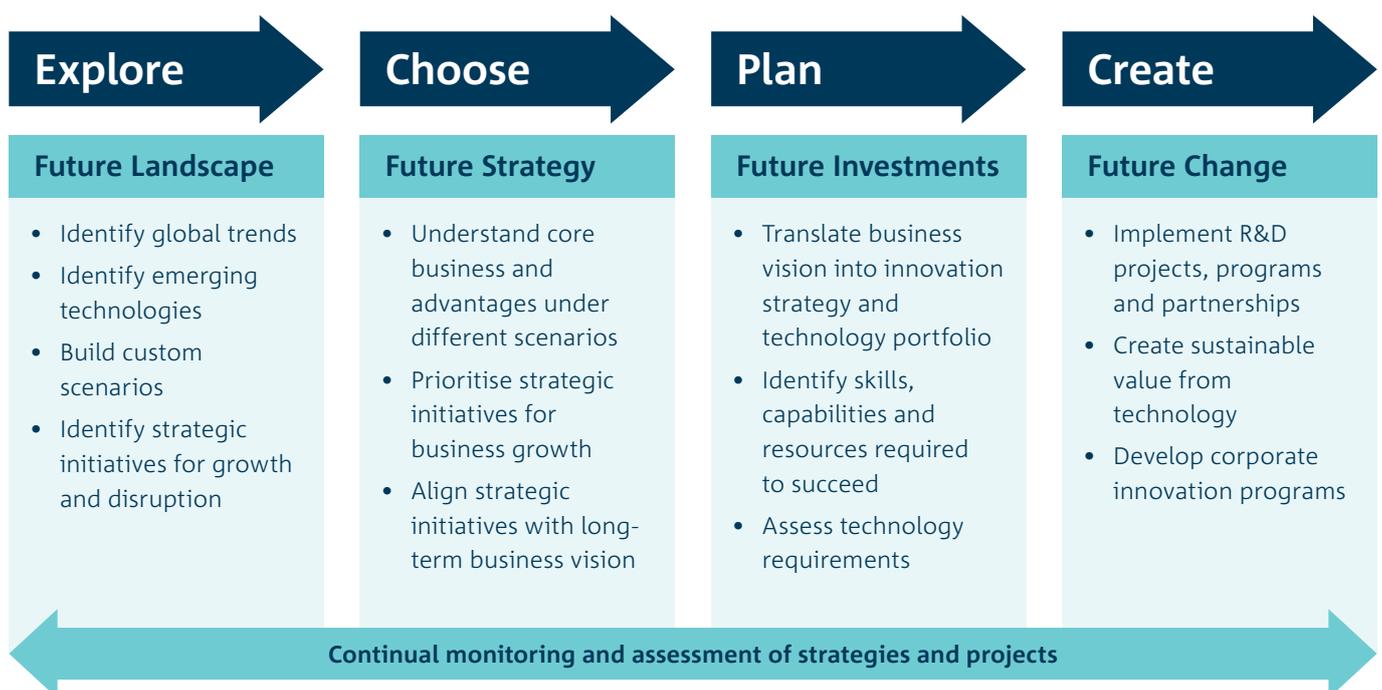
As shown in Figure 14, the framework involves four steps – Explore, Choose, Plan and Create. This section details the key questions, considerations and tools available for implementing each of these steps.

Following this framework and asking the right questions will allow organisations to better understand the allocation of scarce resources (labour, capital), the underlying assumptions that underpin existing business decisions, and the role that innovation can play in helping businesses strengthen their future.

Finally, it is important to note that the framework should not be viewed as a once off activity. Deep understanding and on-going evaluation is critical for ensuring that innovation activities remain relevant and on track. Project teams need to be capable of recognising changes in technology and market levers and understanding their impact on the scenarios and strategies that have been developed. As such, this framework needs to be continuously applied to strategic decision making.

“
Future strategic decision making will need to take into consideration the rapid pace of change, market disruption, and future uncertainty and volatility.
 ”

Figure 14 Scenario planning framework



34 The framework can also be applied to sectoral/national strategic planning, however the discussion has been limited to a corporate lens for this report.

Explore

What is the world going to look like in the future?

The first step of the framework explores the future landscape by considering global economic, societal and environmental trends, as well as emerging technologies and potential disruptors, as discussed throughout this report. Ultimately, the objective of this step is to drive the development

of strategic initiatives for new sources of advantage and strategies for managing industry disruption. Therefore, there is a deliberate focus on identifying long term, stretch-thinking prospects that provide lasting and significant value to the company, rather than 'quick wins'.

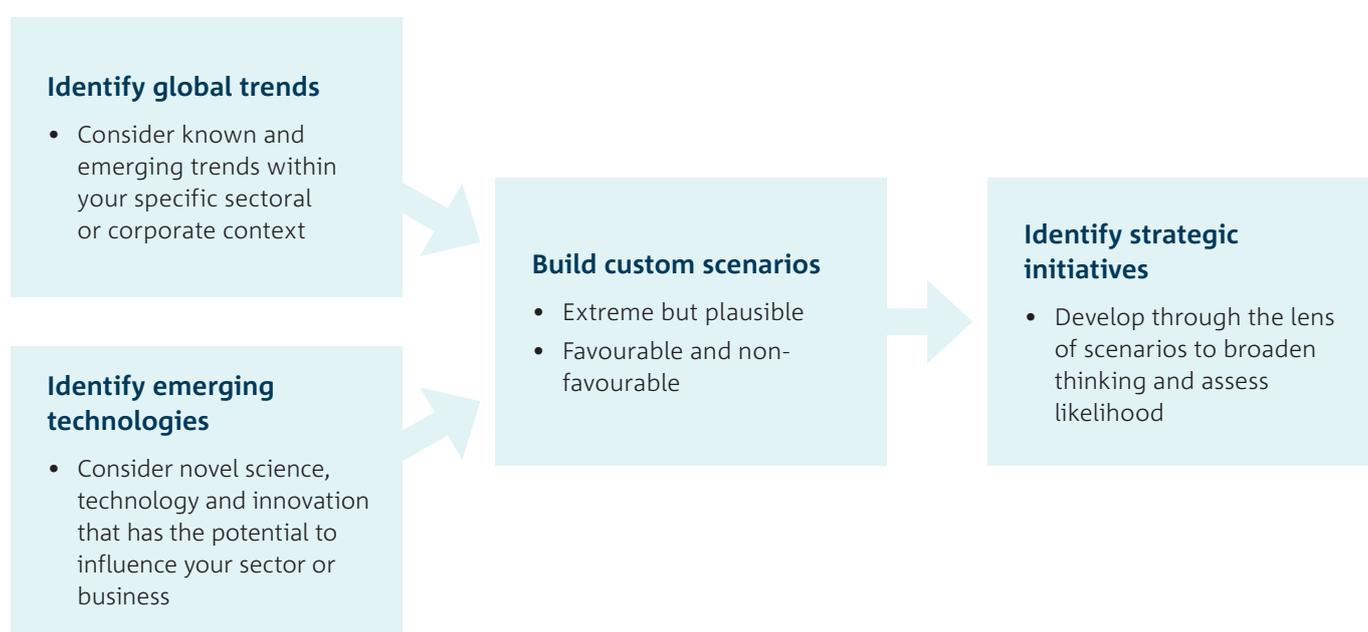


Figure 15 Identifying strategic initiatives

Key questions:

- What global trends and technologies are influencing your industry and what is their impact?
- What is driving the identified trends and technologies in your industry and how might these factors change in the future?
- What would be the impact of these scenarios on your current business model if you were to continue with business-as-usual?
- What investment trade-offs would be required to adjust to each scenario?
- What new sources of advantage/disadvantage arise under each scenario and which disappear?

Choose

How could you position for advantage in these identified futures?

In order to prioritise the strategic initiatives identified in Explore, a current state assessment must be performed on the business to assess the options based on the business's competitive advantage and the level of change that would be required. Using the business's appetite for change, these initiatives can then

be prioritised based on their impact and feasibility (Figure 16). A number of considerations and weightings sit behind both impact and feasibility scores. A single vision can be created from this portfolio of initiatives to guide strategic planning and policy development

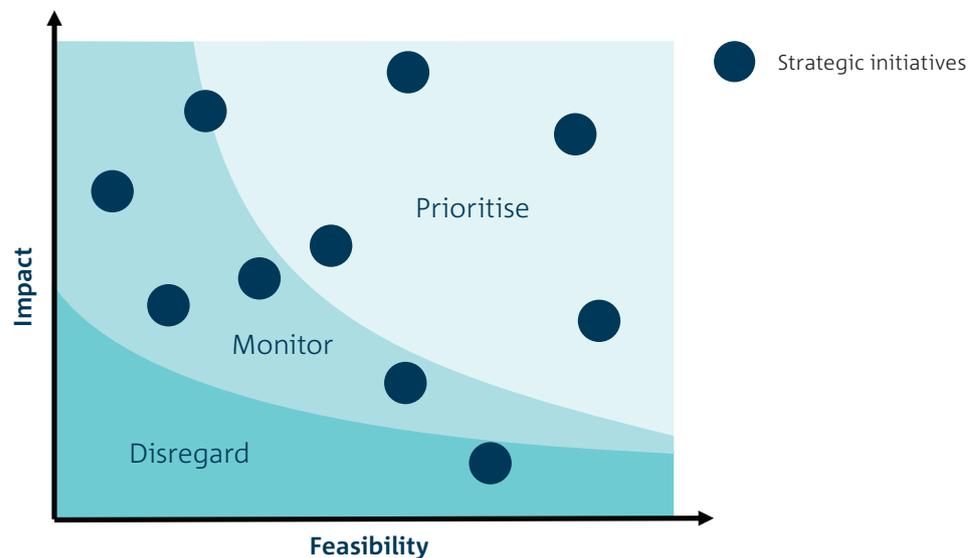


Figure 16 Option prioritisation decision matrix

Key questions:

- What is the current competitive advantage of the business and is it sustainable?
- What is your ideal mix of incremental vs disruptive/breakthrough strategic initiatives?
- Using the custom scenarios, what market conditions could negate or amplify your prioritised strategic initiatives and what triggers might indicate movement towards these conditions?
- What is your business' vision for the next 15 years and how do the prioritised strategic initiatives feed into it?
- Are the prioritised strategic initiatives compatible with each other?

Plan

What is the pathway from your current state to your future strategic position?

This step translates the vision identified in Choose, which is used as an input to corporate strategy, into a tangible plan for achieving the intended future state. This planning may iterate with the Choose and Create steps as deeper investigation can uncover additional factors that

inform strategic decision-making. A key challenge here is clearly understanding when to invest based on the organisation's appetite for risk, its intellectual property stance, the competitive landscape and its ability to maintain investment through the business cycle (Figure 17).

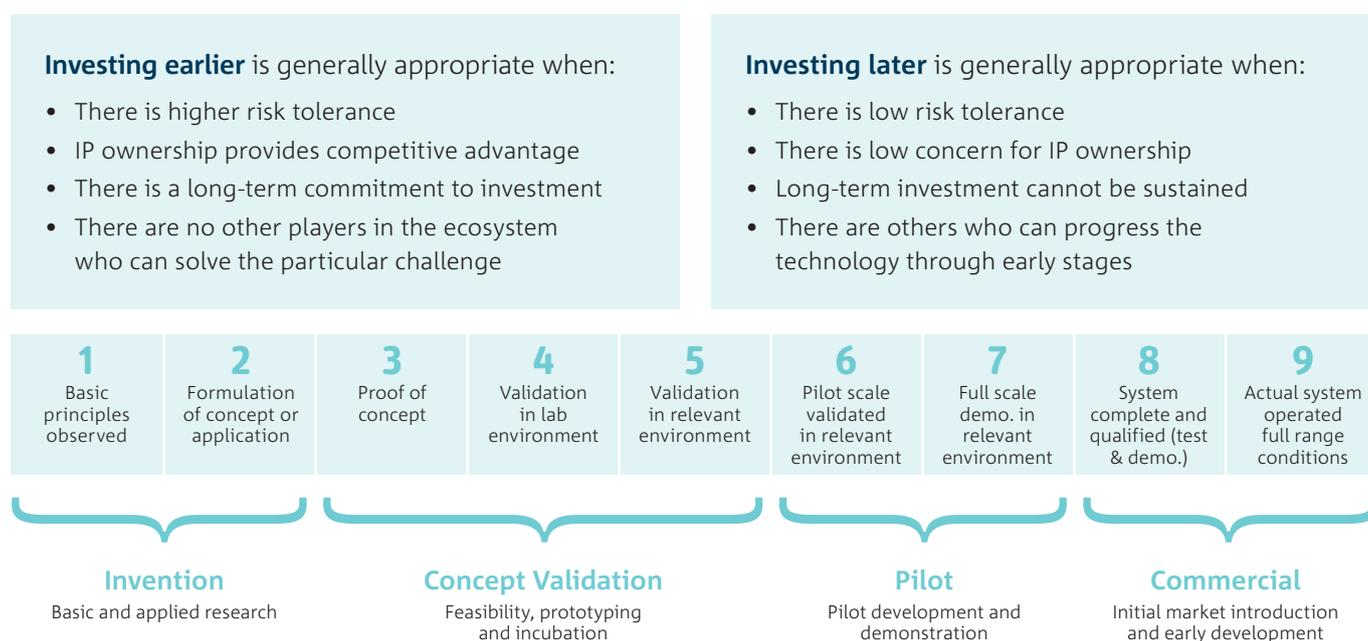


Figure 17 Corporate technology readiness considerations

Key questions:

- How can your business navigate the pathway to your future strategic position while maintaining earnings?
- What does your business need in terms of technology and culture and when do you need it?
- How does your workforce (skills, capabilities, culture) need to change to achieve your business vision?
- Are there opportunities to develop technology from scratch or is it more appropriate to pick-up semi-developed existing technology?
- How will you maintain technology investment for a sustained period to overcome any unforeseen problems (e.g. downturn in the market)?

Create

How do you operationalise the pathway to your future strategic position?

The final step is about transformation and managing processes and projects necessary to execute against the technology portfolio created in Plan. This might involve recruiting or identifying the right mix of skills and technology internally, but could also include finding the right set of collaboration partners – there

is no one-size-fits-all approach. The following framework, adapted from work by Markus Perkmann and Ammon Salter published in the MIT Sloan Management Review, is a useful tool for considering different collaboration models based on project needs (Figure 18).³⁵



Figure 18 Collaboration framework

Key questions:

- Do you have existing partners that have a proven track record for delivery and flexibility in the face of changing requirements?
- Which roles will external R&D and technology partners perform and which will internal resources perform?
- How will technical outcomes of R&D projects be translated into an implementable product or service that fits with existing workflows to create value?
- How can you build a culture of innovation that welcomes the required changes?
- What process and system changes do you need to be effective at sourcing ideas from across the organisation and managing them through to execution?

35 Perkmann M. and Salter, A (2012), How to Create Productive Partnerships with Universities. Sloan Management Review. 53 (4)

The way forward

After decades of economic growth enabled by market-oriented reforms and driven by strong demand for mineral resources, Australia is now facing an uncertain economic future. The investment phase of the mining boom is over. The world is changing rapidly as unprecedented wealth creation is shifting the balance of economic power towards Asia. This presents enormous opportunities for Australia.

But to seize these opportunities and ensure continued growth, established industries will need to boost productivity to remain competitive. At the same time, it will be critical to develop new industries and new businesses that harness emerging technologies and new business models to create the growth engines of the future. Australia has a limited window to seize these new opportunities. If we don't, others will.

Innovation backed by a strong investment in science and technology will be essential to both of these. It will be key to increasing productivity in existing industries through the application of new technologies, such as automation, data analytics and genetics. It will also be critical to developing new industries through the commercialisation of emerging technologies.

A critical question is where to direct investment in science, technology and innovation today to ensure the best possible outcomes in the future. This report outlines a scenarios-based

framework to guide strategic planning and investment decisions under uncertain conditions such as those currently facing Australia.

Each of the four scenario narratives presented in the report presents a divergent view on Australia in 2030. The report also outlines key growth opportunities for five core growth sectors across the scenarios. Although these opportunities differ across the scenarios, in each case science, technology and innovation will play a major role.

The scenarios-based framework presented in this report is necessarily high-level given the breadth of scenarios and industries covered. The intention is to demonstrate the framework as a tool that can be used at a more detailed level within an individual company or sector. For example, at a corporate level it could be customised to guide innovation investments and identify new sources of competitive advantage. At a sector level, it could be used to develop industry roadmaps to identify where investments are most likely to accelerate technology adoption.

The next 15 years are full of opportunities for Australia. With careful consideration, the framework presented in this report can help Australian companies identify new opportunities, build resilience for the future, and ensure sustainable growth for the years ahead.

“

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Appendix

A.1 Sector snapshot calculations

Sector definitions

Sector snapshot statistics were calculated using the following sector definitions.

SECTOR	INCLUDED ANZSIC INDUSTRIES
Food and Agriculture	01 Agriculture 02 Aquaculture 05 Agriculture, forestry and fishing support services 11 Food product manufacturing 12 Beverage and tobacco product manufacturing
Healthcare and Pharmaceuticals	84 Hospitals (private) 85 Medical and other health care services (private) 86 Residential care services (private) 2412 Medical and Surgical Equipment Manufacturing
Manufacturing	13 Textile, leather, clothing and footwear manufacturing 14 Wood product manufacturing 15 Pulp, paper and converted paper product manufacturing 16 Printing (including the reproduction of recorded media) 18 Basic chemical and chemical product manufacturing 19 Polymer product and rubber product manufacturing 20 Non-metallic mineral product manufacturing 21 Primary metal and metal product manufacturing 22 Fabricated metal product manufacturing 23 Transport equipment manufacturing 24 Machinery and equipment manufacturing ³⁶ 25 Furniture and other manufacturing
Mining and METS ³⁷	06 Coal mining 08 Metal ore mining 10 Exploration and other mining support services
Oil, Gas and Energy	07 Oil and gas extraction 17 Petroleum and coal product manufacturing 26 Electricity supply 27 Gas supply

³⁶ Excluding 2412 Medical and Surgical Equipment Manufacturing, which has been included under the Healthcare and Pharmaceuticals sector.

³⁷ The METS sector is broader than the industries listed here, including professional and IT services. As the ABS do not break down these services by industry, some 'Industry at a glance' figures may be under representations.

Methodology

Each sector discussion begins with a snapshot of the sector, as defined by the ANZSIC industry codes listed in the previous table. The following table describes the source and/or method of calculation for the three statistics included for each sector.

STATISTIC	SOURCE / CALCULATION
Industry value add	<p>Industry value add:</p> <p>The absolute dollar figures for industry value add were taken from the ABS data series '81550DO002_201314 Australian Industry, 2013-14'.</p>
Employment	<p>These figures were taken from the ABS data series '81550DO002_201314 Australian Industry, 2013-14' and represent employment as at 30 June 2014.</p>
Annual business spend on R&D	<p>These figures were taken from the ABS data series '81040DO003_201112 Research and Experimental Development, Businesses, Australia, 2013-14' and represent total expenditure on R&D for 2013-14.</p> <p>As this data series was incomplete for the Health and Pharmaceuticals sector ANZSIC codes, and this sector obtains substantial R&D funding from non-industry sources, a different approach was used. For this sector, the sum of R&D expenditure for the 'health' socio-economic objective was combined across business, government and public non-profit organisations (NPOs), private NPOs and higher education. The three data series combined were:</p> <ul style="list-style-type: none"> 'Research and Experimental Development, Businesses, Australia, 2013-14 '8109.0 - Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2012-13' '8104.0 - 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2012'

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