MINERALS DOWN UNDER
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ResourcesQ Foresight Study

Unearthing future resource sector trends and implications for Queensland

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SMI Sustainable Minerals Institute

Minerals Down Under

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Copyright and disclaimer

Important disclaimer

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About the study

ResourcesQ is a Queensland State Government initiative that aims to build a long-term strategic vision for the resources sector that is shared between Government, industry and civil society. The initiative will explore how the State can create a strong, competitive, diversified and agile resources sector in Queensland and maintain Queensland as a leading global resource destination.

This report presents the key findings of a strategic foresight project undertaken by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the University of Queensland (UQ) to help inform *ResourcesQ*. Through extensive desktop research, analysis, interviews and a workshop with senior decision makers in the Queensland Government and the resources sector, we have developed an understanding of how the Queensland resources sector may be impacted by five megatrends over the next 30 years. These megatrends are:

- **New money, new markets:** Rising demand, increasing urbanisation and rapid development of emerging economies are shifting the geography of supply, demand and sources of investment.
- **The innovation imperative:** No more low hanging fruit – innovation is a key route for leveraging and maximising competitive advantage.
- **The knowledge economy:** An increasingly globalised market is emerging for selling know-how and services to the minerals and energy sectors.
- **Tell me more:** Demands for accountability, increased availability of information and new social networks are driving greater scrutiny and raising expectations of fairness and empowerment of citizens.
- **A shifting energy landscape:** New energy sources are changing geopolitics and the economics of resource extraction.

Key findings

The resources sector is one of four 'economic pillars' in Queensland. When indirect as well as direct impacts are taken into account, it contributes 13% of the State's Gross Product and around 20% of full-time jobs. The sector also pays over $2 billion annually in royalties to the State Government. The sector includes a vibrant equipment, technology and services sector. It also encompasses Brisbane-based resource companies operating interstate and overseas, as well as in Queensland.

New money, new markets

- Over the next thirty years, the developing world will become even more important as a driver of supply- and demand-side dynamics of the world's economy. Global Gross Domestic Product (GDP) is predicted to more than double, with much of this growth occurring in Asia, led by China and India. This will translate into further significant increases in global demand for energy and minerals. Countries such as China and India will also become more important as sources of outward investment into the global resources sector.
- Queensland has relatively abundant stocks of many of the minerals and energy resources that the world needs, including coking and thermal coal, a range of base metals, bauxite and unconventional gas. However, Queensland's – and Australia's – ability to take advantage of these market opportunities and to attract future new investment in resources risks being constrained by economic factors such as high exchange rates and high capital and operating costs.
- Unconventional gas production costs in Australia, including Queensland, are now significantly higher than in low risk OECD exporters such as the United States of America (USA) and Canada, where substantial supply growth is forecasted over the next decade. The cost of building new mines in Australia has also risen, to a point where the average cost of constructing new capacity in thermal coal and iron ore in 2011-12 was well above that of the rest of the world (Port Jackson Partners 2012).
- The Fraser Institute's Policy Potential Index (a globally recognised, survey-based measure, of the ease of doing business in a jurisdiction) scores Queensland high for the quality of its geological databases, legal

processes, lack of corruption and security, but ranks the state lower on questions about regulatory uncertainty and complexity, particularly in relation to environmental regulations.

- In Australia, it is becoming increasingly uneconomic to undertake in-country downstream processing of commodities such as iron and steel, aluminium, copper and nickel, because of high costs and the small domestic market. This has potentially significant implications for the Queensland economy, as it reduces the likelihood of the future development of large- scale industries linked to the mining sector, such as aluminium refining and smelting.

The innovation imperative

- Around the world, key resources are becoming harder to access and extract profitably (due to factors such as declining grades, deeper and more remote deposits and geopolitical instability). Falling productivity is also a major issue. A new wave of technology and innovation will be required to tackle these problems.
- If the Queensland resources sector is to remain globally competitive, it must have a strong innovation focus. This is not just a matter of adopting off-the-shelf initiatives developed elsewhere, but of sustaining a culture of innovation and building the skills, capabilities and resources required to develop and implement effective solutions locally.
- Many of the metalliferous mines in north-west Queensland are at a mature stage of the mining cycle and several operations in the region may be mined out during the period 2015-20 (DNRM 2014). Without new discoveries, and/or new mining and processing technologies, it will be difficult for Queensland to take advantage of projected increases in global demand for metals such as copper, lead and zinc.
- Enablers of innovation in Queensland include:
    - a skilled and knowledgeable professional workforce within the resources sector, and more broadly;
    - established education, and research institutions and specialist centres with strong research capabilities in the resources sector, particularly mining-related;
    - a highly successful and diverse Mining Equipment, Technology and Services (METS) sector and also a growing oil and gas services sector;
    - a tradition of research and development (R&D) collaboration.
- Potential inhibitors of innovation include unsupportive corporate policies and practices (e.g. focusing on short-term cost cutting, risk avoidance, excessive secrecy), insufficient understanding of the importance of the innovation sector to Queensland, and variable government support for growing and maintaining the enabling environment.
- Science, technology, engineering and mathematics (STEM) are fundamental to building a highly productive, innovative and technologically driven economy of the future. However, Queensland and Australia more generally are experiencing increasing difficulties in attracting quality students to study in scientific and technical fields.

The knowledge economy

- The developed world is now in the process of shifting to a new model, in which knowledge will be the most important currency. This is also apparent in the global resources sector, where innovations such as cloud computing, use of sensors to enable real time monitoring, enhanced modelling and simulation capacity, hold out the potential to deliver significant productivity gains.
- Rapid advances in information technology are making it easier to locate significant business functions (e.g. control rooms, engineering design, technical and R&D support, financial processing) off-shore, rather than in the country or region where the mining is actually undertaken.
- For Queensland to take advantage of the emerging opportunities presented by the knowledge economy, locally based providers must be able to identify and respond quickly to opportunities and move rapidly from the generation of ideas, through testing and development to delivery.
- Queensland is a relatively small player in the technology support and R&D space, compared to countries such as India. The cost of employing knowledge professionals is also much higher here than in many other countries. This could lead to a situation where, in the future, an increasing amount of knowledge work for the resources sector is done off-shore, rather than locally.

A shifting energy landscape

- Global demand for energy will maintain an upward trajectory in the period up to and beyond 2040. This will be partly met by a diversification of energy sources, but demand for coal and gas is also anticipated to keep increasing.
- Queensland is potentially in a favourable position to exploit the changing energy landscape as a producer. The State has an abundant and diversified resource base including coal, gas, oil shale, uranium and thorium. It has a mature export coal industry and is emerging as a major player in LNG.
- Factors that could prevent Queensland from capitalising on these opportunities include:
    - High capital and operating costs, unless reined in, could limit further investment.
    - While there are large undeveloped resources of unconventional gas and thermal coal, they will be very expensive to develop, because of their relative remoteness and the lack of infrastructure.
    - Community concerns about environmental impacts, unless addressed, may hinder the development of new ways of extracting energy, such as underground coal gasification, or the expansion of export infrastructure such as new ports.

Tell me more

- Earning and maintaining community support for resource development will be one of the most important factors for managing risk in the global resources sector over the next thirty years, especially as levels of environmental and social concern grow in the world's developing economies.
- Although , there have been a number of instances in Queensland where opposition towards resource developments has delayed or stopped projects, there has not, to date, been the same level of community 'push-back' as has been evident in some other parts of the world, and in some other areas of Australia.
- Recent survey work on citizen attitudes to resources (CSIRO 2013) shows that Queenslanders, like many other Australians, are aware of the importance of the sector in their lives and are able to make trade-offs in terms of impacts.
- Successive Queensland governments have been reasonably responsive in addressing the issues that have given rise to community concerns about the scale and nature of resource development. Examples include: providing the public with timely and free access to relevant data through the Open Data Initiative; establishment of a GasFields Commission to deal with issues arising from the rapid development of the Surat Basin for Coal Seam Gas (CSG); and the development of a new regional land use planning framework.
- The capacity of most citizens to engage with highly technical information is limited, which is being compounded by the increasing pace of information availability, and fragmentation and diversification of information sources. New forms of communication and engagement will be required to ensure that the Queensland community has an informed understanding of issues relating to the resources sector.
- Support for the resources sector could erode quite rapidly, if mining and/or gas extraction were perceived in the wider community as causing or contributing to significant environmental damage. Effective regulation and strong environmental management systems, underpinned by a high level of transparency, will therefore be critical to maintaining public confidence in the sector over the longer term.

ResourcesQ will use the information and analysis presented in this study to focus dialogue between Government, industry and the community regarding the priorities for Queensland. It is through this engagement process that *ResourcesQ* will build a long-term strategic vision for the resources sector that is shared between government, industry and the Queensland community.

1 Introduction

1.1 Background

A 30 year vision for Queensland is being developed by the Queensland State Government for each of the four pillars of the State's economy: tourism, agriculture, resources, and construction. Development of the vision for the resources sector is being led by the Department of Natural Resources and Mines (DNRM), through the *ResourcesQ* initiative. *ResourcesQ* aims to build a long term strategic vision for the resources sector that is shared between government, industry and civil society. The initiative will explore how the State can create a strong, competitive, diversified and agile resources sector in Queensland and maintain Queensland as a leading global resource destination.

This report presents the key findings of a strategic foresight project undertaken by CSIRO and UQ to help inform *ResourcesQ*. The aim of the work is to consolidate a set of core insights to help construct a vision for Queensland in 2044 that will enable the State to retain the economic strength currently provided from its resources.

1.2 Methodology

In developing this report, we have combined analysis and consultation to make an assessment of the opportunities and threats posed by future megatrends, and the strengths and weaknesses of the Queensland resources sector. The study involved three major components:

1. We consolidated the data and literature available into a description of the current state of the Queensland resources sector (defined to include mining and primary processing of minerals, and oil and gas extraction).
2. Based on strategic foresight work conducted by CSIRO in the past two years[1], we identified five resource megatrends that are shaping the global industry.
3. We undertook consultation and dialogue with specialists working in the sector from government and industry.

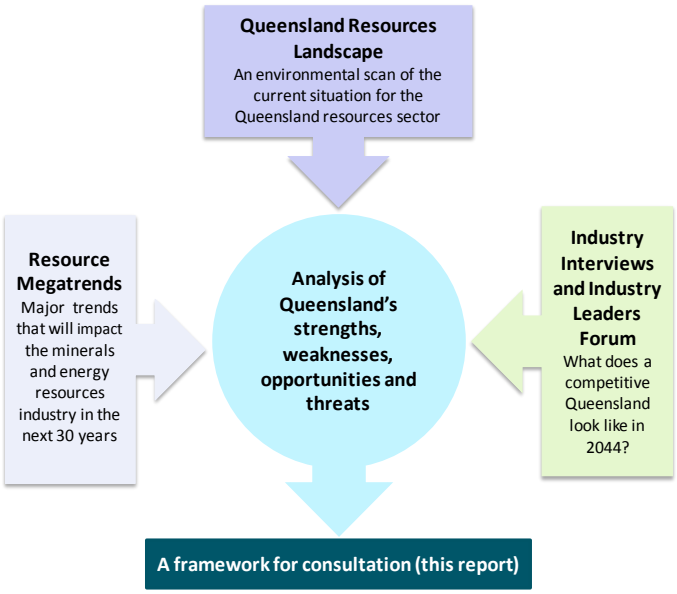

Figure 1: The *ResourcesQ* foresight methodology

[1] For further information see: www.csiro.au/Futures

Megatrends are important patterns of change occurring over the next two decades and create both risks and opportunities. They relate to social, economic, environmental, technological and political drivers. The five megatrends identified in this study are:

- **New money, new markets:** Rising demand, increasing urbanisation and rapid development of emerging economies are shifting the geography of supply, demand and sources of investment.
- **The innovation imperative:** No more low hanging fruit – innovation is a key route for leveraging and maximising competitive advantage.
- **The knowledge economy:** An increasingly globalised market is emerging for selling know-how and services to the minerals and energy sectors.
- **Tell me more:** Demands for accountability, increased availability of information and new social networks are driving greater scrutiny and raising expectations of fairness and empowerment of citizens.
- **A shifting energy landscape:** New energy sources are changing geopolitics and the economics of resource extraction.

2 Minerals and energy resources in Queensland

The Queensland resources sector encompasses the exploration, extraction, production, processing and transporting of thermal and metallurgical (coking) coal, base and precious metals, magnetite, mineral sands, bauxite, oil and gas (conventional and unconventional) and oil shale. The sector also includes the suppliers of equipment and technology, service providers, and research and training organisations, and resource companies based in Queensland that operate outside of the State.

Queensland has a diverse geology, which is reflected in the development of several distinct resource regions. These include:

- Surat, Bowen and Galilee Basins – coal and natural gas;
- Cape York – bauxite and kaolin, silica sand;
- North West Minerals Province – base metals, hydrocarbons, phosphate, gold, molybdenum, uranium, geothermal and shale gas;
- Charters Towers district (Northern region) – gold and limestone; and
- Cooper and Eromanga basins (South-west region) – oil and gas (conventional and unconventional).

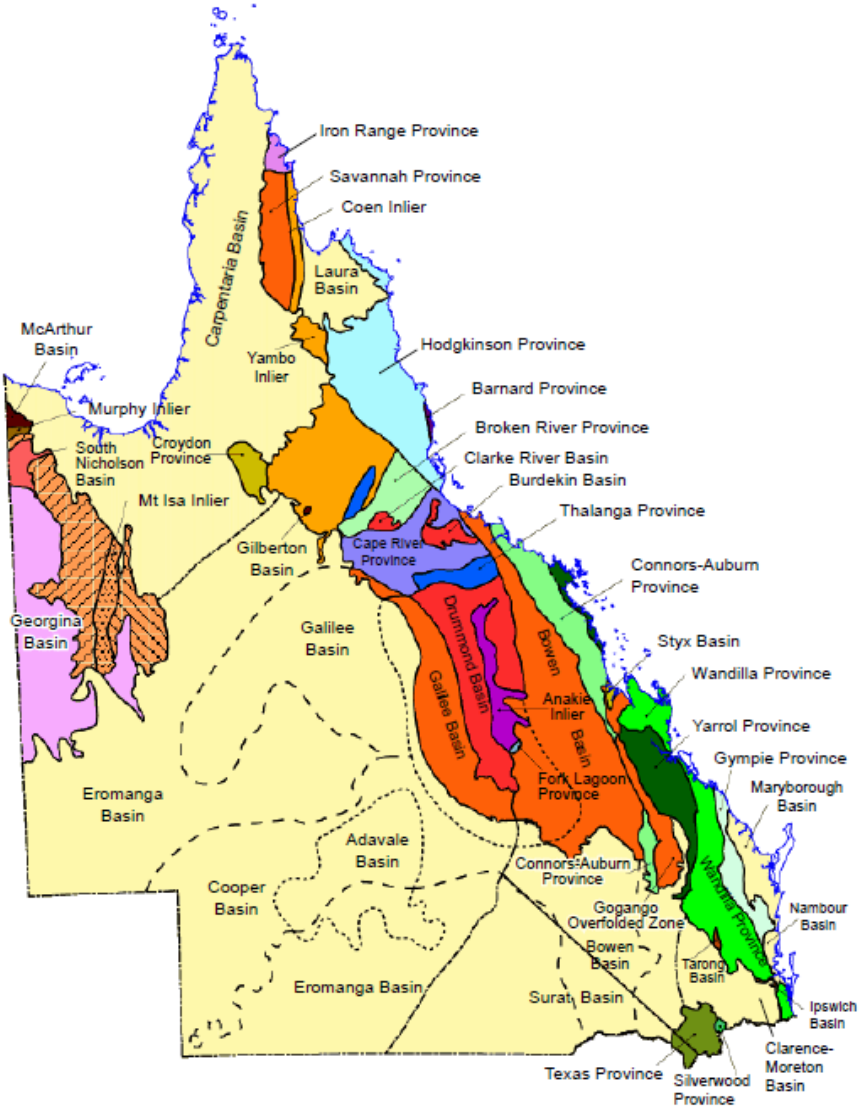

Figure 2: Map of Queensland's Geology

(Source: QGS)

***Contribution to gross state product**:* Queensland's resources sector is an important part of the state's economy. In 2012-13, the sector contributed an estimated $37.9 billion to the Queensland economy, accounting for approximately 13% of gross state product (GSP) (DNRM, 2014). When liquefied natural gas (LNG) plants currently under construction come online, the industry is expected to increase gross state product by over $3 billion (DNRM, 2014).

***Employment**:* As at November 2013, employment in Queensland's resources sectors was still growing, although at a slower rate than in preceding years. According to data from the Australian Bureau of Statistics (ABS) Queensland's exploration, mining and energy sectors contributed 80,300 direct full-time jobs, which was 8,900 more than reported in November 2012. This equated to 4.8% of Queensland's total full-time workforce (ABS, 2013).

It has been estimated that each job in the sector generates three indirect jobs (DNRM, 2013), meaning that the total employment contribution of the resources sector was approximately 320,000 full-time jobs, or 19.5% of Queensland's full-time workforce.

***Expenditure and payments**:* A recent report commissioned by Queensland Resources Council (QRC) estimated that the minerals and energy sectors contributed $37.9 billion in direct spending to the Queensland economy in 2012/13 (Lawrence Consulting, 2013). This comprised:

- $7 billion paid in wages and salaries; and
- $30.9 billion expended on purchases of goods and services (also includes direct community contributions from companies).

The largest economic contribution was from coal mining, which accounted for 53% of total spending. This was followed by coal seam gas (CSG)/LNG (31%) and metalliferous mining (14%).

Just under half of total sector expenditure (46%) was in Brisbane and the south-east corner. The next two most significant regions were Fitzroy (21%) and Mackay (15%). Darling Downs, North-West and Northern regions each accounted for around 5% of total expenditure.

Taxes and royalties: In 2012/13, the resources sector paid approximately $2.1 billion of royalties to the Queensland Government (Office of State Revenue, 2014). This was down significantly from $2.76 billion in 2011/12, primarily as a consequence of falling coal prices. The coal industry is by far the largest contributor of royalties, accounting for well in excess of 80% of annual payments (Office of State Revenue, 2014). The CSG/LNG industry is expected to provide an additional $850 million in royalty revenue annually once the new LNG plants come on stream (DNRM, 2014).

Equipment and Technology Service Sector: Queensland has a highly successful and diverse METS sector and also a growing oil and gas services sector. According to a survey of METS companies conducted by Austmine[1] in 2013:

- gross revenue in the Queensland METS sector was $21.22 billion, or 24% of the national total for the sector;
- the sector employed around 60,000 Queenslanders;
- 149 METS companies were headquartered in Queensland and another 436 companies had offices or operations in the State;
- 58% of companies located in Queensland were exporting; and
- 31% of companies had at least some involvement in the oil and gas (O&G) extraction sector.

[1] Austmine is an industry association for the Australian METS sector. It represents, promotes and actively pursues opportunities for Australian member METS companies (Austmine, 2013). The survey did not cover companies that operated only in the oil and gas sector, so the contribution of this sector has most likely been understated.

3 Resource megatrends shaping the future of resources in Queensland

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

Five resource megatrends have been used to provide an organising framework for the *ResourcesQ* foresight project. These were identified on the basis of their potential significance for the resources sector over the next thirty years. Some elements of the megatrends are already being manifested, some will impact over the next five years (they are "on the horizon") and some will have longer term impacts which are more difficult to anticipate ('over the horizon'). All are interconnected although some will have greater relevance than others in the short term. The five resource megatrends are illustrated below.

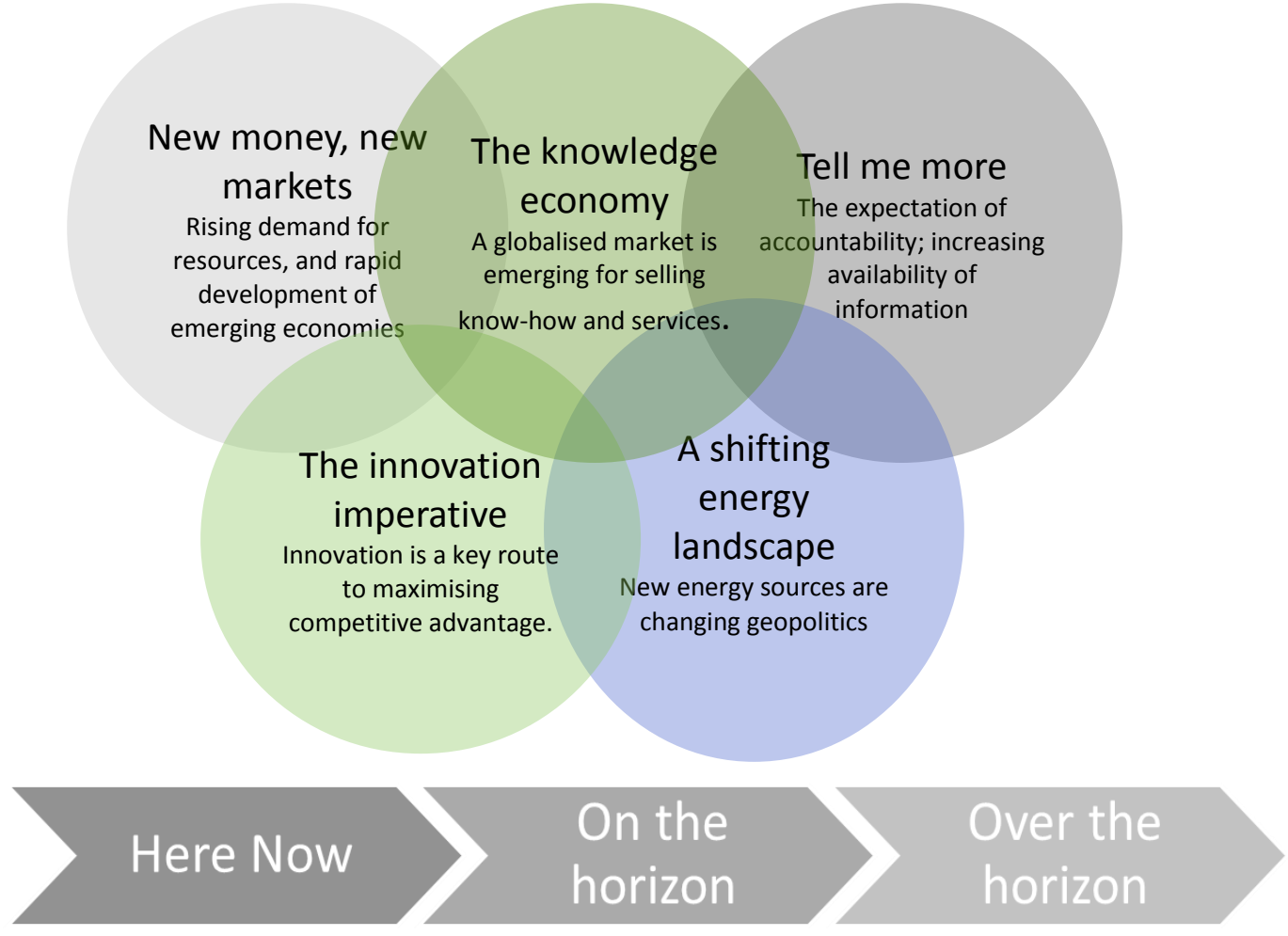

Figure 3: The five resource megatrends informing the *ResourcesQ* foresight project

3.1 New money, new markets

Global Trends

Over the next thirty years, the developing world will become even more important as a driver of supply- and demand-side dynamics of the world's economy. The rapid pace and scale of growth in China, and to a lesser extent India, has already led to a marked increase in demand for energy and the raw materials used in infrastructure development, as well as in the production of consumer goods for the world's fastest growing middle class. These emerging economies are also providing a growing proportion of global resources investment.

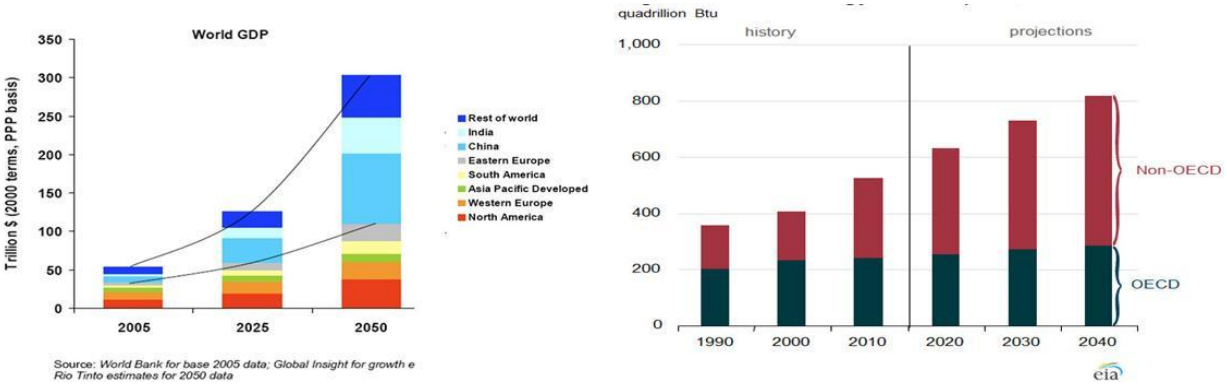

Figure 4: Predicted growth in GDP 2005-2050 and energy consumption 1990-2040

Source: Rio Tinto (2008) and US EIA (2013)

The global economy's 'centre of gravity' (the average location of economic activity across geographies) can be tracked over time and it appears to be on a clear trajectory towards Asia. In 1980 the economic centre of gravity was in the Atlantic Ocean, between the economic powerhouses of Europe and the United States. By 2008, the economic centre of gravity had moved to just south of Izmir, Turkey and by 2050 it is forecast to shift to a location firmly between India and China (Quah, 2011). Rapid economic growth in Asia is pulling the whole world economy eastwards.

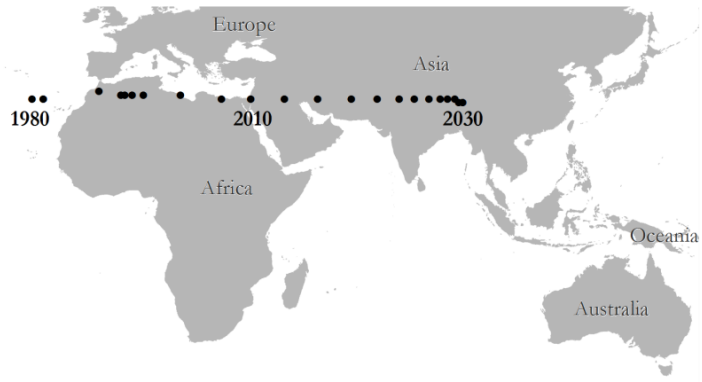

Figure 5: The world's economic centre of gravity, at three-year intervals[1]

Source: Quah (2011)

[1] 2010 onwards represents forecast data

Implications for Queensland

Over the last decade, growing demand from emerging economies, particularly in Asia, has created new market opportunities for Queensland's minerals and energy resources, including coking and thermal coal, copper and other base metals, bauxite and unconventional gas (in the form of coal seam gas). There has also been significant new investment from Asia in Queensland resources.

Between 2006 and 2012, Chinese direct investment in Queensland exceeded US$15 billion, of which 66% was in mining and 32% in O&G (KPMG 2013; p. 13). Chinese and Indian companies have also shown strong interest in the development of the Galilee Basin coal resources and the Japanese have long had a presence in the State's coal industry. Factors which have made Queensland an attractive investment environment include abundant, high quality resources, a stable political and social environment, well-developed infrastructure, and proximity to major markets in Asia. However, Queensland's – and Australia's - capacity to attract future new investment in resources may be constrained by economic factors such as high exchange rates and high capital and operating costs.

Upstream capital costs for Australian O&G projects more than doubled in real terms between 2005 and 2012 and operating costs rose by 45%. For example, Australian unconventional gas production costs are now significantly higher than in low risk OECD[1] exporters such as the United States of America (USA) and Canada, where significant growth is forecasted over the next decade.

The cost of building new mines has also risen, to a point where the average cost of building new capacity in thermal coal and iron ore in Australia in 2011-12 was well above that of the rest of the world (Port Jackson Partners 2012). In addition, it is becoming increasingly uneconomic to undertake in-country downstream processing of commodities such as iron and steel, aluminium, copper and nickel, because of high costs and the small domestic market.

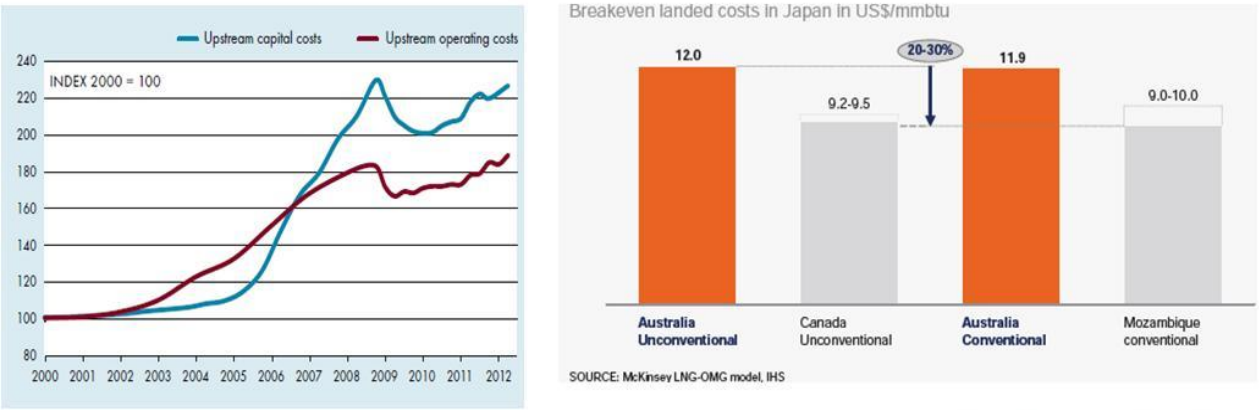

Figure 6: Oil and gas upstream capital and operational costs, illustrated alongside landed cost comparison for gas production – Canada and Australia

Source: APPEA (2013) and McKinsey (2013)

[1] Organisation for Economic Co-operation and Development

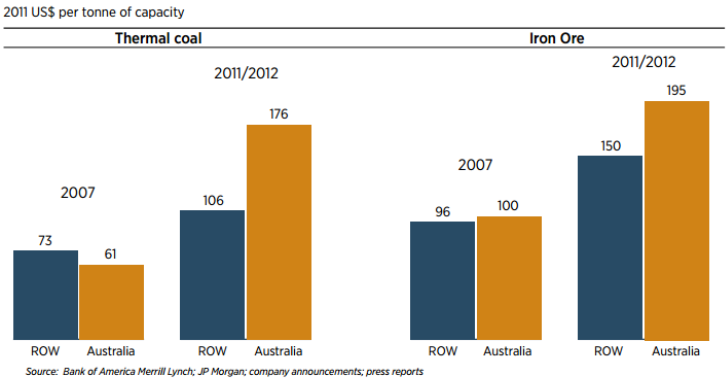

Figure 7: Capital Spend to Build a Tonne of New Capacity

Source: Port Jackson Partners (2012)

In the case of metalliferous mining, many of the mines in north-west Queensland are at a mature stage of the mining cycle and several operations in the region may be mined out during the period 2015-20 (DNRM 2014). Without new discoveries, and/or new recovery technologies, it will be difficult for Queensland to take advantage of projected increases in global demand for metals such as copper, lead and zinc. Developing new energy resources located in the more remote areas of the State (e.g. coal in the Galilee Basin, unconventional gas in far-west and far north Queensland) will also require very large investments in infrastructure.

Another factor which has the potential to impact negatively on Queensland's attractiveness as an investment destination is the regulatory environment. Queensland's ranking on the Fraser Institute's Policy Potential Index[1] (a globally recognised, survey-based measure, of the ease of doing business in a jurisdiction) has declined over the last decade, both globally and compared to Western Australia, the other major Australian resources state. In the 2012-13 survey, Queensland scored highly for the quality of its geological databases, legal processes, lack of corruption and security, but ranked lower on questions about regulatory uncertainty and complexity, particularly in relation to environmental regulations.

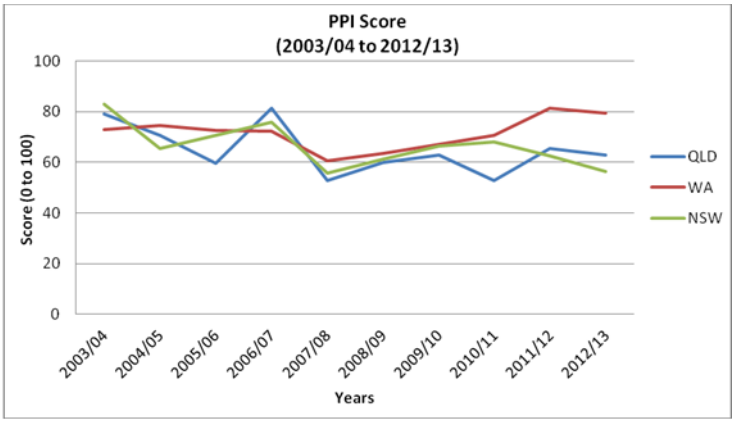

Figure 8: Queensland ranking on the Fraser Institute PPI index (2003/4 – 2012/13) against New South Wales and Western Australia

[1] The PPI is compiled through an annual survey of executives of mining and exploration companies. More than half of those completing the survey in 2012-13 were from the exploration sector, so the views of this sector drive the index scores, to a large extent.

3.2 The innovation imperative

Global Trends

A new wave of technology and innovation will be required in the future, as key resources becomes harder to access and extract profitably (due to factors such as declining grades, deeper and more remote deposits and geopolitical instability). In the case of mining, the challenges include:

- *Declining ore grades:* As richer deposits are mined out, ore grades for key minerals such as copper continue to fall. This in turn is driving up mining and processing costs (Humphries 2012).
- *Deeper deposits and complex ores:* As shallow deposits are depleted, miners are being forced to dig deeper, leading to higher extraction costs. Mining now regularly reaches depths of over one kilometre, with gold mines of the Witwatersrand field in South Africa now at depths exceeding four kilometres (Giurco et al., 2009).
- *Rising labour costs:* Labour costs continue to increase globally as the resources sector competes for people with the technical and managerial skills required to execute projects. In resource-rich countries such as Chile and Australia, resource employees are amongst the highest paid workers in the economy, earning more than twice the national average (ABS, 2013b; Korinek, 2013). Among the world's top 40 mining companies, average employee costs increased by 13% in 2012, even though reported headcounts grew by only 2% (PwC, 2013). In the short term, wages and salary growth can be expected to moderate as prices for minerals ease, but in the long term the cost of labour is likely to remain a major issue for the industry.
- *Cost and availability of energy & water:* Resource processing requires significant energy inputs and these requirements will most likely increase as grades decline and the industry is required to go deeper. In Australia, energy costs currently account for up to 15% of total mining and mineral processing input costs (Australian Government Department of Industry, 2013). Furthermore, many of the world's mines are located in arid and semi-arid regions, where gaining access to water for use in mining is an ongoing challenge. Energy and water costs are likely to continue to increase as companies move to more remote regions in search of new deposits. There will also most likely be increased costs associated with environmental compliance.
- *Falling productivity:* Multiple studies have documented a decline in productivity in the global mining industry over the last decade (PwC, 2014; Boston Consulting Group 2014; Ernst Young 2014). This is attributable to several factors, including a preoccupation with growth over efficiency, and a loss of internal control over costs.

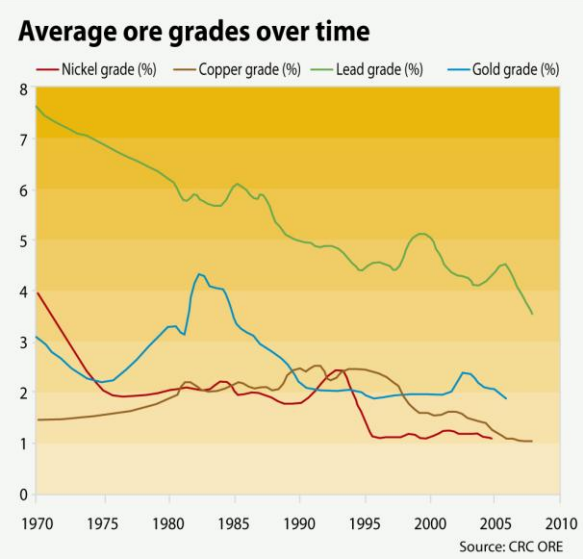

Figure 9: Average ore grades over time

Source: CRC ORE

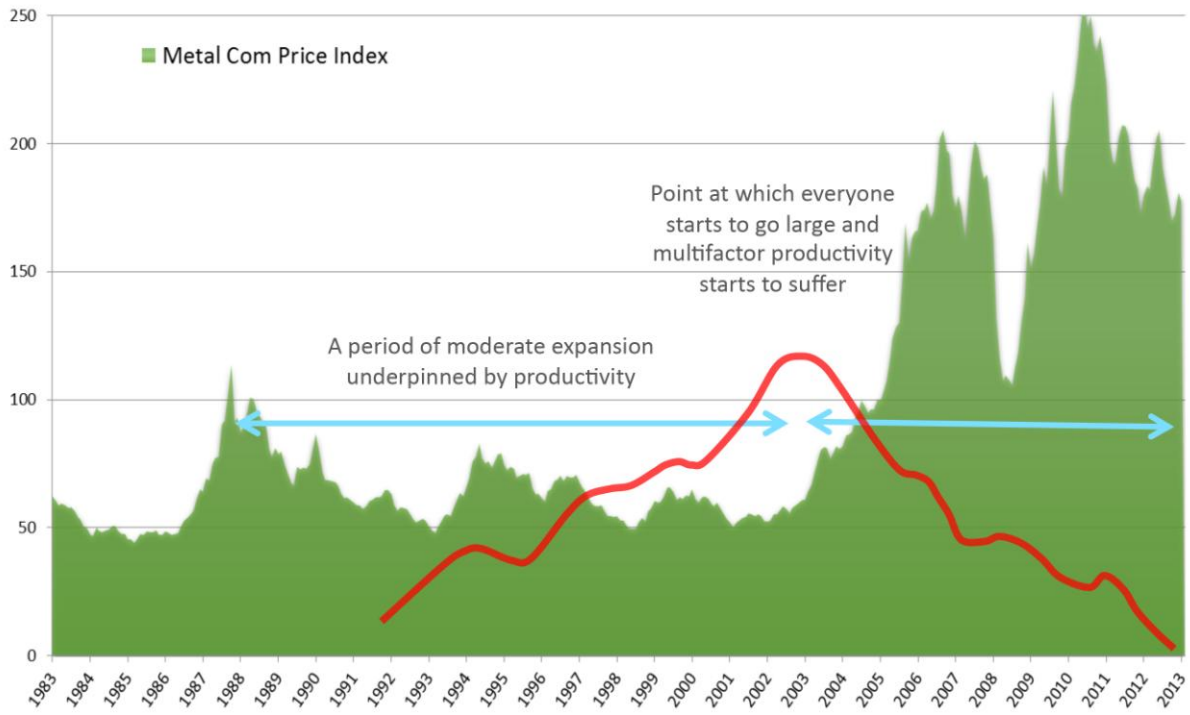

Figure 10: Global productivity trends in the metals sector

Source: CRC ORE

In the case of the O&G sector, geopolitical constraints and depletion of existing reserves are requiring companies to shift to more complex sources of supply (e.g. deep-water oil, unconventional gas, tar sands). These resources tend to be more expensive to develop and present more technical risks. As with mining, productivity and costs are ongoing issues for the sector globally, although these challenges are greater in some countries than others (Australia, for example, is both expensive and suffers from low productivity).

In both the mining and the O&G sectors, a range of innovations are being developed in response to these challenges. In mining, current areas of significant innovation include: new exploration targeting technologies; alternative mining methods such as block caving, deep mass mining, in situ recovery and top coal caving; growing use of remote operation and monitoring facilities, and autonomous underground and open-cut equipment; innovative approaches to water management; integrated, data driven, management systems; and energy efficient processing. In O&G, major areas of innovation include: developments in seismic imaging to enable reservoir sweet spot identification pre-drill; production stimulation (including 'fraccing') to increase recovery factors in unconventional deposits (especially shales); the development of floating LNG plants to process far-offshore, stranded gas; and, initiatives to improve the environmental footprint of O&G operations.

Implications for Queensland

The Queensland mining and O&G sectors are facing many of the same challenges that confront these sectors globally. As already noted, declining ore grades and diminishing reserves are already significant issues for the metalliferous sector; mining productivity has fallen significantly over the last decade in line with global trends(see figure below); and, there are significant cost pressures in both the mining and CSG/LNG sectors.

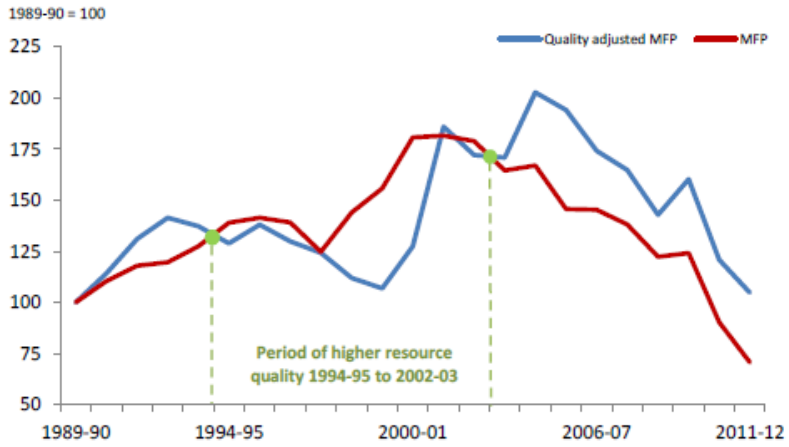

Figure 11: Mining productivity trends in Queensland 1989-90 – 2011-12

Source: Queensland Treasury and Trade (2013)

If Queensland is to meet these challenges and remain competitive, it is critical that the mining and O&G sectors continue to innovate. This is not just a matter of adopting off-the-shelf initiatives developed elsewhere, but of sustaining a culture of innovation and building the skills, capabilities and resources required to develop and implement effective solutions locally.

Queensland currently has some significant strengths in this regard. As well as providing a relatively stable and reliable operating environment, the State has been recognised by the World Bank as a global innovation hotspot (Trade & Investment Queensland, 2014). It has established education, and research institutions and specialist centres with strong research capabilities in the resources area (see 'The Knowledge Economy', below) and it also has a vibrant, outwardly-focused METS sector (see Section 2).

The presence of a highly skilled workforce and world class research has helped to nurture a strong culture of innovation and R&D collaboration. Successful collaborations include the Australian Coal Association Research Program (ACARP), cooperative research centres such as the Cooperative Research Centre (CRC) for Mining and the CRC for Optimising Resource Extraction (CRCORE), The University of Queensland's Centre for Coal Seam Gas and the Gas Industry Social and Environmental Research Alliance (GISERA).

However, there are also several factors that could make it difficult for Queensland to retain and grow its reputation as an innovation hub:

- As a lightly populated state in a lightly populated country, Queensland has a limited talent pool relative to its competitors (e.g. India) in the technology support and R&D space. The cost of that talent is also much higher in Australia than in countries such as India.
- There are limited and/or inconsistent incentives for companies in Australia to invest in R&D, and only limited additional support available at the State level.
- International promotion of Queensland-based advances in innovation has been more reactive than proactive and the coal industry has tended to dominate the focus.
- Protective attitudes to intellectual property (IP) have the potential to hinder collaboration and data sharing across industry and research institutions (although this is not an issue specific to Queensland).

3.3 The knowledge economy

Global Trends

The developed world is now in the process of shifting to a new model, in which knowledge will be the most important currency. The 'knowledge economy' is defined by Powell and Snellman (2004) as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance as well as equally rapid obsolescence". The authors discuss the idea of how a modern day car is less a product of metal fabrication and is instead a smart machine, using computer technology to integrate safety, entertainment and performance.

As emerging economies develop into resource powerhouses of the future, a likely lack of human capital and skills in these regions will open up opportunities for developed countries with more advanced skills and education systems to export their knowledge. At the same time, as discussed above, the industries of developed countries are facing major productivity challenges that will only be addressed through new expertise and innovation. Regions with a history of success in extractive industries and a desire to invest in building expertise should be best placed to capitalise on these opportunities.

For mining, which has historically been a more labour intensive industry than O&G, innovations now under way will have a significant impact on the type of work available and the numbers of people required on-site. Recent Australian research has shown that remote tele-operation and automation are likely to significantly reduce the number of mining jobs available in the mining regions over the next twenty years and beyond, with likely resultant drops in population in those regions (McNab et al. 2013). Rapid advances in technology are also making it easier to locate significant business functions (e.g. control rooms, engineering design, technical support, financial processing) off-shore rather than in the country or region where the mining is actually undertaken.

Implications for Queensland

For Queensland to take advantage of the opportunities presented by the rise of the knowledge economy, locally based providers must be able to identify and respond quickly to opportunities and move rapidly from the generation of ideas, through testing and development to delivery.

Queensland's current strengths in this regard are:

- an existing, globally-linked, outwardly focused METS sector (as discussed)
- world class education and training facilities (see below)
- established research institutions and specialist centres with strong research capabilities and a sectoral approach to R&D collaboration
- relatively easy access to other mining regions, and to the Asia-Pacific in particular
- a high standard of living and an appealing lifestyle
- an established information technology (IT) infrastructure, in which Brisbane is an emerging as Australian hub for IT services (Brisbane Marketing 2014).

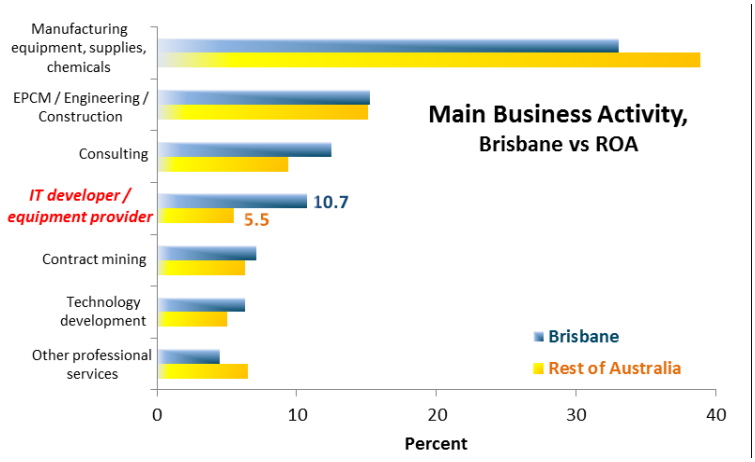

Figure 12: Main Business Activity, Brisbane vs. Rest of Australia

Source: Brisbane Marketing (2014)

Conversely, there is a risk that Queensland's ability to operate as a global provider of knowledge services in the future could be constrained by:

- high employment costs and cost structures, which are already making it difficult to compete with offshore providers;
- a relatively small local talent pool and increasing difficulties in attracting quality students to study in scientific and technical fields;
- limited awareness of the current and potential significance of the knowledge sector to the resources industry, and the fragmentation of knowledge and accountability between different jurisdictions of government, research institutions and industry.

Education and skills

Equipping youth with knowledge and relevant skills for the resources sector is an important long-term investment for both industry and government. Science, technology, engineering and mathematics (STEM) are fundamental to building a highly productive, innovative and technologically driven economy of the future (Department of Innovation, Science, Research and Tertiary Education, 2012).

Queensland has a solid existing education infrastructure with world class education and training facilities which deliver skills, new technology and innovation. This includes ten universities and various technical and vocational education institutes that offer mining focused study and skills development (The State of Queensland, 2014). In the O&G space, for example, UQ has recently started a Masters of Science Degree in Petroleum Engineering in conjunction with Heriot Watt University in the UK, with strong support from the gas industry.

Again, though, Queensland – and Australia –also face a number of threats in this space:

- Across Australia, the number of senior school students enrolling in mathematics and science studies is declining, and students are increasingly choosing 'softer' sciences and lower-level mathematics (Falkiner, 2012).
- A higher proportion of tertiary students complete majors in biology and other natural and physical sciences than in chemistry, mathematics and physics (Dobson, 2012).
- School education standards, particularly in maths and science are declining and not keeping pace with global leaders.
- The high cost of living in Australia and unfavourable exchange rates are currently making it harder to attract high quality international students to Australia.
- It has been difficult to get alignment between tertiary education and industry and market-place needs.

3.4 Tell me more

Global Trends

Heightened community expectations of accountability are translating into greater levels of sustainability reporting and regulation as well as increased levels of community action. Earning and maintaining community support for operations will be one of the most important factors for managing risk over the next thirty years, especially as levels of environmental and social concern grow in the world's developing economies.

There is growing recognition globally that successful resource developments require not only the formal approval of government, but the broad acceptance of local communities and other key stakeholders; what is now widely referred to as a 'social licence'(Prno, D.S. Slocombe 2012). Resource companies increasingly realise that environmentally and socially responsible practices are needed to earn and maintain community support and approval; it is no longer enough for companies to simply meet the formal obligations of a licence to mine (Moffat and Zhang, 2014). For more than 20 years, the mining and minerals industry has been under pressure to improve its social, developmental, and environmental performance. The sector has been asked to become more transparent and is increasingly subject to third-party audit or review. The same is also occurring in the O&G sector, although possibly to a lesser extent, as a much larger part of that sector is controlled by State-owned entities.

As a consequence of the proliferation of the internet, it is now relatively easy to track the practices of both local and global corporations and industries. Demands for transparency and accountability have led to an increase in sustainability reporting and increased revenue transparency. Today 95% of the world's 250 largest companies conduct sustainability reporting on a regular basis, compared to just 35% back in 1999 (KPMG, 2011). According to the same study, 84% of the resources industry is now reporting on corporate responsibility initiatives. Under the auspices of the Extractive Industries Transparency Initiative, a multi-stakeholder initiative to improve revenue management practices in resource-rich countries, a growing number of countries are also reporting on what resource companies are paying to governments, and how that revenue is being used.

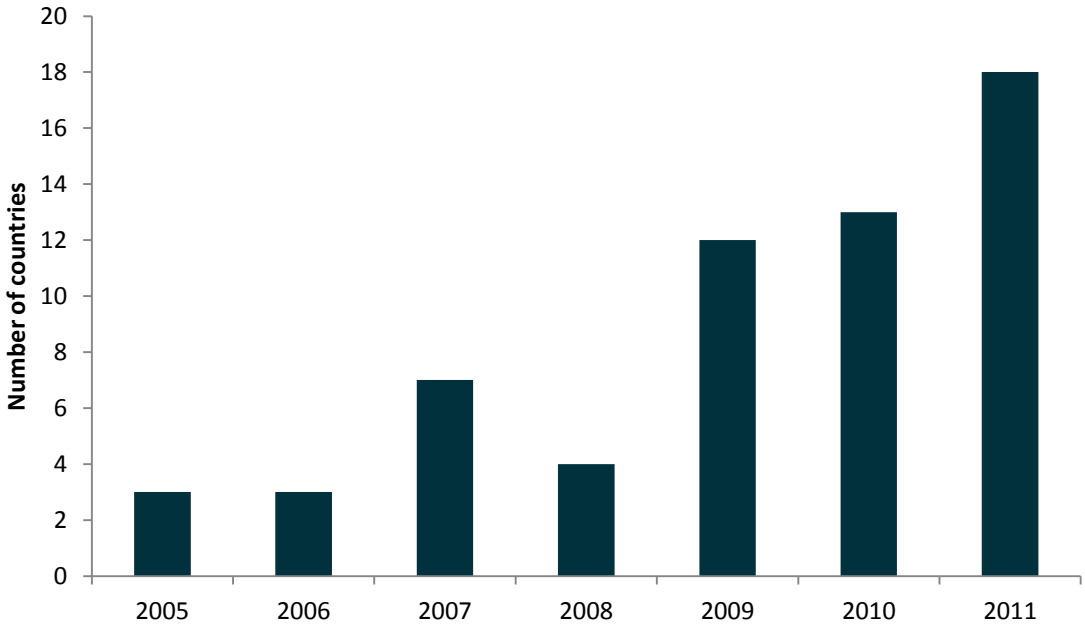

Figure 13: Number of countries that published reports under the Extractive Industries Transparency Initiative (EITI)

Source: EITI (2011)

Despite these efforts, there appears to be a growing number of instances of resource sector developments being delayed, interrupted, and even shut down due to public opposition (Browne et al., 2011, Davis and Franks, 2011, Prno and Slocombe, 2012 and Thomson and Boutilier, 2011). Various activist NGOs, particularly those concerned about environmental and human rights issues, have also mounted effective campaigns specifically targeted at sections of the mining and O&G sectors.

A related development has been the relatively recent rise of what has been termed 'resource nationalism', which is a shorthand term to describe initiatives by governments aimed at increasing the financial return to government and society from resource extraction activities. This has ranged from increases in taxes and royalties, through to local content requirements, attempts to revise contractual terms and, in a few cases, nationalisation. A key driver here has been the perception of governments and communities that they are not getting their 'fair share' of the benefits of resource extraction.

Implications for Queensland

In line with global trends, there have been a number of instances in Queensland where opposition towards resource developments has delayed or stopped projects; most notably, in the CSG sector and in relation to mining developments proposed on or near high quality agricultural land. There is also currently a well-organised non-government organisation (NGO) campaign against the expansion of the coal industry, focused on tapping into community concerns about climate change and damage to the Great Barrier Reef. However, to place this in perspective, there has not been the same level of disruption as has been evident in other parts of the world, or even other parts of Australia such as New South Wales.

Recent survey work on citizen attitudes to resources (CSIRO 2013) shows that Queenslanders, like many other Australians, are aware of the importance of the sector in their lives and are able to make trade-offs in terms of impacts. Moreover, when people do object to resource development they usually do so through lawful, peaceful, means. This is in contrast to the situation in a number of other resource rich countries, where resort to violence and disruption is much more the norm.

A strength of Queensland is that successive governments have been reasonably responsive in addressing the issues that have given rise to community concerns about the scale and nature of resource development. For example, the Queensland Government has recently taken steps towards providing the public with timely and free access to relevant data through the Open Data Initiative; a range of regional and local consultative mechanisms have been established, including a GasFields Commission; and new land access protocols have been developed, along with a revamped regional land use planning framework. There is also a well-established legal framework in place for engaging with Indigenous people about resource development on traditional lands.

Figure 14: Key results from an independent survey of public views about mining

Source: CSIRO (2013)

At the same time, the future 'social licence' of the Queensland resources sector should not be taken for granted. The capacity of citizens to engage with highly technical information is problematic, which is being compounded by the increasing pace of information availability, fragmentation and diversification of information sources and proliferation of information channels. There is also the issue of diminishing trust in traditional information sources. New forms of communication and engagement will be required to ensure that the Queensland community has an informed understanding of the resources sector.

There is also a risk that community support for the resources sector could erode quite rapidly, if mining or O&G extraction were to be seen as causing significant environmental damage. Effective regulation and strong environmental management systems, underpinned by a high level of transparency, will therefore be critical to maintaining public confidence in the sector over the longer term.

3.5 A shifting energy landscape

Global Trends

New energy sources are changing geopolitics and the economics of resource extraction and revolutionising business models. Markets have restructured and economies are in transition. As a consequence, issues such as the improvements in energy recycling, ensuring resource security, finding new energy sources and understanding the rise of the United States as both supplier and consumer have become serious concerns. In the future, new energy sources will be brought online and models for extraction and processing will likely change and evolve in response.

Various analysts have highlighted the need for huge levels of new investment to meet potential future global demand for minerals and energy. For example, in a recently published study, McKinsey& Co. (2013) has estimated that global annual investment in O&G would need to grow by 100-160% to meet the expected increase in demand for energy over the period 2013-30. For minerals the equivalent estimated increase is in the range of 80-120%.

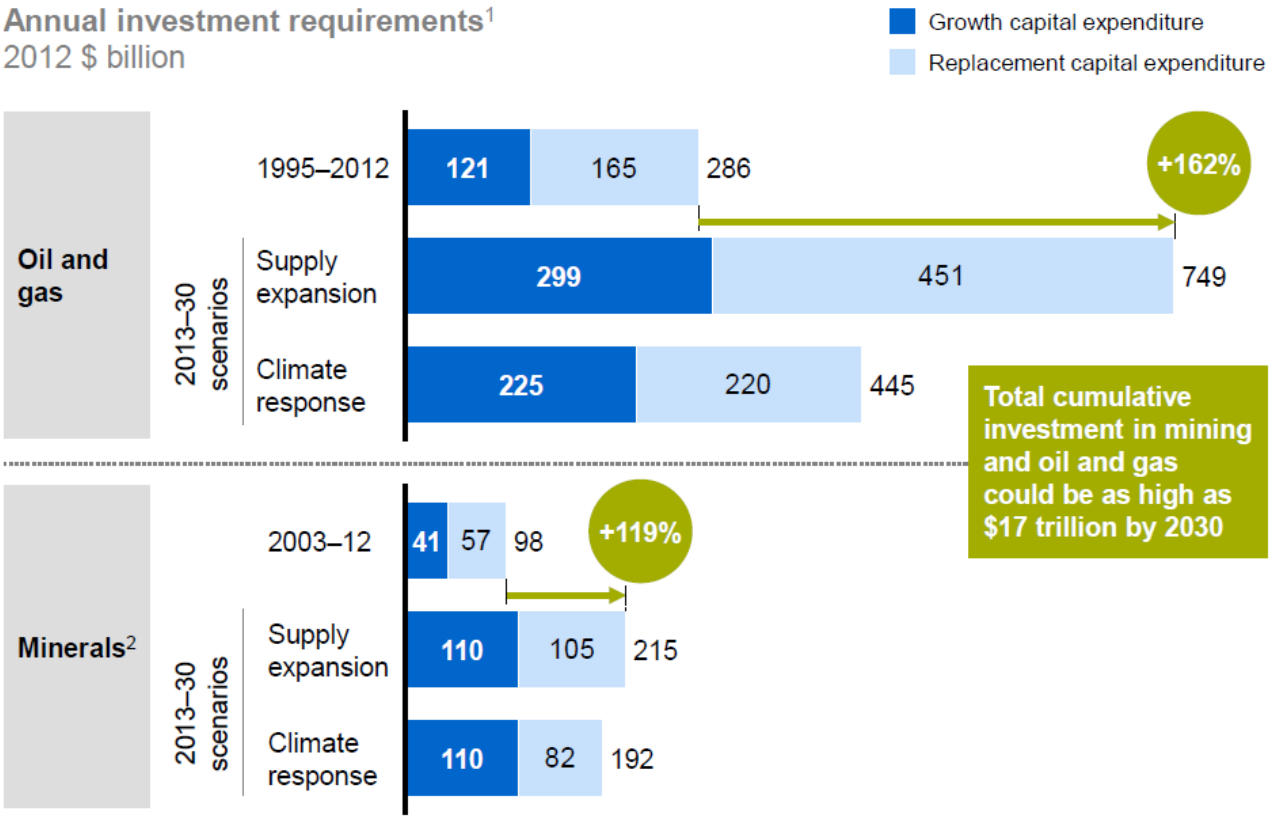

Figure 15: The scale of new investment required to meet projected demand

Source: Mckinsey (2013b)

Traditional sources such as thermal coal are coming under pressure as environmental pressures gain traction with energy consumers and costs increase (US EIA, 2013). Even so, demand for coal is anticipated to keep rising, especially for higher quality seaborn (i.e. export) coal, as there is currently no other economically viable way of meeting rising global demand for energy.

Global demand for natural gas is also predicted to increase significantly in coming decades and within the 30 year time horizon, other sources (renewable, CSG, shale oil and gas, uranium and thorium, geothermal) have significant potential to grow.

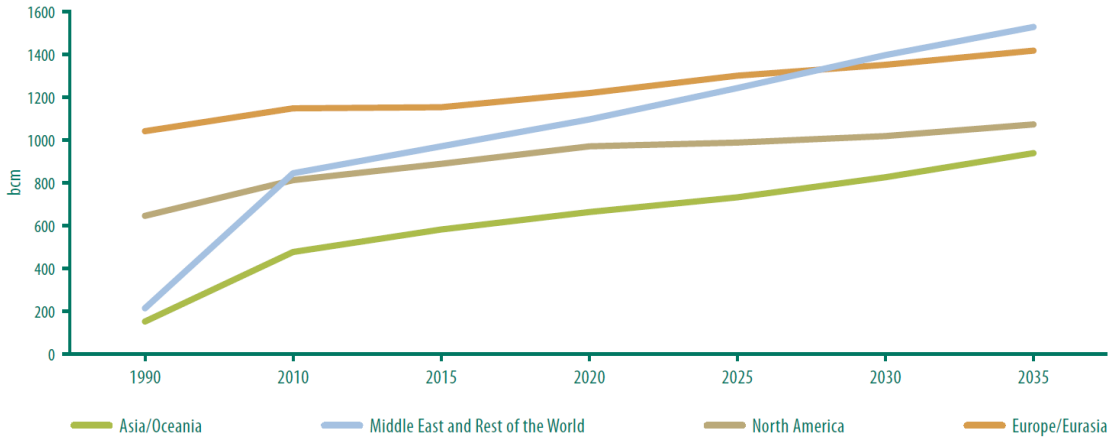

Figure 16: Projected Increase in demand for natural gas

Source: IEA (2012)

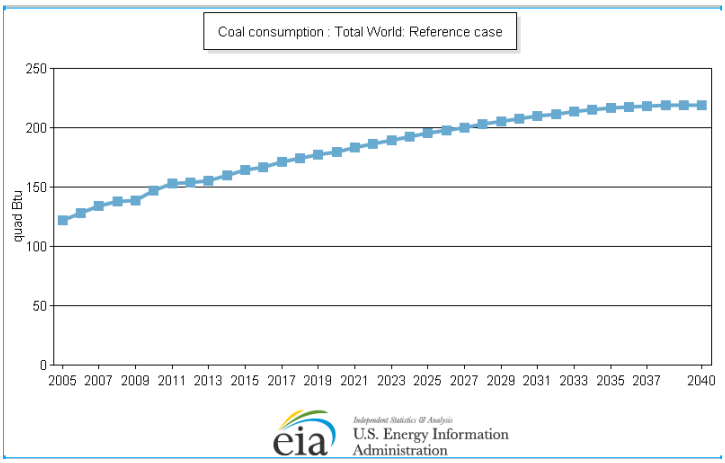

Figure 17: Projections of coal consumption

Source: US EIA (2013)

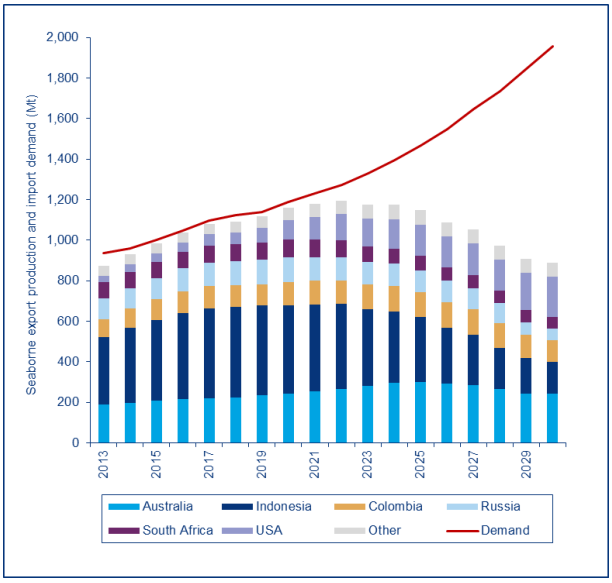

Figure 18: Seaborne thermal coal – supply and demand (2013-2030)

Source: Wood Mackenzie

Implications for Queensland

Queensland is potentially in a favourable position to exploit the changing energy landscape as a producer. The State has an abundant and diversified resource base including coal, gas, oil shale, uranium and thorium. It has a mature export coal industry and is emerging as a major player in CSG. However, there are also several factors that could prevent Queensland from capitalising on these opportunities:

- There is a significant risk that high costs relative to our international competitors could weaken Queensland's market position and make it more difficult to attract investment.
- While there are large undeveloped resources of unconventional gas and thermal coal, they are mostly a long way from the coast and in areas where there is very little existing infrastructure, making these resources very expensive to develop.
- Community concerns about environmental impacts may hinder the development of new ways of extracting energy, such as underground coal gasification, or the expansion of export infrastructure such as new ports.
- There is considerable uncertainty about the size of the future global market for uranium.

Queensland also faces some significant challenges as a consumer of energy, which could, in turn, impact on the ability of the State's resources sector to reduce energy costs. Specifically:

- There are economic, structural and political barriers to reducing dependency on traditional energy sources (e.g. coal) and to increasing investment in alternative ways to harness production of cheaper energy.
- Queensland, like the rest of Australia, is highly dependent on liquid fuels for transport. Most refined products (petrol, diesel, aviation fuel) used are imported, and there are limited strategic petroleum reserves.

4 Looking ahead: resilience and adaptability

The one thing we know about the future is that it is uncertain. As international systems of finance, supply chains, health, energy, the Internet and the environment become more complex and interdependent, the risk of sudden shocks to the system grows. In the resources sector, we see the effect of this uncertainty in the increasing volatility of commodity prices as the trading environment changes.

The question is therefore how to ensure that new directions in Queensland are sufficiently resilient to deliver stability, and sufficiently adaptable to react to risks and shocks. This will require processes and institutions that are globally competitive yet locally flexible.

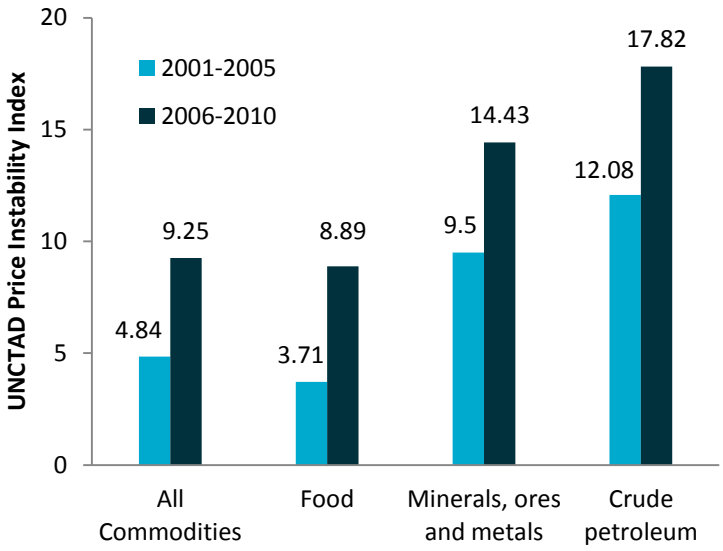

Figure 19: UNCTAD Price Instability Index: Comparison between 2001-2005 and 2006-2010

According to the World Economic Forum Global Risk Report 2014, the risks that are considered to be high impact and to have a high likelihood are mostly environmental and economic in nature: greater incidence of extreme weather events; failure of climate change mitigation and adaptation; water crises; severe income disparity; structurally high unemployment and underemployment; and fiscal crises in key economies.

The risks perceived to be most interconnected with other risks are macroeconomic –fiscal crises, and structural unemployment and underemployment – with strong links between this macroeconomic risk nexus and social issues, such as rising income inequality and political and social instability. The failure of global governance emerges as a central risk that is connected to many different issues.

No.	Global Risk
1	Fiscal crises in key economies
2	Structurally high unemployment/underemployment
3	Water crises
4	Severe income disparity
5	Failure of climate change mitigation and adaptation
6	Greater incidence of extreme weather events (e.g. floods, storms, fires)
7	Global governance failure
8	Food crises
9	Failure of a major financial mechanism/institution
10	Profound political and social instability

Source: Global Risks Perception Survey 2013-2014.
Note: From a list of 31 risks, survey respondents were asked to identify the five they are most concerned about.

Figure 20: Top 10 Global Risk Perceptions

However, the risks that most command attention are largely socio-cultural, relating to emerging instabilities in a multi-polar world. These include:

- Changing demographics, growing middle classes and fiscal constraints will place increasing domestic demands on governments, deepening requirements for internal reform and shaping international relations. Managing this risk will require flexibility, fresh thinking and multi-stakeholder engagement.
- The generation coming of age in the current decade faces high unemployment and precarious job situations, hampering their efforts to build a future and raising the risk of social unrest. In developing countries, an estimated two-thirds of the youth are not fulfilling their economic potential. In advanced economies, expensive, traditional educational systems graduate individuals with high debts and mismatched skills. This points to a need to adapt and integrate professional and academic education.
- So far, cyberspace has proved resilient to attacks, but the underlying dynamic of the online world has always been that it is easier to attack than defend. The world may be only one disruptive technology away from losing control of the online environment, meaning the Internet would cease to be a trusted medium for control, communication or commerce. The politics of preserving, protecting and governing the common good of a trusted cyberspace is an international challenge.

For a visionary Queensland, operating as a resources powerhouse in the 21st century, these risks need to be acknowledged and addressed by industry, government and civil society alike. Partnership and collaboration are keys to building the resilience required to operate effectively in this uncertain global environment. If there is one message from this foresight study, it is that a multi-dimensional approach will be required to deliver a strong Queensland resources sector in 2044. Several cross-cutting strategies emerge from thinking about the future, all of which require cross-departmental collaboration.

5 Conclusion

In this report, we have focused on how the Queensland resources sector may be impacted by five megatrends over the next 30 years. For each of these megatrends, the report has provided insights into what the trend means for the Queensland resource sector, identified existing strengths and constraints, and highlighted opportunities and challenges for the sector.

This report has provided an information base to consider a future where Queensland:

- is a preferred place to do business, thanks to it continued drive to be globally competitive;
- embraces its innovative potential based on a strategic and targeted investment in fresh thinking, data accessibility, innovative research and technology transfer;
- is a globally recognised hub of services to resource operations around the world due to its appropriately skilled workforce, entrepreneurial suppliers, and an ability to deliver additional value through integrated supply chains;
- is comprised of informed and engaged communities willing to partner with resource operators to share the benefits accruing from the State's resource endowment;
- is an educator of the next generation of resource sector innovators, professionals and employees due to new models of primary, secondary and tertiary education that deliver relevant technical skills and knowledge and the ability to operate effectively in a globally connected world; and
- continues to be an energy powerhouse, due in part, to its timely diversification into non-traditional energy resources.

ResourcesQ will use this information base to focus dialogue between government, industry and the community regarding the priorities for Queensland. It is through this engagement process that *ResourcesQ* will build a long-term strategic vision for the resources sector that is shared between government, industry and the Queensland community.

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SMI is a world leading research institute dedicated to finding knowledge-based solutions to the sustainability challenges of the global minerals industry. Our purpose is to develop practical solutions to the challenges of operating sustainably in the resources sector. We have a unique inter-disciplinary approach including expertise in engineering, science and the social sciences. Our work covers all facets of the life of mine from geology, to minerals extraction, water management issues, minerals processing, workplace health and safety, mine rehabilitation and community engagement.